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DIFFERENCES IN ESTIMATES DUE TO CHANGES IN METHODS OF DATA COLLECTION

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Abstract

A study is discussed which was designed to investigate differences in responses to a face-to-face survey versus a telephone/mail interview. The study originates from a large scale Dutch sample survey. The results of both methods of interviewing can be compared on the basis of an experiment: in two specific months both a telephone/mail survey and a face-to-face survey were held. The estimates based on the group of telephone respondents and those based on the face-to-face respondents were not the same. It turned out that the differences were significant and can to a large extent be explained by coverage errors, by the structure of the response, and by the length of the reporting period.

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1. Introduction

The impact of nonsampling errors on the accuracy of estimates is a well-known phenomenon. With the introduction of telephone interviewing new attention is paid to the differences in responses which might be induced by the mode of data collection. Apart from problems related to sample design, there are also problems like coverage errors, nonresponse errors, operator errors and reporting errors. Some of these occur also in face-to-face surveys and were studied earlier. The research on nonsampling errors in relation to telephone interviewing is however modest. Relevant literature is Groves and Kahn (1979), Assael and Keon (1982) and Wolfle (1979). Especially the paper of Marquis and Blass (1985) highlights current research on nonsampling error in relation to telephone interviewing methods and gives an extensive list of references.

The study on which we report here originates from a large Dutch sample survey namely the National Travel Survey (NTS). The aim of this survey is to obtain insight in the mobility of the Dutch population aged 12 years or older. An extensive description of the NTS is given in Moning (1985). In our study we concentrate on the impact of the mode of data collection on two variables: the mean number of journeys people make and the mean distance of these journeys.

To reduce the costs of surveys of the Netherlands Central Bureau of Statistics, the fieldwork of the NTS had to be changed. From 1978 until 1984 the data were collected in a face-to-face interview but from 1985 on the data are collected using a telephone/mail interview. This different way of collecting the data and some other changes in the survey process lead to estimates which differ significantly from those obtained in the face-to-face survey. There were time and cost constraints which made it impossible to investigate the impact of each separate component. We summarize the changes in Table 1. One can clearly see that there are a number of changes in the data collection procedure. The most important changes are without any doubt the different way of communication of the interviewer with the respondents and the number of days for which the respondents report their journeys.

To study the effect of these changes, two experiments were held in June 1983 and in June 1984. In both months the regular NTS (sample sizes resp. 1470 and 1380) was held and also an extra sample was taken for the 'new' NTS (sample sizes resp. being 1610 and 1440). Both surveys were conducted and the results of these two surveys were compared. Other factors like the number of recalls to not-at-homes were taken care of in as much as possible the same way as in the face-to-face survey. It appeared that the estimates for several characteristics differed significantly.

Table 1. Comparison between the National Travel Survey from 1978-1984 and the National Travel Survey from 1985.

National Travel Survey 1978 - 1984	National Travel Survey 1985 - onwards
a sample of households based on a sample of adressess	a sample of households based on a sample of telephone numbers (excl. secret numbers)
first visit by interviewer, collecting general information of household	telephone call by interviewer,collecting general information of household (direct data entry and control)
interviewer gives and explains diary	interviewer sends diary
respondent reports during 2 days or more	respondent reports for only one day
second visit of interviewer, checking and collecting diaries	respondent sends diary to CBS
	second diary is send if first diary is not returned
	third diary is send if second diary is not returned
processing general household information	

The nonresponse rate in the telephone/mail survey was slightly smaller (43%) then in the face-to-face survey (47%). Table 2 summarizes some of the results. For the estimated number of journeys per person per day the telephone/mail respondents yield larger estimates for the categories "car-

driver", "passenger of car", "train" and "walking". The estimated number of journeys by "bus/tram/metro" is however smaller. For the estimated number of kilometers we see almost a complete shift of the results: the estimates on the basis of the telephone/mail respondents are (except for "bus/tram/metro" and "motor bike") larger. For the total of all categories the telephone/mail results are about 7 percent larger for the number of journeys and about 11 percent larger for the number of kilometers.

Table 2. Estimated number of journeys per person per day by mode of transport

Mode of transport	Estimated number of journeys (p.p.p.d.)			Estimated number of kilometers (p.p.p.d.)		
	average regular	average tel/mail	diff. (%)	average regular	average tel/mail	diff. (%)
bicycle	1.11	1.13	+2	3.7	4.1	+11
car-driver	0.99	1.12	+13	13.3	14.4	+8
walking	0.60	0.63	+5	0.8	0.9	+13
passenger of car	0.43	0.45	+5	8.0	8.1	+1
bus/tram/metro	0.10	0.09	-10	1.3	1.3	0
moped	0.05	0.05	0	0.2	0.3	+50
train	0.04	0.05	+25	1.5	1.9	+27
motor bike	0.01	0.01	0	0.2	0.2	0
total	3.35	3.59	+7	29.6	32.8	+11

In this paper we try to explain these differences in the estimates caused by changes which took place in the data collection process. There are 5 major causes:

1. A different population:
   In the telephone survey we do not reach the population of non-telephone owners nor the people with a secret telephone number. The first population is about 8 percent of the original population whereas the second population is about 4 percent.

2. A different way of establishing contact:
The persons in the telephone/mail survey are contacted differently. This can have an impact on the composition of the response. Respondents which co-operate in a face-to-face interview may be reluctant to participate in a telephone survey or the other way round. We do not have any quantitative information about such a possible shift. The different way of contacting can also have effects on the quality of the data.

3. A different length of reporting period:
The length of the period for which the respondents report about their journeys has been reduced from 2 to 3 days in the face-to-face interview to only 1 day in the telephone survey. This can have an effect on the number of reported journeys, an effect which is well-known from experiences with budget surveys.

4. A different type of diary:
The diary in which the journeys are reported is simplified. This was necessary because the explanation which was given by the interviewer could not be so extensive as in the face-to-face survey. The impact which this change might have on the results can not be assessed. See Brög (1977) for a study on the possible influence of such a change.

5. A different nonresponse:
The diary was send by mail to the respondents and it had to be returned by mail also. It is likely that the respondents differ from the respondents in the face-to-face survey. Hendrikx (1979) found in another NTS study that the response of elderly people (who are/could be physically disabled) is much larger when the diary is collected by the interviewer than in the situation when the diary has to be mailed by the respondent. A number of papers on nonresponse bias in mail surveys indicate an overrepresentation of people with a higher education. See Goudy (1977) for a review.

We have studied three aspects of the differences which are found namely the possible causes 1, 3 and 5. In section 2 results are given which originate from the regular survey. We have calculated estimates for the

total population based on the sample of non-telephone owners and on the sample of telephone owners. For a number of variables the results of the population of non-telephone owners differ considerably from those of the telephone owners. In section 3 we try to standardize the distribution of the respondents in the telephone/mail survey to the distribution of respondents in the face-to-face survey with respect to background variables. After standardization we still find a difference between the two groups in respect to the number of journeys and the mean distance of the journeys per day. In section 4 we study the impact of the length of the reporting period on the results. Section 5 concludes this paper with some final remarks.

2. The target population and the population of telephone owners

In the telephone experiment we are faced with a coverage error: only the telephone owners which do not have a secret number can be reached. Observe that when random digit dialing is used we do not have this problem of secret numbers. Furthermore we assume that households have only one telephone number. A very small percentage of households in the Netherlands have secret numbers as well as a non-secret telephone number. We also neglected the fact that people who have a shop or workingplace at home, can have more than one number. In the present study we assumed that households have no telephone or one telephone number. The frame population is defined as the persons which might be reached in this telephone survey. (See also Lessler (1980) for more about definitions about frames and populations). The noncoverage population consists of persons which can not be reached because they do not have a telephone or because they have a secret telephone number. The coverage error can induce a bias if the study variables in the target population differ from those in the frame population. It can be derived that in simple random sampling the bias $B(\bar{y})$ in the estimator $\bar{y}$ for $\bar{Y}$, based on the frame population only, can be written as

$$B(\bar{y}) = N_{nc}(\bar{Y}_{fp} - \bar{Y}_{nc})/N_{tp}, \qquad (2.1)$$

in which N_{nc} indicates the total number of persons in the noncoverage population, N_{tp} this number for the target population, $\bar{Y}_{fp}$ the mean of the

study variable y for the frame population and $\bar{Y}_{nc}$ the mean of the study variable for the noncoverage population. It is obvious, like in nonresponse research, that the bias is composed of two parts: the amount of noncoverage (N_{nc}/N_{tp}) and the difference between the frame population and the noncoverage population in respect to the study variable.

The amount of coverage of the frame population is about 88 percent. The population of non-telephone owners is in the Netherlands about 8 percent whereas the telephone owners with only a secret telephone number consists of about 4 percent of the population. We are especially interested in the differences between the frame population and the noncoverage population. In the regular NTS there is information about telephone ownership and about the study variables. Estimates for the total population based on the frame population, the target population and non-coverage population, can be calculated using the data of the respondents in the face-to-face survey.

In the regular NTS an extensive post-stratification is used in which auxiliary variables urbanization (4 categories), day of the week (7 categories) and month (12 categories) are used. This post-stratification was especially constructed for the estimation of the number of journeys and the number of kilometers. As the noncoverage population is about 12 percent of the target population, the number of respondents per stratum which belong to the noncoverage population is roughly also about 12 percent of the original number of respondents. For this study we therefore combined the 336 strata into 48 strata (urbanization by month).

For each stratum h (h=1,..,48) we know the total number of respondents n_h, the number of respondents which own a telephone (excl. secret numbers) n_{h1} and the number of respondents which do not own a telephone (incl. secret numbers) n_{h0}. We calculate adjustment factors based on the 48 strata for the "old" weights which were based on the 336 strata. With these adjustment factors and the "old" weights we can make estimates for the whole population as if we had only interviewed telephone owners, and as if we had interviewed only non-telephone owners. We then compare these estimates with the estimates for the target population. The adjustment factor for the telephone owners in stratum h is given by

$$A_{h1} = (n_{h1} + n_{h0}) / n_{h1} \qquad (2.2)$$

and for the non-telephone owners we have

$$A_{h0} = (n_{h1} + n_{h0}) / n_{h0}. \qquad (2.3)$$

The new weights are the product of the old weights and the adjustments factors. In this way estimates for each of the populations are calculated. In fact we calculate estimates for $N_{tp}\bar{Y}_{fp}$ and $N_{tp}\bar{Y}_{nc}$ and we compare them with $N_{tp}\bar{Y}_{tp}$. Table 3 gives these estimates for several characteristics (in millions), although the strata were not originally made for this purpose. If an estimate based on only non-telephone owners is smaller then the corresponding estimate for telephone owners, then one may say that on the average, in the population of non-telephone owners, the mean of the study variable is smaller. For example the estimate of the total number of people which have a driving licence is smaller when we only interview people which do not have a telephone then in the case we interview only people which have a telephone. This means that among non-telephone owners there is a smaller proportion of persons which have a driving licence.

Table 3 shows that the mean of some study variables differs much in the several populations. For example when we estimate the total number of persons with a driving licence, based on a sample of telephone owners, we find 6.07 million persons. The estimated based on a sample of adressess is however 5.97 million. One can draw the conclusion that in the frame population, being the persons which can be reached because they have a telephone with a nonsecret telephone number, there are relatively more people which have a driving licence, relatively more heads of household, less unattached and more people who still follow education. Furthermore, there are more persons with no own income, more persons with a high income, less people with a season ticket, less older people but also less people with age 18-25 years. There are relativily more persons going to school. Regarding the possession of means of transport we find in the frame population a relativily much greater possession of a car and a bike and a smaller proportion of persons with no means of transport. Regarding the

mobility we see that the estimated number of journeys for the total population based on the frame population is much larger than the one based on the noncoverage population. The estimated total distance of the journeys is also much larger. Of course some of these results are based on interactions between variables.

Table 3. Estimates for the total population based on the frame population, the noncoverage population and the target population (in millions).

variable	based on the		
	Frame population	Noncoverage population	Target population
persons with driving licence	6.07	4.44	5.97
persons with motor licence	0.68	0.63	0.68
head of household	10.43	9.73	10.39
persons living alone	0.94	2.19	1.01
persons living together	6.75	5.80	6.70
still education	6.93	5.60	6.85
no own income	3.69	3.16	3.66
income > dfl 38 000	0.72	0.21	0.69
fixed work address	3.47	3.36	3.46
no season-ticket (bus,tram)	10.49	10.35	10.48
older then 64 years	1.40	1.58	1.41
18 - 25 years	1.27	2.35	1.33
students,at school	1.73	1.68	1.73
possessing only bike	5.24	5.28	5.25
possessing car and bike	3.22	1.98	3.15
possessing only car	0.60	0.54	0.60
possessing no mode of transport	0.89	1.78	0.94
number of journeys (x1000)	13.50	12.06	13.44
number of kilometers (x1000)	115.81	87.57	114.00
number of respondents	16 159	1 018	17 177

When the overall results based on the frame population are compared with those of the target population, we see that the differences are only moderate. This is due to the fact that although the noncoverage population is rather different from the frame population, the size of the noncoverage population is rather small. Therefore the ultimate effect on the estimates is small. This can easily be seen by formulae (2.1). Kersten (1984) showed, using balanced halfsamples that the estimated standard error of the esti-

mate of 13.44 billion journeys is 0.7 percent. The standard error of this estimate is larger than the difference which can be caused by the different population of respondents. For the estimate of 114.0 billion kilometers the estimated standard error is 1.4 percent. The noncoverage effect on this estimate is slightly larger than the standard error.

Table 4. Estimated number of journeys and kilometers (per person per day) for the total population.

Subpopulation	Estimated number of journeys based on			Estimated number of kilometers based on		
	Target pop.	Frame pop.	Diff. (%)	Target pop.	Frame pop.	Diff. (%)
Overall mean	3.43	3.45	+1	30.40	30.94	+2
Male	3.45	3.47	+1	37.16	37.50	+1
Female	3.41	3.44	+1	23.93	24.48	+2
Head of Household	3.36	3.48	+4	38.84	39.01	+0
Income:						
0 - dfl 8 000	3.88	3.91	+1	26.66	26.02	-2
8 000 - dfl 17 000	3.07	3.04	-1	23.81	25.62	+8
17 000 - dfl 24 000	3.29	3.26	-1	35.20	35.52	+1
24 000 - dfl 38 000	3.75	3.77	+1	43.08	42.75	-1
Low education	3.46	3.43	-1	28.83	29.73	+3
Middle education	3.77	3.86	+2	38.95	39.34	+1
12 - 15 year	3.68	3.66	-1	19.83	20.81	+5
18 - 25 year	4.00	4.07	+2	38.77	40.59	+5
35 - 45 year	3.49	3.58	+3	39.88	41.74	+5
65 year or older	2.19	2.22	+1	16.07	16.42	+2

Table 4 gives the estimates for the total population based on the frame population and the target population per person per day. Several subpopulation levels are considered. For the mean number of journeys we see sometimes serious differences at subpopulation levels (head of household, middle education, 18-25 year and 35-45 year). For the number of kilometers per person per day we find that the estimate for the total population based on the frame population is about 2 percent larger. For the categories income dfl 8 000 - 17 000, 12-15 year, 18-25 year and 35-45 year

quite large differences are obtained. All in all we can conclude that the differences in the population can not account for the whole gap between the estimates of the telephone/mail survey and the regular NTS. The coverage problem may lead to a difference of about 1% for the number of journeys and 2% for the average distance.

3. Differences due to the structure of the nonresponse

Table 2 showed that there are differences in the estimates based on the regular NTS and the telephone/mail survey. This might of course be due to the sampling error or to the structure of the nonresponse. To study this possible effect we have standardized or 'scaled' the respondents of the telephone experiment to the distribution of the respondents of the regular NTS of June 1983. This has been done using linear weighting techniques. For the theory on this weighting procedures see Bethlehem and Keller (1983). For this study we have deleted respondents of which the age, sex, urbanization or marital status were unknown. However, if the income was unknown, these respondents were still included in the scaling procedure.

Using linear weighting, the respondents of the telephone experiment are given such weights that the weighted distribution of a number of background variables for the telephone survey is exactly the same as those for the regular survey. This procedure can be applied for one background variable but also for several variables at once. We know from other research that the following variables have a large correlation with mobility characteristics: age, sex, marital status, ownership of a vehicle, driving licence, urbanization and income. The telephone respondents have been weighted in a number of ways and Table 5 presents some of the results. When only one variable is used, for example A, then only the marginal distribution of Age is used for the estimation. If two variables are mentioned, for example U+A, it means that both the marginal distribution of Urbanization and the one of Age are fitted. When U*A is stated, it is meant that each combination of these variables is used in the estimation procedure. This in fact corresponds to the ordinairy post-stratification by urbanization and age.

Table 5. Estimates for the number of journeys and the distance of the journeys for the respondents in the telephone experiment for some weighting procedures (sample size is 1 414).

Standardization to	Estimated mean number number of journeys	Estimated number of kilometers
Age + Income	3.60	30.53
Age + Sex	3.56	32.09
Age + Marital status	3.56	32.70
Age + Urbanization	3.58	32.09
Age + Vehicle	3.58	31.54
Age + Driving licence	3.55	31.78
Income + Marital status	3.67	31.34
Income + Urbanization	3.73	31.71
Income + Sex	3.71	31.73
Marital status + Sex	3.62	32.66
Marital status + Urbanization	3.65	33.04
Urbanization + Sex	3.56	31.88
Vehicle + Driving licence	3.62	31.81
A+S+U	3.58	31.94
A+S+I	3.60	30.68
A+S+M	3.56	31.86
A+S+D	3.55	31.73
A+S+V	3.58	31.44
A+M+D	3.56	31.80
A+M+U	3.58	31.78
A+M+I	3.61	30.54
A+I+U	3.61	30.40
A+V+D	3.58	31.59
A*S+M	3.58	31.98
A*S+I	3.60	30.59
A*S+U	3.60	32.09
A*S+V	3.59	31.51
A*S+S*D	3.57	31.61
Regular NTS	3.39	28.73
Telephone/mail	3.65	32.98
Mean of 39 weighting schemes	3.61	31.80

One can observe that weighting by a single background variable sometimes does not have effect at all (see for example Age). A combination with other background variables can however produce different results. The

lowest estimate for the average number of journeys is 3.55 and the largest is 3.73. The estimates for the distance vary from 30.40 to 33.11. Comparison with the estimates of the regular NTS and of the telephone/mail respondents shows that the gap between the estimates of the regular NTS and the telephone experiment can not totally be contributed to the difference in sample composition (see bottom of Table 5). Only a part of the gap can be explained by it. When we examine the average of the weighting procedures we see that the gap is declined from 3.65 to 3.61 (at most 3.55) for the number of journeys and from 32.98 to 31.80 (at most 30.40) for the number of kilometers. The possible impact of the nonresponse structure is therefore respectively 1% (at most 3%) and 4% (at most 9%).

4. Differences due to the change in length of the reporting period

In the NTS 1978-1984 the respondents reported about their journeys during two or three days in their diary. In the telephone/mail experiment and in the NTS from 1985 on, the reporting period is only one day. The impact of this change is studied using the data of the NTS of 1983 and by only taking into account the journeys which were reported on the first day. The journeys reported on the first days Sunday and Monday had to be ignored due to the small number of observations on these days. These days are, due to fieldwork procedures, seldom the first day of the reporting period. Tuesday however is overrepresented as the first day therefore the journeys which were reported on such first days were also neglected. The study is conducted for the Wednesdays, Thursdays, Fridays and Saturdays of 1983. In this way we obtain ınsight in the effect of the reporting period. The data on the first days were processed and weighted in the similar way as the regular NTS (post-stratification by urbanization, day of the week and month). Due to the fact that there were to less third day reports to permit a good comparison between the journeys on the first, second and third day, the last two categories were combined. The estimates are given in Table 6.

It appeared in this study that when the reported period is restricted to only one day, the estimated number of journeys increases with about 2 percent (per person per day). The estimated number of kilometers (per person per day) is about the same for both reporting periods. The increase in

the number of journeys is especially due to an increase of reported short journeys to shops (walking or cycling). Such 'overreporting' has also been found in budget surveys in which people report about their shoppings. The data collection method which is used has an upward impact on the estimate and for surveys designed for measuring expenditures and studying event history this is cumbersome.

Table 6. Estimates for different length of the reporting period (Indexed on the reporting period of two or three days = 100)

Variable	Length of reporting period	
	one day	two or three days
number of journeys	102	100
by mode of transport		
car passenger	101	100
car driver	100	100
bicycle	101	100
walking	104	100
by purpose of journeys		
to and from work	102	100
social	99	100
shopping	107	100
entertainment, sport	96	100
mean distance	100	100
by mode of transport		
car passenger	100	100
car driver	100	100
bicycle	100	100
walking	106	100
by purpose of journeys		
to and from work	102	100
social	98	100
shopping	108	100
entertainment, sport	92	100

5. Conclusions

The differences which are found in the results of the regular NTS and the telephone/mail experiment of the NTS originate from several sources. We

have studied three possible sources and found that none of these alone can be put responsible for the gap in the results. We summarize the results in Table 7.

Table 7. Review of the possible impact of various sources to the differences in the estimates

	Estimated mean number of journeys	Estimated mean distance of journeys
Telephone/mail experiment	3.59	32.8
Regular NTS	3.35	29.6
difference	7%	11%
perhaps due to		
noncoverage	1%	2%
nonresponse structure	1%	4%
reporting period	2%	0%
unexplained	3%	5%
standard error of estimate	2%	3%

As can be seen there remains a difference in the estimates, even when all effects go in the same direction. The remaining gap can not be explained by sampling error. We were however not able to study the impact of the simplification of the diary nor the impact of the mailing of the diary by the respondent. Those studies would require specific fieldwork experiments with balanced samples. We have been able to find some causes for the differences in the estimates. One may wonder if and how the results of our analysis can be generalized. The results of the analysis on coverage error can be generalized more easily than the results of the analysis of the reporting period. Of course one should keep in mind that the study reflects the Dutch situation. The nonresponse structure in a telephone/mail survey is different from the structure in a face-to-face survey, but this was already known from other studies. It is confirmed in our analysis. Finally, again evidence has been found that the length of the reporting period has an impact on the reported values.

6. Literature

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