

# Optimising survey costs in a mixed mode environment

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## Abstract

Mixed mode surveys, i.e. a combination of various survey modes (e.g. face-to-face, web, mail, fixed telephone, mobile telephone), is increasingly used in probability based sample surveys due to the need of optimising the survey process from the cost and quality point of view. The cheap survey modes (like web surveys) usually face lower coverage and response rates and correspondingly also higher biases. On the other hand, higher coverage and response rates are usually correlated with more expensive survey modes (like personal interviewing). In addition, in mixed mode surveys the solicitation stage can be entirely separated from the data collection, e.g. we can use a mail letter to invite respondents to a web questionnaire. Large number of possible mode combinations may thus appear, especially if three, four or five waves of follow-ups are used. Consequently, the corresponding costs & errors model is a very complex one. In this paper, we first theoretically describe a general approach to the problem of balancing costs and errors in a mixed-mode survey environment. Then, we demonstrate initial results of a pilot study, where mean square error (i.e. the compound bias and sampling error) as a measure of data quality was observed at fixed survey costs for several mixed-mode research designs. Finally, we present the approach used to address this problem in the future research.

**Keywords:** survey data collection, survey costs, optimization, survey quality, mixed mode, mean square error, survey error

## 1 Introduction

Survey data collection is the most important instrument of empirical data collection in social sciences and in official statistics. Its use is, however, becoming more and more aggravated because of declining response rates and increasing research costs. This substantially contributes to the widespread use of one particular survey mode, i.e. web surveys which offer new possibilities for cost reductions. On the other hand, their usage further exposes the problems of data quality. Especially critical are again response rates that are usually significantly lower in web based surveys compared to those in traditional survey modes (Lozar Manfreda et al., 2008). In addition, web surveys are often based on self-selected (access) panels of respondents, without a probability selection of sampling units. This is a very severe limitation, particularly for official and academic research (Vehovar et al., 2008).

Despite of several unresolved methodological issues, the web based survey data collection is becoming the leading approach in empirical research, at least in developed countries (Vehovar & Lozar Manfreda, 2008). This is especially true for marketing and opinion research. The usage is considerably lower in academic and official surveys of the general population, which usually require strict probability selection of sampling units. However, the increasing requests to optimize their data collection approaches are making a transition to web surveys an important challenge also for academic and official institutions. Investigation of possibilities for the implementation of web surveys into probability-based surveys is one of the priority tasks in the field of survey methodology and social science research methodology in general. National research foundations already approved several large research projects to address these issues (e.g. in USA, Germany, UK, Netherlands, Slovenia etc.). Increasing investigation of the potentials for integration of the web survey mode appears also in the in ESS (*European Social Survey*) research, the largest European cross national social science research project.

One promising way to address the methodological problems of web surveys is the utilization of mixed-mode approaches, which combine different solicitation and data collection modes. While these approaches are solving the survey quality part of the problem (e.g. nonresponse, noncoverage), the consequences for survey costs typically remain rather unclear (Vehovar et al., 2002). Ignoring the cost aspects is especially problematic for research on nonresponse in web surveys. Numerous existing comparisons of web with other survey modes – related to response rates, effects of incentives and nonresponse bias, etc. – are basically unfair to the web surveys as the cost savings in the web data collection are usually not taken into account. For example, if a mail survey performed with higher response rate than a web one, this is only partial information, because we ignored the cost savings. Considering the same costs, the web mode might perform much better if the savings in web survey were invested into solicitation and/or incentives for the web survey. The comparison of response rates (under equal costs for all options) might thus be dramatically different.

We can identify rich literature related to the nonresponse problem in web surveys. However, the specific relationship between nonresponse rates and nonresponse bias in web surveys has been investigated very rarely (Groves, 2006; Groves et al., 2006; Kypri, 2004; Stieger et al., in press; Webber et al., 2007). It is even harder to find studies that would also involve costs (e.g. Karr & Last, 2006; Vehovar et al., 2001; Vehovar & Lozar Manfreda, 1998).

In this paper, we present results from an initial step of a research project, funded by Slovenian Research Agency (#J7-0004 C). The final objective of the project is the optimization model that will support decision making as regards the optimal solicitation and mode selection options at each step of a complex probability-based survey process. We first present the research approach (2) and describe the pilot study (3). Next, we present preliminary results (4) and, finally, summarize conclusions as well as planned future activities (5).

## 2 Research approach

We address the problem of optimization through the relation between **costs** and bias using the **mean square error (MSE)** concept (Kish, 1965). In this regards, the main

aim of the study is to identify the design with the optimal MSE at the given costs. We already mentioned the separation of the solicitation from the data collection in mixed-mode surveys. Consequently, the costs must be also observed separately for the solicitation and separately for the data collection in each wave of contacting respondents.

Depending on the mode, the variable costs of the solicitation activities typically include mailing and/or interviewers' costs, solicitation part of telephone calls, incentives and administrative costs. On the other hand, the actual data collection costs embrace, for example, the costs of telephone or face-to-face interviews, paper questionnaire costs, data entry for mail surveys etc. Of course, those individuals who refuse the participation in the survey do not affect the costs of data collection, but only the solicitation part of the costs. Beside these two types of variable costs certain fixed costs need to be taken into account as well. As a sum, the total **costs** are basically a (very complex) linear function of the number of units that were subject to a certain mixed-mode treatment (i.e. solicitation or data collection) at specified steps (waves) of the survey.

With respect to the data quality measures, we use here a simple estimate of the **mean squared error** (MSE). MSE is an old and well-known concept (Kish, 1965) that measures the accuracy of the estimates. For a particular estimate, it is calculated as a simple sum of the sampling variance and the squared bias of this estimate.

Of course, this approach has several operational problems that need to be taken into account:

- A true value of a variable, which is needed to estimate the bias, is generally unknown. The closest approximation is usually assumed to arise from a control group. The control group can be defined as the experimental group with the highest response rate (e.g. face-to-face mode).
- Another problem is the identification of the key variables for which to calculate the MSE. There might be more key target variables, each having own optimization properties.

Nevertheless, our approach is as follows: for each experimental mixed-mode design (i.e. experimental cell) we perform an empirical implementation (or simulation) with the same given fixed costs. For each design we calculate the costs as well as the estimates of the sampling variance and the bias for several key variables. Finally, we compare the corresponding MSE across various design options (i.e. experimental cells) to see which design provided the best data quality at the given costs.

This initial step offers a promising potential for further development of a model that would perform optimal calculations at a sample unit level. This means that within a given cost model, within a given sampling error estimation model and particularly within a given estimation model for nonresponse bias, the application would automatically propose an optimal decision (i.e. a selection of the most appropriate solicitation and data collection mode) for each unit at each step (i.e. wave) of the survey process. For example, the unit that in the first wave did not respond to the letter with invitation to web questionnaire and refused to participate in a telephone survey in the second wave, would be advised by the model about the best strategy for further contacting of such unit.

### 3 Pilot study: Survey design

The pilot study was based on an official Eurostat survey – conducted annually in all EU member and candidate countries – about ICT usage by individuals and in households. In Slovenia, the survey was conducted in May 2008 among Slovenian citizens 10-75 years of age.

In this 2008 round, the Statistical Office of the Republic of Slovenia (SORS) was independently investigating the option for utilization of the telephone mode for this survey, which had been in past years (2004-2007) conducted face-to-face. So from the SORS's part there already exist an experimental design with a part of the sample (total gross sample from the Central Population Registry is  $n=2504$ ) where survey data collection was conducted face-to-face, while the other part was done using telephones (fixed or mobile).

Based on cooperation with the SORS, the University of Ljubljana, Faculty of Social Sciences (FSS), conducted further mixed modes experiments on an additional sample from the Central Population Registry ( $n=794$ ). There, only the persons of age 10-50 were included into the survey to avoid segments with low internet penetration. The FSS design was prepared with full cooperation of SORS, e.g. same cover letter, same information brochure enclosed, similar timing etc. However, because data from the SORS were not available at the time of the analysis (due to formal restrictions regarding data publishing), we here limit our focus on the FSS's part and only estimate the face-to-face design of the SORS's part.

The FSS survey was performed using an experimental design that manipulated different combinations of survey modes (web, mail, telephone) and types of incentives (no incentive, a small gift and monetary incentive). The basic experimental design is further presented in Table 1.

**Table 1: Basic experimental design and number of units in different experimental conditions**

	Mail or web	Mail, no web option	CATI or web	CATI, no web option*	F2F, no web option*	Total
<b>No incentive</b>	205	94	94	828	1676	2897
<b>Non monetary</b>	100	/	100	/	/	200
<b>Monetary (5€)</b>	100	/	100	/	/	200
<b>Total</b>	405	94	294	828	1676	3297

Notes: \*Data collected in the official study by SORS, the other cells conducted by FSS.

In the beginning of June 2008, individuals included in the FSS sample were split into three large groups. They have all received a pre-notification letter, one group with a non-monetary incentive (a wallet for coins), other cash incentive (5€) and the third group no incentive. Each letter was signed by the director-general of the SORS and by the dean of the FSS. Those in the groups with the web option were further provided with a unique access code and offered the possibility to complete the questionnaire on the web already in this first wave – i.e. in the first mailing (with the pre-notification letter only).

Approximately ten days after the pre-notification letter, non-respondents to the mail/web group and all individuals in the mail-only group received a paper questionnaire by mail with a business-reply envelope. At the same time, the telephone interviewing of nonrespondents from the CATI/web group started. Both groups with web option were still offered to participate on the web, either by providing them the identification code again in the mailing with the paper questionnaire (the mail/web group) or by repeating the code by an interviewer during the telephone contact (in the CATI/web group).

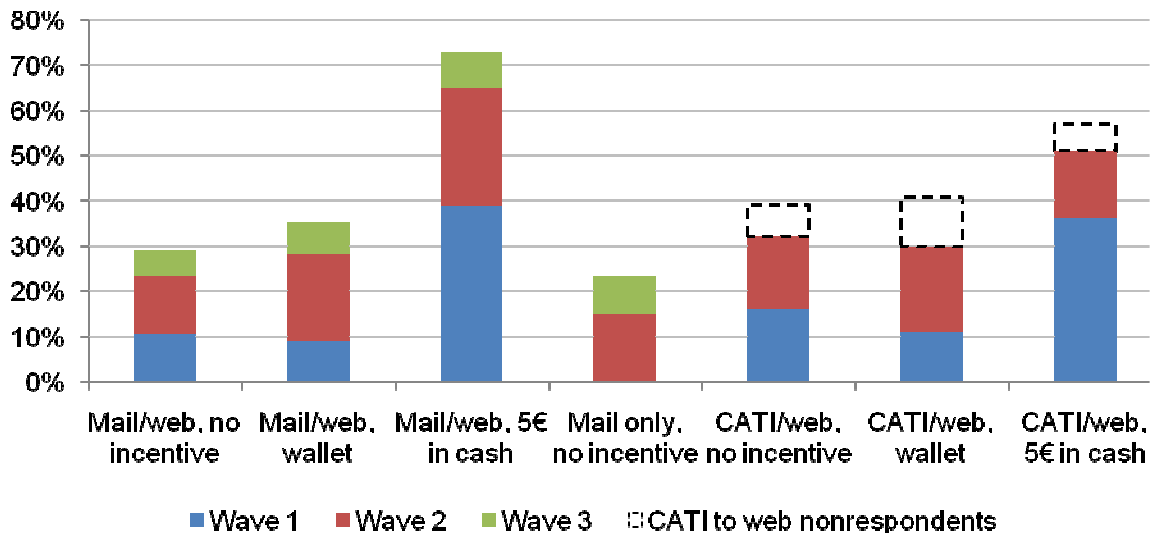
Non-respondents from the groups with the mail mode (mail/web and mail-only) were contacted again with a mail reminder about three weeks after the initial mailing. We thus have three waves of contacts for the “mail & web option” and “mail-only” group and two waves for the “CATI & web option” group.

## **4 Results**

### ***4.1 Response rates***

The comparison of response rates between different experimental groups (see Figure 1) shows a strong effect of the financial incentives, which especially boosted responses to the web survey (which was the only option in the first wave of data collection). The highest total response rate, amounting to 73%, was achieved in the mail/web group with the monetary incentives of 5€. The monetary incentives were also effective in the CATI/web group, where a total response rate was 51%. This effect is especially prominent in the first wave of the surveying in both groups with monetary incentives, when respondents were able to answer the questionnaire only on the web. Response rates in the other groups were significantly lower (amounting to around 30%), with the lowest (23%) being in the mail-only group with no incentives.

It should be noted that some of the telephone respondents promised to answer the web questionnaire in the telephone interview, but never actually completed the questionnaire. A total response rate for the groups with CATI and web option, which would be achieved if all these respondents answered the questionnaire (or, were interviewed by the telephone), is presented with the dashed part of the chart on the Figure 1.



**Figure 1: Response rates by waves in experimental groups.**

In 2007, the same survey conducted by the SORS achieved the response rate of 73% using a face-to-face mode and 46% using CATI. The SORS’s preliminary analysis of the 2008 survey response rates shows that the face-to-face mode produced the response rate of 67%, while the response rate for the CATI was 47%. A face-to-face follow up to the former mode successfully converted 58% of nonrespondents.

The mail/web mode with the monetary incentives in our experiment thus resulted in the same response rate as the face-to-face mode utilized by the SORS in 2007 and higher than the SORS’s face-to-face mode in 2008. On the other hand, the CATI/web mode without incentives in our experiment produced the response rate of 32%, which is lower than the CATI mode used by the SORS. This is partly due to CATI respondents who opted to participate on the web, but did not do so. Additionally, the telephone interviewing in our experiment started in the second half of June, when several individuals might had already been on holidays.

#### **4.2 Costs and errors**

The costs of surveying for each wave within each experimental group were estimated using the approach described in the Section 2. We roughly estimated the costs of the face-to-face mode, using response rates from the survey conducted in 2007 by the SORS. This presented the basis for the cost model, which enables fixing the costs and response rates for a direct comparison. The model takes into account all fixed and variable costs as well as response behaviour, separately for each wave in each experimental group. Due to the simplicity, we present here only the results that were obtained in the final wave of each group, i.e. in the third wave for the groups with the mail/web mode and the second wave for the other groups.

The mean square errors were estimated for two variables:

- a respondent’s use of the internet in the last three months,
- age of a respondent.

As a true population value for each of these variables, the values from the SORS’s face-to-face survey from 2007 are used (as mentioned, the 2008 data were not

available at the time of the analysis). The bias for the face-to-face group is therefore set to zero.

The optimal design is the design where the product of the costs and errors is the lowest. However, for demonstrational purposes the effects are much more evident if we compare the data quality (measured with estimated MSE) at fixed costs. For this reason we here omit the results based on the actual (or same) sample sizes and present only the results with simulated sample sizes (either equal initial sample sizes or sample sizes allowed by the defined fixed costs budget).

Table 2 and 3 show the following key findings:

- With the fixed costs of 2000€, very different initial sample sizes need to be selected. This directly reflects differences in the costs of the designs.
- Different initial sample sizes, biases of key variables and structures of the costs introduce large changes into the relation between errors and costs if compared to the situation where we apply the same initial sample sizes. For example, because of a higher response rate, the CATI/web mode with the monetary incentives is now performing better than the mail/web mode with the non-monetary incentives when observed for the average age of respondents (Table 2). With fixed budget we can clearly see the “costs” of desired data quality.
- Response rates are not really important as long as there is no bias. For example, mail only (no incentive design) option performs the second best in the Table 2, despite of a very low response rate.
- The obtained picture is very complex, which is evident from the fact that the bias produced by different modes substantially differs between the variables. For example, the mail mode performs well for the estimation of the age of respondents, but poorly for the estimation of the Internet use. This suggests that several variables need to be taken into account in order to address the problem of optimization.
- The face-to-face option is superior due to a small bias despite its high costs (relatively low costs of this option in this very example are due to cheap student interviewers in Slovenia, which can be hired without taxes).

**Table 2: Initial sample sizes and MSE at the fixed costs of 2000€, calculated for the average age of respondents.**

Group	Response rate	Costs = 2000 €			
		Initial sample size	$\bar{X}$ (s)	Bias	MSE
Mail/web, no incentive	29%	717	28,56 (10,85)	2,49 (9%)	6,7
Mail/web, wallet	35%	346	32,24 (11,26)	-1,19 (-4%)	2,5
Mail/web, 5€ in cash	73%	218	28,71 (11,24)	2,34 (8%)	6,2
Mail-only, no incentive	23%	732	30,24 (11,85)	0,81 (3%)	1,5
CATI/web, no incentive	32%	568	35,10 (13,79)	-4,05 (12%)	17,4
CATI/web, wallet	30%	279	29,90 (11,13)	1,15 (4%)	2,8
CATI/web, 5€ in cash	51%	184	29,90 (10,00)	1,15 (4%)	2,4
F2F*, no incentive	73%	198	31,05 (11,80)	0,00 (0%)	1,0

\* Based on the SORS's survey from 2007, costs roughly estimated.

**Table 3: Initial sample sizes and MSE at the fixed costs of 2000€, calculated for the percentage of respondents who used the Internet in the last three months.**

Group	Response rate	Costs = 2000 €			
		Initial sample size	$p$	Bias	MSE
Mail/web, no incentive	29%	717	0.895	-0.13 (-14%)	0.016
Mail/web, wallet	35%	346	0.886	-0.12 (-13%)	0.014
Mail/web, 5€ in cash	73%	218	0.958	-0.19 (-20%)	0.036
Mail-only, no incentive	23%	732	1.000	-0.23 (-23%)	0.053
CATI/web, no incentive	32%	568	0.900	-0.13 (-14%)	0.017
CATI/web, wallet	30%	279	0.833	-0.06 (-8%)	0.005
CATI/web, 5€ in cash	51%	184	0.860	-0.09 (-10%)	0.010
F2F*, no incentive	73%	198	0.770	0,00 (0%)	0.001

\* Based on the SORS's survey from 2007, costs roughly estimated.

## 5 Conclusions

We addressed here a very essential question of the contemporary survey research: is it possible to provide probability sample surveys – with high enough response rates to prevent damaging nonresponse biases – by relocation of the savings from the cheap web survey data collection into the solicitation stage (incentives, invitations, mixing modes etc.)? Or alternatively: can the web data collection compete with standard modes in probability sample surveys employing mixed modes if the same amount of financial resources is used?

Although this pilot study was based only on a relatively small sample sizes, some important guidelines for further research were obtained.

- The comparison of the response rates across the different modes shows a strong effect of the financial incentives, which especially boosted the responses to the web survey. While this confirms that the incentives can be effectively used for heightening the response rates in the web surveys, it also confirms that it may create an additional bias for the certain variables. With the incentives we may just get an additional overrepresentation of specific segments (i.e. internet users) and shrink the contribution of nonuser segments.
- We found some indication of substantial differences between respondents to the mail and the telephone modes, which will require further investigation.
- The bias is generally lower when observed for the age of the respondents, which implies that various survey topic are susceptible to the mode and the nonresponse errors differently.
- All designs with the web mode involve high biases and thus they all perform low as regards the cost/MSE ration, even when response rates are high (with incentives). Obviously, these designs would need further follow-ups with traditional modes to compete with the face-to-face option. It seems that the face-to-face option can be challenged only if cheap web option would be followed with a telephone or face-to-face surveying of non-respondents.

On the basis of these findings, further research steps will be taken:

- (1) A meta-analysis of published mixed-mode surveys that will scrutinize different approaches to recruit respondents by using various data collection modes (web, telephone, mail and face-to-face surveying). A starting point for the analysis will be the WebSM database, established by the EU Framework Programme (Web Survey Methodology, <http://WebSM.org>).
- (2) New experiments will be performed in 2009 and 2010 that will also include mobile phone surveys. Mixed-mode surveys will be used to study ICT usage in households as well as the impact of ICT on social relations. In addition, *a priori* estimates will be used as starting values in the cases of missing empirical data. Of course, posterior data are continuously added on the basis of new surveys.
- (3) The obtained results will serve as a starting point for a development of an advanced statistical model for optimization of the survey strategy for each individual respondent at each wave of a survey process. The model will be

grounded on operations research and Markov chain processes and will take into account improved cost and data quality estimates.

- (4) Finally, the algorithm will be integrated into an interactive web application for the implementation of mixed mode surveys, which will provide a real-time support for making decisions on further solicitation and data collection steps.

Such model and its further developments will allow the analysis of different scenarios with varying initial sample sizes and cost restrictions, thus presenting the basis for successful approaches of introduction of the web into probability survey data collection.

## References

- Groves, R. M. (2006) Nonresponse Rates and Nonresponse Bias in Household Surveys, *Public Opinion Quarterly*, 70, 646-675
- Groves, R. M. et al. (2006) Experiments in Producing Nonresponse Bias, *Public Opinion Quarterly*, 70, 720-736
- Karr, A.F., Last, M. (2006) Survey Costs: Workshop Report and White Paper, Report from the *Survey Cost Workshop*, Washington
- Kish, L. (1965) *Survey Sampling*, Wiley, New York
- Kypri, K. (2004) Assessment of Nonresponse Bias in an Internet Survey of Alcohol Use, *Alcoholism: Clinical & Experimental Research*, 28, 630-634
- Lozar Manfreda, K. et al. (2008) Web Surveys Versus Other Survey Modes: A Meta-Analysis Comparing Response Rates, *International Journal of Market Research*, 50, 79-104
- Stieger, S. et al. (in press) Forced response in online surveys: bias from reactance and an increase in sex-specific dropout, *Journal of the American Society for Information Science and Technology*, in press
- Vehovar, V., Lozar Manfreda, K. (1998) How many mailings are enough, in: *Nonresponse in survey research, Nachrichten spezial, No. 4*, Koch, A. & Porst, R. (Eds.), Zentrum für Umfragen, Methoden und Analysen, 139-149
- Vehovar, V. et al. (2001) Sensitivity of electronic commerce measurement to the survey instrument, *International Journal of Electronic Commerce*, 6, 31-51
- Vehovar, V. et al. (2002) Nonresponse in Web surveys, in: *Survey Nonresponse*, Groves, R. M. et al. (Eds.), Wiley, 229-242
- Vehovar, V. et al. (2008) Probabilistic methods in surveys and official statistics, in: *Handbook of Probability: Theory and Applications*, Rudas, T. (Ed.), Sage, 225-239
- Vehovar, V., Lozar Manfreda, K. (2008) Overview: Online Surveys, in: *The Sage handbook of online research methods*, Fielding, N. G. et al. (Eds.), Sage, 177-194
- Webber, K. et al. (2007) What's in a Mode? Assessing the Use of Mixed Modes to Reduce Nonresponse Bias in a Federal Survey. Paper presented at the *American Association for Public Opinion Research (AAPOR) 62th Annual Conference*, Anahaim