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Non-response Follow-up for Business Surveys

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ABSTRACT

Follow-up of nonrespondents in business surveys is a time and resource intensive activity. Given the decline in response rates, non-response follow-up takes on more and more importance to ensure continued quality of estimates produced. Given a fixed budget to follow-up non-responding units, what is the best way to select units for non-response follow-up in business surveys? Should all non-respondents be followed up or just a sample of them? If a sample is followed-up, how should it be selected? Should the sample be selected using simple random sampling (SRS), stratified SRS or probability proportional to size (PPS) sampling? These questions were addressed in two ways. Firstly, a simulation study compared the Monte Carlo biases and mean square error using data from an existing survey. Secondly, the exact follow-up sample size for a follow-up using simple random sampling and assuming uniform response rates was developed.

Key Words: Sub-sample, Business surveys.

RÉSUMÉ

Le suivi des non-répondants aux enquêtes auprès des entreprises est une activité qui consomme énormément de temps et de ressources. Or, compte tenu de la baisse des taux de réponse, le suivi de la non-réponse s'impose de plus en plus si l'on veut maintenir la qualité des estimations produites. Pour un budget de suivi des unités non répondantes fixe, quelle est la meilleure façon de choisir les unités à suivre dans les enquêtes auprès des entreprises ? Faut-il faire le suivi de tous les non-répondants ou seulement auprès d'un échantillon d'entre eux ? Dans ce cas, comment sélectionner l'échantillon ? Par sondage aléatoire simple (SAS), SAS stratifié ou probabilité proportionnelle de la taille ? Nous répondons à ces questions de deux manières. D'abord, nous comparons par étude de simulation les biais de Monte-Carlo et l'erreur quadratique moyenne à l'aide de données tirées d'une enquête existante. Ensuite, nous définissons la taille précise de l'échantillon de suivi par sondage aléatoire simple, en considérant que les taux de réponse sont uniformes.

Mots Clés: Sous-échantillon, Enquêtes auprès des entreprises.

1. INTRODUCTION

Collection research is currently a hot topic amongst national statistical agencies looking to increase response rates and/or reduce collection costs. With the extremely high costs of collecting survey data, even a small increase in efficiency can translate into significant monetary savings. Recognizing this opportunity, much research has been done in recent years on how collection costs can be managed despite the growing reluctance of businesses and individuals to respond to survey requests. Much of the research done to date looks to tap into the growing availability of process data, or paradata, to adapt collection methods in order to ensure continued high response rates. In particular, they focus on follow-up of non-respondents given the high costs associated with these follow-ups and the possibility of reducing the potential of non-response bias.

Much of the research done to date has been on adaptive collection designs (also called adaptive survey designs, responsive collection designs, responsive survey designs or simply responsive designs in the literature). Groves and Heeringa (2006) define a responsive survey design as one that uses paradata, or process data, to guide changes in the features of data collection in order to achieve higher quality estimates per unit cost. Beaumont, Bocci and Haziza (2014) note that the literature on adaptive collection designs has mainly focussed on developing procedures that aim at reducing the nonresponse bias of an estimator which is not adjusted for nonresponse (see for example Schouten, Cobben and Bethlehem, 2009, and Peytchen, Riley, Rosen, Murphy and Lindblad, 2010). Beaumont, Bocci and Haziza (2014) argue that any information (e.g. auxiliary data, paradata) that can be used during collection to reduce nonresponse bias can also be used at the estimation stage. In other words, the nonresponse bias that can be removed at the collection stage through an adaptive collection procedure, could also be removed at the estimation stage through appropriate nonresponse weight adjustments. They suggest that adaptive collection procedures, such as call prioritization, cannot reduce the nonresponse bias to a greater extent than a proper nonresponse weight adjustment.

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In one of the first papers to discuss non-response, Hansen and Hurwitz (1946) proposed subsampling non-respondents in order to eliminate non-response bias. They considered the following case: questionnaires are mailed out and after a certain period of time, a sample of non-respondents is followed-up by personal interviewers to obtain their responses. They showed how the responses to the initial mail-out can be combined with those from the non-response follow-up responses to obtain an unbiased estimator of the variable of interest. A very strong assumption that they made was that the response rate of the non-response follow-up would be 100%. In today's environment, this assumption is not realistic as personal interviews are becoming more and more costly and, more importantly, businesses and individuals are becoming more and more reluctant to respond to surveys.

Up until now, the vast majority of the literature on collection research targets household surveys, and not much is reported on this subject for business surveys. Although business surveys typically use simple sample designs, they do possess certain characteristics which can pose collection challenges. Business populations are very highly skewed with a small number, relative to the population size, of businesses representing a large portion of the economic activity. Because of this skewness, business surveys typically use stratified simple random or stratified Bernoulli sample designs, which include a take-all stratum where all units are selected with certainty. These take-all units are the large businesses which can contribute significantly to the overall estimate and without which could lead to biased estimates. Because of this, it is essential that they be contacted and that their responses are received. In addition, business surveys are usually conducted through mail-out/mail-back or electronic questionnaire collection with computer assisted telephone follow-up with representatives of the business for non-response. Thus the use of incentives, either for interviewers or respondents, is not really appropriate. Finally, the size of the business may be highly correlated to its ability, or its willingness, to respond. Large businesses typically have staff capable of responding to questions on the questionnaire (for example, accountants) whereas small businesses may have to pay an outside accountant to obtain the requested information.

In the remainder of the paper, we present some work done on sub-sampling non-respondents for the purpose of non-response follow-up in the business survey context. Some notation is introduced in the next section. Section 3 describes the simulation study that was used to investigate possible sub-sampling designs. Results are presented in section 4 and a few words on calculating an optimal sub-sample size are given in section 5. Section 6 presents some conclusions.

2. NOTATION

Suppose that we have a population of units, U, stratified into L strata $U = \cup U_h$, $h=1, \ldots, L$, where U_h is the population in stratum h. The set of sampled units from U are denoted as s_1. The set of sampled units in stratum h are denoted as sample s_{1h}, and the probabilities of selection for unit i in stratum h is denoted as π_{1hi}, where $i = 1, \ldots, n_h$ and $h = 1, \ldots, L$. The sampled units in stratum h are sent a questionnaire: suppose that n_{hr} of these units respond with probabilities p_{1hi}. After a certain period of time, a sample of the non-respondents, of size n_{2h}, is selected from the set of non-respondents s_{1hnr} in stratum h with probabilities π_{2hi} for follow-up. For simplicity, we assume that the original stratification is retained for the follow-up sample. The follow-up procedure is performed via telephone and the response propensity for these units is p_{2hi}, and this will most likely differ from their probability of response to the mailout. Follow-up of non-responding units continues until a fixed budget is expended or all followed-up units respond or are resolved (that is, the unit is assigned a final outcome of respondent or refusal), whichever comes first. If not all the followed-up units respond, a weighting adjustment is required to account for the outstanding non-responding units.

We consider the following estimator

$$\hat{Y} = \sum_h \sum_{i \in s_{1hr}} w_{1hi} y_{hi} + \sum_h \sum_{i \in s_{2hr}} \widetilde{w}_{2hi} y_{hi} \tag{2.1}$$

where s_{1hr} is the set of units in the h-th stratum that responded to the initial mailout, s_{2hr} is the set of units in the h-th stratum that responded to the follow-up, $w_{1hi}=1/\pi_{1hi}$ is the weight associated with the original sample selection, $\widetilde{w}_{2hi} = w_{1hi} \times 1/\pi_{2hi} \times a_{2hi}$ is the non-response adjusted weight for the units that responded to the follow-up and y_{hi} is the variable of interest for the i^{th} unit in the h^{th} stratum.

The non-response adjustment was calculated over all strata and not at the stratum level to avoid the situation where a stratum may not have any respondents to the follow-up contact. The adjustment is

$$a_{2hi} = \frac{\sum_h \sum_{i \in s_{2h}} w_{1hi}/\pi_{2hi}}{\sum_h \sum_{i \in s_{2hr}} w_{1hi}/\pi_{2hi}}.$$

The performance of this estimator was investigated for different sub-sampling scenarios through a simulation study, which is described in the following section.

3. SIMULATION STUDY

This section describes each of the steps involved in the simulation: the data used, mailout collection, the selection of a follow-up sample, follow-up collection, and estimation.

3.1 Data used for the Simulation

The starting point of the simulation was a sample from Statistics Canada's Monthly Survey of Food Services and Drinking Places (MSFSDP). Two variables were used, the frame variable 'Revenue' and the survey variable 'Sales'. Both variables are available for all the units selected in the sample, with the Sales variable being imputed for approximately 15% of the units (those which did not respond to the survey). The correlation between Revenue and Sales is 83%.

As is typical for business surveys, the MSFSDP is stratified by province, industry and size strata (take-all and one or more take-some strata). For more on the MSFSDP, see Statistics Canada (2017). Each 'Take All' stratum within a province industry combination consists of the large and important businesses which are usually all followed up. Such units were excluded from the study, and we included a total of 2,375 units in the study, from the 63 'Take Some' strata. The set of sampled units in the study are denoted as s_1. This sample is stratified into strata s_{1h}, where h=1,...,63. Note that the goal of the study is to investigate the collection process. That is, the sample s_1 is fixed, whereas the response process is simulated.

3.2 Mailout Collection

Data collection for business surveys typically begins with the mailout of questionnaires or an invitation to an electronic questionnaire to the units selected in the sample. The respondents to the mailout are denoted as $s_{1r} = \sum_h s_{1hr}$, and the nonrespondents as $s_{1nr} = \sum_h s_{1hnr}$. Nonresponse to the mailout is simulated as follows. Before the start of the simulation each unit is assigned a probability of response, denoted p_{1hi} for unit i in stratum h. Nonresponse is randomly generated based on the values of p_{1hi}.

Two different response scenarios were considered:

1) Uniform: p_{1hi} = 50% for all units, regardless of the characteristics of the units. Under this scenario, the expected number of respondents to the mailout is 1187.5 (=2,375/2).
2) Correlated to the variable of interest: p_{1hi} is based on the following logistic function:

$$\text{Ln}\left(\frac{p_{1hi}}{1-p_{1hi}}\right) = -0.31 + 0.000004\, y_{hi},$$

   where y_{hi} is the value of the the variable of interest. The constants, -0.31 and 0.000004, were chosen so that the expected number of respondents to the mailout under this scenario is also approximately half of the initial sample. Note that there is a 97% correlation between p_{1hi} and the variable of interest.

3.3 Follow-up Sample

The next step in the simulation is to select a follow-up sample from the mailout nonrespondents (s_{1nr}). The follow-up sample is denoted s_2. The following designs were considered for the follow-up sample:

1) Follow-up of all mailout nonrespondents.
2) A simple random sample selected from s_{1nr} (the original stratification is ignored).
3) A stratified SRS selected from s_{1nr} using the original stratification. Sample allocation is proportional to the number of mailout nonrespondents.

4) A sample selected systematically from s_{1nr} with probability proportional to the frame variable, Revenue. The original stratification is ignored.
5) A sample selected systematically from s_{1nr} with probability proportional to Revenue multiplied by the design weight. The original stratification is ignored.

Note that the size variables used for the PPS sampling were trimmed from below to the 5th percentile to remove zeros, and some extremely small values which were causing instability.

The simulation was run with follow-up sample sizes of 100, 200, 300, 400, 500, 700, 900, and approximately 1,188 for the follow-up of all nonrespondents.

3.4 Follow-up Collection

In business surveys, follow-up collection is typically done by telephone. Multiple phone call attempts are sometimes necessary in order to reach and get a response from a unit. The collection process is simulated at the call attempt level with each call attempt randomly assigned one of the following possible outcomes:

1) Response: a response is obtained from the unit. The unit is 'finalized'; that is, it is removed from the calling queue so that it does not get called again.
2) Final Nonresponse: the unit is finalized as a nonrespondent; it should not be called back again and the unit is removed from the calling queue. An example of this outcome is a refusal.
3) Still in-progress: the unit needs to be called again; it is therefore returned to the calling queue (it is not finalized). An example of this outcome is an attempt where no contact was made, or an attempt where an appointment was made for a call back.

The 'response' outcome and 'final nonresponse' outcome are both final outcomes, in the sense that the unit is removed from the calling queue and from collection. This is in contrast to the 'still in-progress' outcome where the unit is returned to the calling queue so that it can be called again.

For each sampled unit, the probability of each outcome is assigned before the start of the simulation. The probability of a 'response' is denoted as $p_{2hi}^{(1)}$, the probability of a 'final nonresponse' is denoted as $p_{2hi}^{(2)}$, and the probability of a 'still in-progress' is denoted as $p_{2hi}^{(3)}$, for unit *i* in stratum *h*. Two different response scenarios were considered:

1) Uniform: $p_{2hi}^{(1)}$ = 25%, $p_{2hi}^{(2)}$ = 5%, and $p_{2hi}^{(3)}$ = 70% for all units, regardless of the characteristics of the units.

2) Correlated to the variable of interest: The probability of a 'response' is based on the following logistic function:

$$\mathrm{Ln}\left(\frac{p_{2hi}^{(1)}}{1-p_{2hi}^{(1)}}\right) = -1.29 \ + 0.000002\, y_{hi} + 0.3\, Z,$$

   where y_{hi} denotes the variable of interest and Z is a Normal (0,1) variable. The constants, -1.29, 0.000002, and 0.3 were chosen so that the expected number of units with a 'response' outcome is approximately 25% of the sample when the expectation is calculated over the entire sample. The other two probabilities are defined as follows: $P_{2hi}^{(2)} = \frac{0.05}{0.75}\left(1 - P_{2hi}^{(1)}\right)$, and $P_{2hi}^{(3)} = \frac{0.70}{0.75}\left(1 - P_{2hi}^{(1)}\right)$. Note that there is a 61% correlation between $P_{2hi}^{(1)}$ and the variable of interest.

Some units are called several times. For each call, the same probabilities, $p_{2hi}^{(1)}, p_{2hi}^{(2)}$, and $p_{2hi}^{(3)}$, are used to randomly generate the outcome of the call. The unit remains in the calling queue until it is finalized, and an outcome of 'response' or 'final nonresponse' is obtained.

The simulation takes cost into account by charging a cost for each call attempt. The amount charged depends on the outcome of the attempt: a 'response' outcome has a cost of 5 units, a 'final nonresponse' outcome has a cost of 2 units, and a 'still in-progress' outcome has a cost of 1 unit. In practice, cost is related to the length of the phone call. The simulation assumes that phone calls with a 'response' outcome tend to be longest, and phone calls with a 'still in-progress' outcome tend to be shortest. The total collection budget is fixed at 3,000 units. Collection ends when the budget runs out, or when there are no more cases left in the calling queue (i.e., all units are finalized), whichever occurs first.

At the end of collection, there are two types of nonrespondents: the units that were finalized with a 'final nonresponse' outcome, and those that were not finalized, i.e., the budget ran out while they were still in the calling queue. Both types of nonrespondents are taken into account through weighting adjustments. The nonrespondents to the follow-up are denoted as $s_{2nr} = \sum_h s_{2hnr}$, whereas the respondents are denoted as $s_{2r} = \sum_h s_{2hr}$.

The final step of the simulation is to create weights and produce estimates. The stratified SRS estimator of the total that was used in the study is given by equation (2.1).

4. SIMULATION RESULTS

Four response scenarios, with varying degrees of realism, were considered for the simulation study:

- Scenario 1: A uniform response mechanism for both the mailout and follow-up. That is, the probability of response is the same for all units and is independent of the variable of interest and that of other units. Although this scenario is not very realistic, it will serve as a baseline scenario with which to compare the other scenarios.
- Scenario 2: The probability of response is correlated to the variable of interest for the mailout, and uniform for the follow-up.
- Scenario 3: The probability of response is uniform for the mailout, and correlated to the variable of interest for the follow-up.
- Scenario 4: The probability of response is correlated to the variable of interest for both the mailout and the follow-up. This scenario is probably the most realistic.

The simulation was performed under each scenario with the follow-up sample designs described in Section 3.3. For each response scenario and design, 1000 simulations were performed and the estimator given by equation (2.1) was computed. The follow-up sample designs were evaluated by comparing their Monte Carlo relative bias (RB) and relative root mean square error (RRMSE), which were calculated as

$$\text{RB} = \left(1/\tilde{Y}\right)\left(\frac{\sum_{r=1}^{R}\hat{Y}_r}{R} - \tilde{Y}\right) \times 100\%$$

and

$$\text{RRMSE} = (1/\tilde{Y})\sqrt{\frac{\sum_{r=1}^{R}(\hat{Y}_r - \tilde{Y})^2}{R}} \times 100\%,$$

where $\tilde{Y}$ is the estimate for the variable of interest based on the original sample and the original weights, $\hat{Y}_r$ is the estimate based on the r^{th} replicate of the simulation, and R is the number of replicates in the simulation (R=1000).

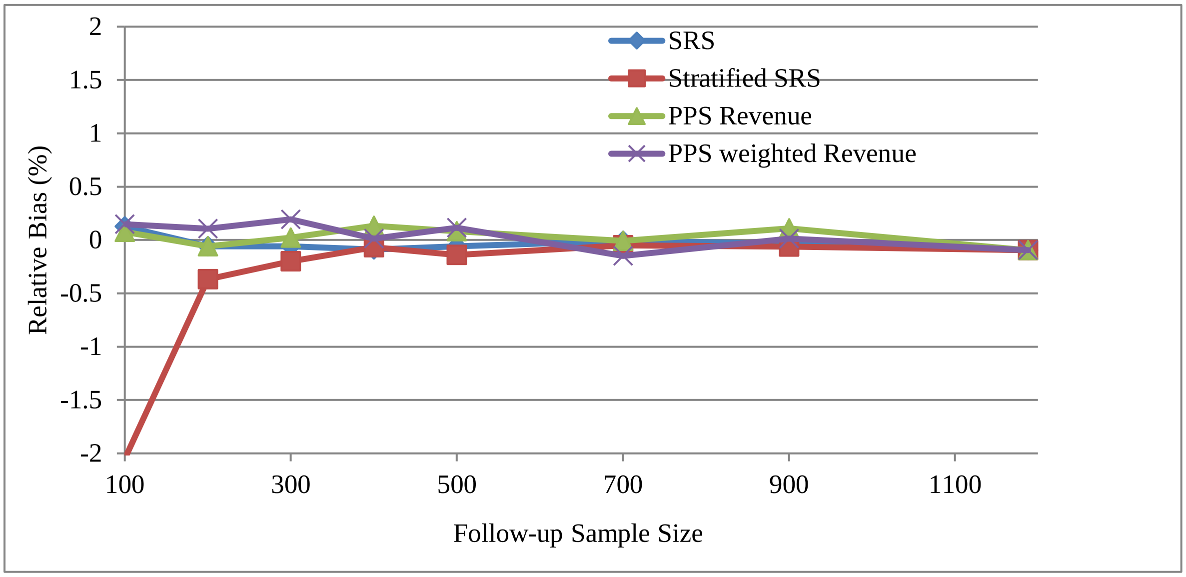
We observed that for follow-up sample sizes of 100 to 400, all the units are finalized with an outcome of 'response' or 'final nonresponse' before the end of collection. For sample sizes of 500 or over, the collection budget runs out before all the units are finalized. More specifically, we observed that at the end of collection, on average approximately 440 cases are finalized and the other units remain in the calling queue with an outcome of 'still in-progress'. The collection budget used for the simulation was just large enough to finalize approximately 440 units. This is key to understanding the results of the study.

The above observation implies the following. As the follow-up sample size increases from 100 to 400, the number of respondents increases. On the other hand, as the follow-up sample size increases from 500 to 1188, the number of respondents remains roughly constant while the number of nonrespondents increases, which implies that the response rate to the follow-up decreases. The increase in the number of nonrespondents can be explained by a smaller average number of call attempts per sample unit as the sample size increases.

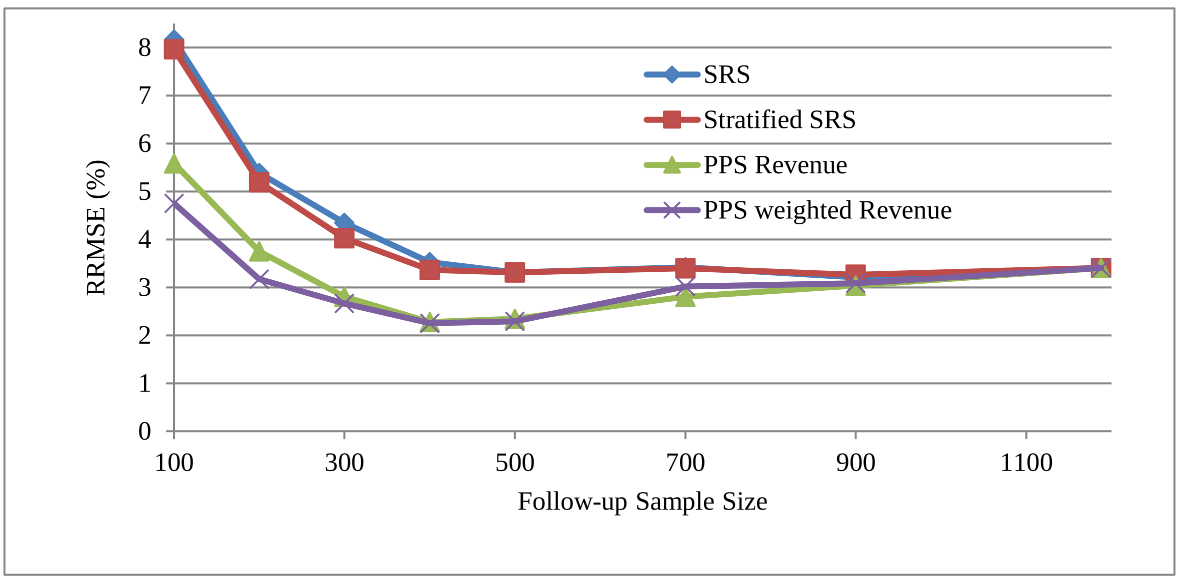
4.1 Results for Response Scenarios 1 and 2

This section provides results for the scenarios where the probability of response to the follow-up is uniform. In scenario 1, the probability of response to the mailout is uniform but in scenario 2 it is correlated to the variable of interest. The results of the two scenarios are similar as any potential non-response bias introduced in the mailout due to the probability of response being correlated to the variable of interest (scenario 2) is essentially eliminated through the follow-up. From Graph 4.1, one can see that the RB is approximately zero for all follow-up sample sizes and designs.

Graph 4.1: RB versus Follow-up Sample Size for Scenario 1



Graph 4.2: RRMSE versus Follow-up Sample Size for Scenario 1

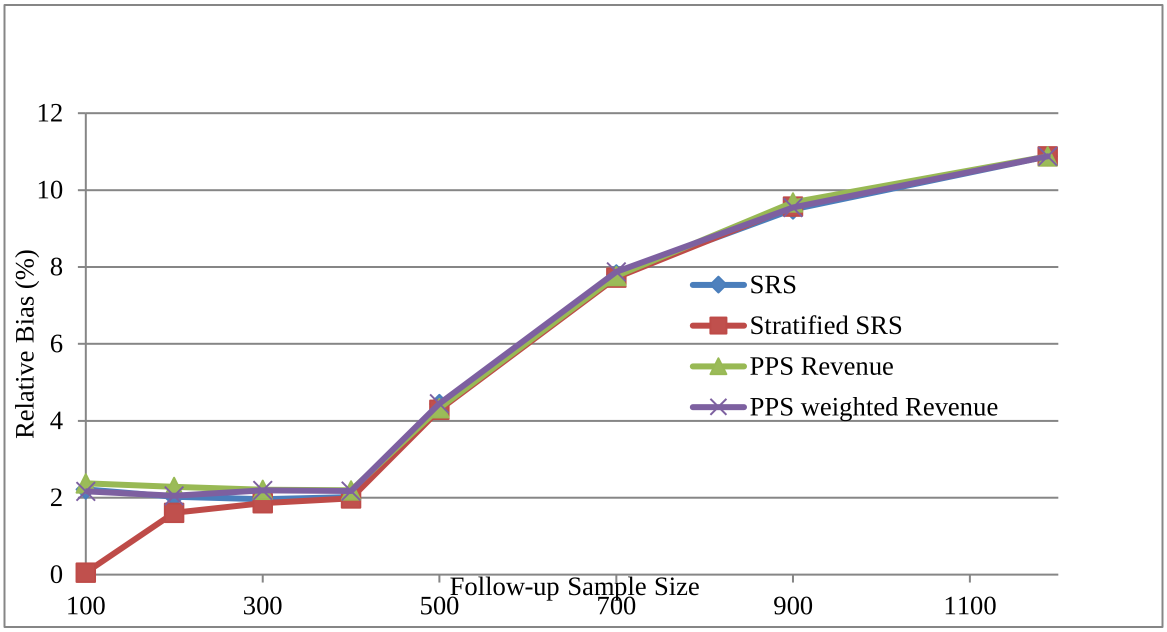


The only exception is the stratified SRS design with a follow-up sample size of 100. The allocation strategy for the follow-up sample does not ensure that at least one unit is selected from each stratum, and therefore, for smaller follow-up sample sizes (e.g., 100), some strata end up with no follow-up sample. This causes a negative bias because the mailout nonrespondents are not represented in strata with no follow-up sample. As the sample size increases from 100 to 400, the number of follow-up respondents increases, and it follows that the RRMSE decreases (see Graph 4.2). For sample sizes greater than 400, the number of respondents remains constant so the RRMSE remains constant for the SRS and stratified SRS designs. Finally, the PPS designs seem to be more slightly efficient than the SRS and stratified SRS designs. However, for sample sizes greater than 400, the gains in efficiency diminish as the sample size increases. The results for scenario 2 are similar and are not shown here.

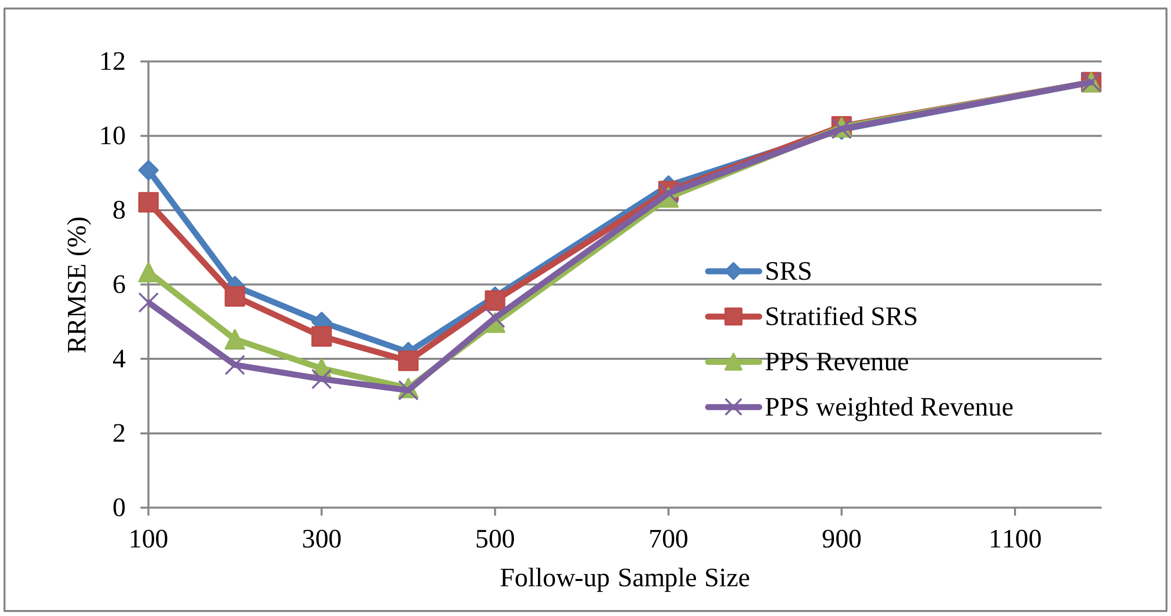
4.2 Results for Response Scenarios 3 and 4

The results for scenario 3 (the probability of response is uniform for the mailout, and correlated to the variable of interest for the follow-up) are given Graphs 4.3 and 4.4.

Graph 4.3: RB versus Follow-up Sample Size for Scenario 3



Graph 4.4: RRMSE versus Follow-up Sample Size for Scenario 3



From Graph 4.3 one can see that the relative bias is lowest for sample sizes less than 400, where the units are all finalized before the budget runs out. The lower relative bias for a stratified SRS design with a follow-up sample size of 100 is due to strata with no follow-up sample, as previously mentioned. Note, that since the probability of responding to the follow-up is related to the variable of interest, a bias exists as expected. In terms of the RRMSE (Graph 4.4), it is minimized for a sample size of 400. For sample sizes greater than 400, increasing the sample size increases the nonresponse rate, which explains why the relative bias and RRMSE increase. The PPS designs seem to be slightly more efficient than the SRS and stratified SRS designs. However, for sample sizes greater than 400, the gains in efficiency diminish as the sample size increases. The results for scenario 4 (probability of response at the mailout and follow-up are correlated to the variable of interest) are similar to those for scenario 3 and are not shown here.

5. OPTIMAL FOLLOW-UP SAMPLE

Looking at the graphs in Section 4, there appears to be a follow-up sample size where the RRMSE is at a minimum. In the cases where the follow-up response mechanism is uniform, the minimum corresponds roughly to the sample size where it is just large enough to expend the collection budget (in the simulation this is approximately 440 units). If a larger sample size is selected, the RRMSE remains approximately the same for the SRS and stratified SRS case but there is a slight increase for the PPS sampling plan. In the cases where the follow-up response mechanism is not uniform there is clearly a sample size which minimizes the bias (and thus the RRMSE), after which the addition of follow-up sample increases both the bias and the RRMSE. This sample size is the same as in the uniform follow-up case as it corresponds to the minimum sample size which expends the total collection budget.

To estimate this sample size we assume, for simplicity, that the probabilities to respond to the follow-up are uniform across all units and strata. That is, $p_{2hi}^{(1)} = p_2^{(1)}$, $p_{2hi}^{(2)} = p_2^{(2)}$ and $p_{2hi}^{(3)} = p_2^{(3)}$ for all *h* and *i*. Note that if the probabilities to respond are not uniform, then the selected units in the follow-up sample could be grouped into mutually exclusive and exhaustive groups and the probabilities to respond could be treated as uniform with each group. For simplicity, we restrict ourselves to only one group.

In the first round of the follow-up sample of non-respondents, attempts are made to contact all $m = \sum_h n_{2h}$ sampled units. In this round, it is expected that $mp_2^{(1)}$ units are successfully contacted and respond, $mp_2^{(2)}$ units are contacted but refuse to respond and that $mp_2^{(3)}$ units cannot be contacted and remain in the calling queue. If the status of all units have been finalized or the expected cost of the first round, $m\left(c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)} + c^{(3)}p_2^{(3)}\right)$, is larger than the total budget, c, then the follow-up stops. However, if this cost is less than the total budget and there are still units in the follow-up queue, then the follow-up continues with the $mp_2^{(3)}$ units which remain. The expected cost for round 2 is $mp_2^{(3)}\left(c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)} + c^{(3)}p_2^{(3)}\right)$. If budget still exists, as well as units to follow-up, then follow-up continues until the total budget is exhausted. Suppose the budget is exhausted after round a^*. The total expected cost after round a^* is

$$\begin{aligned} c^* &= m\left(c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)} + c^{(3)}p_2^{(3)}\right)\left(1 + p_2^{(3)} + p_2^{(3)^2} + \cdots + p_2^{(3)^{(a^*-1)}}\right) \\ &= m\left(c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)} + c^{(3)}p_2^{(3)}\right)\frac{\left(1 - p_2^{(3)^{a^*}}\right)}{1 - p_2^{(3)}}. \end{aligned}$$

Solving for *m* gives

$$m^{a^*} = \frac{c^*\left(1 - p_2^{(3)}\right)}{\left(c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)} + c^{(3)}p_2^{(3)}\right)\left(1 - p_2^{(3)^{a^*}}\right)}.$$

Letting $a^* \to \infty$, implies that m^{a^*} tends to

$$m^{\infty} = \frac{c\left(1 - p_2^{(3)}\right)}{\left(c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)} + c^{(3)}p_2^{(3)}\right)}. \tag{5.1}$$

Note that $m^{a^*} > m^{\infty}$ since $\left(1 - p_2^{(3)^{a^*}}\right) < 1$, which implies that the smallest *m* is m^{∞}. This choice will also lead to the largest number of respondents given the total follow-up budget. Denote $p_f = p_2^{(1)} + p_2^{(2)}$ and $c_f = \frac{c^{(1)}p_2^{(1)} + c^{(2)}p_2^{(2)}}{p_f}$. Since $p_f = 1 - p_2^{(3)}$, equation (5.1) can be written as

$$m^{\infty} = \frac{cp_f}{\left(c_f p_f + c^3(1 - p_f)\right)}. \tag{5.2}$$

Using the values of $c^{(1)}$, $c^{(2)}$, $c^{(3)}$, $p_2^{(1)}$, $p_2^{(2)}$ and $p_2^{(3)}$ in section 4, we have $c_f = 4.5$, $p_f = 0.3$ and $c^{(3)} = 1$. Applying equation (5.2) gives an expected cost per finalized case of 6.83 units. Dividing the total budget by this expected cost gives the optimal sample size. For the simulation data (input) in section 4, we would have m^{∞}=3000/6.83 = 439, which agrees with the results obtained in the simulation.

6. CONCLUSIONS

Follow-up of nonrespondents is an important step of the collection process for business surveys, particularly in the situation where the probability to respond is related to the variable of interest. When the response mechanism is uniform (essentially scenarios 1 and 2), the method of follow-up does not really make a difference in terms of relative bias nor the RRMSE. Note that although, the simulation work demonstrates a slight increase in efficiency by using a PPS design for the sub-sample, the gains are far from significant.

The assumption of a uniform response mechanism is quite strong (Scenarios 1 and 2) and probably not realistic in real life. Scenarios 3 and 4 are probably more representative of what happens in practice and these show that sub-sampling can help reduce the bias and increase the efficiency of estimates. The simulations indicate that there exists a sub-sample size which minimizes the bias and the RRMSE and is related to the budget available. This sub-sample size corresponds to the number of units which would just expend the entire follow-up budget and would maximize the number of follow-up responses and minimize the number of follow-up non-responses. Under a simplified scenario, this sample size is derived and presented in the paper.

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