Effect of Nonresponse Sources and Call Backs on the Estimation of Survey Nonresponse Bias

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Abstract

The article aims to examine the components of nonresponse error in sample surveys. Response and nonresponse rate relations are examined. Computation of household and individual person nonresponse rates have also been covered. Components of nonresponse bias is determined. Methodology of subsampling from nonrespondent's is illustrated.

Key words: Call backs; Nonresponse bias; Nonresponse error; Nonsampling error; Number of calls; Response rate; Sources of nonresponse; Unit nonresponse.

1. Introduction

The term *nonresponse* can be defined as failure to measure some of the units in the selected sample. Nonresponse affects estimates in two ways, which are by introducing a possible bias in the estimates and increasing sampling variance because of the reduced sample. The relationship between the bias and the size of nonresponse depends on the magnitude of nonresponse and the differences in the characteristics between respondents and nonrespondents. Empirical evidence has shown that the nonrespondents are often different from the respondents in many characteristics.

Nonresponse issues have been the concern of survey researchers for many years. Early studies of Hansen & Hurwitz (1946), Durbin (1954), Durbin & Stuart (1954), Kish & Hess (1959) and Bartholomew (1961) initiated the basic research in this area. Latest research in this area is covered in Ayhan (2004), Groves (1989), Groves & Couper (1998), Groves *et. al*. (2001), Kocak (2001), and Platek & Gray (1986).

This work continues by examining the types of nonresponse and their classification in the next section. Response and nonresponse rate relations are examined methodologically. An alternative methodology is also proposed. Computation of household and individual persons survey nonresponse rates followed by the components of nonresponse bias. Estimation of nonrespondents from subsampling methodology is illustrated. The work is finalised by the conclusions of this study.

2. Types and Classification of Nonresponse

In this section, types of nonresponse and classification of nonresponse is summarized below.

2.1. Types of Nonresponse

As a result of survey operations, generally three types of nonresponse may occur.

(1). *Unit nonresponse*. Unit nonresponse refers to unavailability of response from the selected sample unit to the whole questionnaire. Unit nonresponse can be evaluated at two stages.

a) *Household survey nonresponse*. Household nonresponse is the first stage of not obtaining any answer from the household survey respondent.

b) *Individual survey nonresponse*. Individual nonresponse is the next stage of not obtaining any answer from the individual survey respondent.

Information for these two stages are obtained separately and later related nonresponse components are computed jointly, which is described in later sections.

(2). *Partial nonresponse*. Partial nonresponse occurs when a respondent refuses to answer a group of questions or a complete questionnaire module.

(3). *Item nonresponse*. Item nonresponse occurs when a respondent refuses to answer single question(s).

The partial nonresponse and item nonresponse is not evaluated under the present work.

Unit nonresponse can be defined as occurring at the initial meeting when all members of an eligible household refuse to participate in the survey or when no one can be contacted after repeated attempts. Many studies related to nonresponse have been conducted in the literature, so there seems to be a need to have an extensive review on the subject. This study only focuses on the unit nonresponse in surveys. The term *nonresponse* is used instead of the term *unit nonresponse* in this paper. Information on the *types* and *classification* of nonresponse sources are covered in the following sections.

2.2. Classification of Nonresponse Sources

In surveys, nonresponse errors are examined and classified in different categories. According to Lindström (1983), studies of nonresponse errors in surveys and their effects can be divided into 6 main categories by type of problem as; *evaluation studies, presentation of nonresponse by variables, study of response rounds, comparison of data collection methods, assessment of compensatory methods,* and *analysis of nonresponse characteristics*.

Some methods generally accepted for handling the causes of nonresponse problem are described as follows. According to Kish (1995), the nonresponse reasons can be classified as *not at homes, refusals, incapacity or inability, not found,* and *lost schedules*. On the other hand, sources of nonresponse is classified by Cochran (1977) as *not at homes, noncoverage, unable to answer,* and *hard core*.

Moser & Kalton (1979) classified the non-response reasons as *unsuitable for interview, movers, refusals, away from home,* and *out at a time of call*. Unlike Kish and Cochran, Moser & Kalton have accepted a separate category for the *movers*. The other categories point the same portion of nonresponse with different group names.

From the above classifications, it is clear that the reasons of nonresponse should be diverse. On the other hand, classification and analysis of nonresponse reasons should follow the same standard within a given survey. For the present work, the following classification is used for the reasons of nonresponse as; *not at home, away from home, refusal, incapacity, address not found, lost schedules,* and *living elsewhere*. Alternative approaches for nonresponse classifications are also mentioned by AAPOR (2002), Ayhan (1981 & 1998), and Lynn et al (2002).

3. The Proposed Methodology

When we examine the nonresponse components in terms of reasons, it is possible to decompose it in the following manner. We can use the following form ($R_i = N_i / N$) of the rate and the size ($N_i = \sum_{j=1}^{J} N_{ij}$) to illustrate the mechanism, where $i = 1, 2$ and $j=1, 2, ..., J$.

$$R_i = \frac{N_i}{N} = \frac{\sum_{j=1}^{J} N_{ij}}{N} = \frac{N_{i1} + N_{i2} + ... + N_{iJ}}{N}$$

For the nonresponse stratum (where $i = 2$), the relation takes the following form;

$$R_2 = \frac{N_2}{N} = \frac{\sum_{j=1}^{J} N_{2j}}{N} = \frac{N_{21} + N_{22} + ... + N_{2J}}{N}$$

The unweighted nonresponse components will not represent the selection of the number of calls from the restricted choice set. Therefore, a weighted components will be proposed for the ideal estimator, in the following form.

$$R_i = \frac{N_i}{N} = \frac{\sum_{j=1}^{J} W_{ij} N_{ij}}{N} = \frac{W_{i1} N_{i1} + W_{i2} N_{i2} + ... + W_{iJ} N_{iJ}}{N} \qquad \text{where} \quad \sum_{j=1}^{J} W_{ij} = 1 \quad \forall j$$

For the nonresponse stratum (where $i = 2$), the relation takes the following form;

$$R_2 = \frac{N_2}{N} = \frac{\sum_{j=1}^{J} W_{2j} N_{2j}}{N} = \frac{W_{21} N_{21} + W_{22} N_{22} + \ldots + W_{2J} N_{2J}}{N}$$

3.1. Number of Calls

Number of calls can vary according to the mode of data collection. There are no established number of calls which will be ideal for most surveys. There are no gold standarts established for the number of recalls in sample surveys. WFS (1977) and Groves (1989) have proposed some lower bound values for the number of calls in personal (face to face) interview surveys. You may achieve higher number of calls in telephone surveys in comparison to personal interview surveys, where the cost and timing of enumeration per sample unit will be lower. The number of total calls also differs for different nonresponse reasons. Number of total calls, is based on the *first visit* and *number of recalls* (call backs) for each case, which is illustrated in Table 1 and 2.

Table 1. *Relationship between the number of calls and nonresponse reasons*.

Symbol	Nonresponse reasons (1)	Number of total calls (2)	
		Household survey	Personal interview survey
N_{21}	Not at home	1 + 3 = **4**	1 + 2 = **3**
N_{22}	On vacation	1 + 0 = **1**	*NA*
N_{23}	Refusal	1 + 1 = **2**	1 + 2 = **3**
N_{24}	Incapacity	1 + 0 = **1**	*NA*
N_{25}	Address not found	1 + 0 = **1**	*NA*
N_{26}	Lost schedules	*NA*	*NA*

(1): Based on Kish (1995), (2): Based on WFS (1977) & Ayhan (1981), *NA*: Not Applicable

Table 2. *Relationship between the nonresponse reasons, number of calls and its probability*.

Symbol	Nonresponse reasons	Number of total calls		Weighted proportion of calls from the restricted choice sets
		Household survey	Personal interview survey	
N_{21}	Not at home	4	3	$\frac{1}{2}\frac{4}{9} + \frac{1}{2}\frac{3}{6} = \frac{17}{36} \cong \frac{1}{2}$
N_{22}	On vacation	1	0	$\frac{1}{2}\frac{1}{9} + 0 = \frac{1}{18}$
N_{23}	Refusal	2	3	$\frac{1}{2}\frac{2}{9} + \frac{1}{2}\frac{3}{6} = \frac{13}{36} \cong \frac{1}{3}$
N_{24}	Incapacity	1	0	$\frac{1}{2}\frac{1}{9} + 0 = \frac{1}{18}$
N_{25}	Address not found	1	0	$\frac{1}{2}\frac{1}{9} + 0 = \frac{1}{18}$
N_{26}	Lost schedules	0	0	0
N_2	**Total**	**9**	**6**	**1**

4. Response and Nonresponse Components

The population size of *N* can artificially be devided into response and nonresponse stratum. We can use the following form ($R_i = N_i / N$) of the rate and the size ($N_i = \sum_{j=1}^{J} N_{ij}$) to illustrate the mechanism, where *i = 1, 2*. Response rate ($R_1 = N_1 / N$) is the ratio of responses to the total selected sample, and nonresponse rate ($R_2 = N_2 / N$) is the ratio of nonresponses to the total selected sample. Here the following relations $N_1 + N_2 = N$, $R_1 + R_2 = 1$, $(1 - R_1) = R_2$ holds for these two strata.

The survey data will only be collected for the response strata. The response strata will have the mean μ_1 which is based on the N_1 observations. Where, the response stratum mean will be, $\mu_1 = N_1^{-1} \left[\sum_{j=1}^{N_1} X_{1j} \right]$. The unknown mean μ_2 of the nonresponse stratum which is based on the N_2 observations will be, $\mu_2 = N_2^{-1} \left[\sum_{j=1}^{N_2} X_{2j} \right]$. Where the population mean μ should be based on all selected sample elements, rather than enumerated, and should take the following form $\mu = N^{-1} \left[\sum_{j=1}^{N} X_j \right]$.

Household response rate (*HRR*) is computed as the ratio of (n_1 / n) from the selected sample. Individual response rate (IRR) is calculated by the multiplication of household response rates and individual response component. Individual response component is calculated as respondent individuals (m_1) over, enumerated individuals (m). These calculations are given with the following formulas;

Household response rate, *HRR* = n_1 / n

Individual response component, *IRC* = m_1 / m

Individual response rate, *IRR* = (*HRR*)(*IRC*) = $(n_1 / n)(m_1 / m)$

Household nonresponse rate (*HNRR*) can be taken as the complement of the household response rate (*HRR*).

HNRR = 1 – *HRR* = [1 – (n_1 / n)] = (n_2 / n)

Individual nonresponse rate (*INRR*) is calculated by the multiplication of *household nonresponse rate* and *individual nonresponse component*. Individual nonresponse component is calculated by taking *nonrespondent individuals* (m_2) over *enumerated individuals* (m).

Individual nonresponse component, *INRC* = m_2 / m

Individual nonresponse rate, *INRR* = (*HNRR*)(*INRC*) = $(n_2 / n)(m_2 / m)$

5. Components of Nonresponse Bias

Moser and Kalton (1979) stated that, the bias of nonresponse occurs when the response stratum mean μ_1 is used instead of the total population mean μ . When we examine the situation in terms of expectations from all possible sample means, the source of nonresponse bias is based on the use of $Lim_{n \to \infty} E(\bar{x}_1) = \mu$ instead of $Lim_{n \to \infty} E(\bar{x}) = \mu$, where $Lim_{n \to \infty} E(\bar{x}_1) \neq \mu$ but $Lim_{n \to \infty} E(\bar{x}_1) = \mu_1$.

By assuming the amount of nonresponse as constant for the survey then, we can illustrate the bias of using the response stratum mean $\bar{x}_1$, instead of the selected total sample mean $\bar{x}$. Here the population mean μ can be evaluated as the weighted mean of response and nonresponse strata. Following the illustration of Moser and Kalton (1979), the nonresponse bias due to the use of response stratum mean as the estimator will be,

$$B(\bar{x}_1) = \mu_1 - \mu = \mu_1 - (R_1\mu_1 + R_2\mu_2)$$
$$= \mu_1(1 - R_1) - R_2\mu_2 = R_2(\mu_1 - \mu_2)$$

The effect of bias is based on the amount of nonresponse rate and the difference between the response and nonresponse strata means.

6. Estimation of Nonrespondents from Subsampling

The nonresponse bias of the stratum mean estimator is given as,

$$B(\bar{x}_1) = \mu_1 - (R_1\mu_1 + R_2\mu_2)$$

The design mean can be evaluated as,

$$\hat{\mu} = R_1\bar{x}_1 + R_2\mu_2$$

Since μ_2 is not known, the sample estimator of this will be used, and weighted estimator will take the following form,

$$\bar{x}_w = \sum_{i=1}^{2} R_i x_i = R_1\bar{x}_1 + R_2\bar{x}_2^*$$

where $\bar{x}_1 = n_1^{-1}\left[\sum_{j=1}^{J} X_{1j}\right]$ and $\bar{x}_2 = n_2^{-1}\left[\sum_{j=1}^{J} X_{2j}\right]$ is unknown. By taking a random subsample of size m_2, a new estimator of the nonresponse stratum mean will take the following form, where $m_2 = f_b(n_2)$.

$$\bar{x}_2^* = m_2^{-1}\left[\sum_{j=1}^{J} X_{2j}\right] = \hat{\mu}_2 \text{ and } E(\bar{x}_2^*) = \mu_2$$

Here f_b is the subsampling rate from the nonresponse stratum and can be taken as $f_b = 0.05$.

The expected value of the subsample estimator will be, $Lim_{n\to\infty} E(\bar{x}_2^*) = \mu_2$.

On the other hand, the desired estimator of the sample mean is, $\bar{x} = n^{-1}\left[\sum_{j=1}^{J} X_j\right]$.

7. Conclusions

Response and nonresponse rate relations are examined by their corresponding components. The relationship between the nonresponse reasons and number of calls on the nonresponse amounts are also investigated. The effect of bias is based on the amount of nonresponse rate and the difference between the response and nonresponse strata means.

Estimation of new responses are based on nonresponse stratum values which are obtained from subsampling of nonrespondents. By this means, nonresponse stratum has now new response values, which is based on the subsample.

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