

Determining Subsampling Rates for Nonrespondents

Rachel M. Harter¹, Traci L. Mach², Janella F. Chapline¹, John D. Wolken²

National Opinion Research Center at the University of Chicago¹

Board of Governors of the Federal Reserve^{2†}

Abstract

It is becoming increasingly common to subsample nonrespondents to increase weighted response rates, or to maintain response rates while reducing costs. Response rates and costs are not the only factors affected by subsampling, however. Subsampling increases variability in the weights, which in turn increases the design effect and decreases the effective sample size. Subsampling also may affect the number of completed cases. At what rate should the nonrespondents be subsampled? If sufficient information is available from prior rounds or other sources, the decision can be made on the basis of constraints in terms of weighted response rate, design effect, cost, or the number of completed cases. The constraints applied might depend on whether the subsampling rate decision is made prior to initial sample selection or in the midst of data collection. We will review the literature, present possible decision rules, and illustrate those rules with screener data from the 2003 Survey of Small Business Finances.

Keywords: Subsampling, Double Sampling, Two Phase Sampling, Sequential Sampling, Nonresponse Bias

1. Introduction

Traditionally the survey design challenge has been to make inferences at a specified precision level for minimal cost, or, conversely, to achieve the best possible precision for a fixed cost. Declining response rates in recent years have added to the challenge, increasing the risk of nonresponse bias.

Back in 1938, Neyman proposed a sample design that came to be known as double sampling. In 1946, Hansen and Hurwitz applied the idea to subsampling nonrespondents for special handling to elicit response. The initial data collection method, applied to the larger sample, was relatively inexpensive, while follow-up methods used for the subsample, though more effective, were also more expensive. For example, the initial data collection mode may be by mail, with in-person interviews attempted for a subsample of nonrespondents.

Double sampling, also known as two phase or sequential sampling, as described in most standard sampling textbooks, has a variety of different uses. Cochran (1977)

and Lohr (1999) present the method as a way to 1) obtain valuable auxiliary data for ratio or regression estimation relatively inexpensively when it is not readily available for the whole population, or to 2) stratify cases prior to ultimate sample selection. Nonrespondent subsampling is a special case of the latter in which the stratifying information is based on whether or not cases responded to an earlier relatively inexpensive mode of data collection. All cases that respond initially are assigned to the “easy” stratum in which all cases are sampled, and nonrespondents are assigned to the “difficult” stratum for subsampling. In some textbooks [Rao (2000), Levy and Lemeshow (1991)], subsampling of nonrespondents is the primary use of double sampling. Thompson (1992) suggests double sampling of nonrespondents for callbacks to reduce nonresponse bias. As Hansen, Hurwitz, and Madow (1953) point out, double sampling combines the economies of low cost data collection in the first phase with the nonresponse bias reduction on the reduced subsample. Deming’s textbook for business surveys (1960) suggests double sampling in an example.

A question that naturally arises is – at what rate should the nonrespondents be subsampled? In section two, we highlight specific studies that have subsampled nonrespondents, focusing on the subsampling rates used and, in some cases, the rationale for using them. In section three, we review the theory and conventional wisdom on the topic. In section four, we present additional ways of determining acceptable subsampling rates given various types of constraints. Finally, we use screener data from the 2003 Survey of Small Business Finances (SSBF) to illustrate these methods in section five.

2. Examples

Existing surveys that employ double sampling use a variety of subsampling rates, for a variety of reasons. Here are a few examples, some of which are described by Parker and Dugoni (2003).

2.1. American Community Survey (ACS)

The American Community Survey (ACS) conducted by the U.S. Census Bureau consists of three modes of data collection in overlapping three-month cycles. In the first month of a cycle, the sample addresses determined to have a valid mailing address are sent a questionnaire

[†] The views expressed herein are those of the authors. They do not necessarily reflect the opinions of the Federal Reserve Board or its staff.

through the U.S. Postal Service. In the second month, telephone contact of all mail nonrespondents for which telephone numbers are available is attempted. In the third month, a subsample of the remaining incomplete cases is selected for in-person interviewing. The phase 2 subsampling rates were 2-in-3 for units without mailable addresses and 1-in-3 otherwise [Tersine and Starsinic (2003)]. These rates were based on the tract-level expected rate of completed interviews.

2.2 Chicago Health and Social Life Survey (CHSLs)

In the Chicago Health and Social Life Survey (CHSLs), conducted by the NORC Population Research Center at the University of Chicago in 1995 [NORC (1996)], nonrespondents were subsampled when the response rates were lower than originally expected. Although resulting in slightly fewer completes than desired, by subsampling 1-in-4 nonrespondents the weighted response rate was boosted from 64 to 71 percent.

2.3 2006 National Survey of Family Growth (NSFG)

The 2006 National Survey of Family Growth (NSFG) was conducted by the University of Michigan [ISR] for the National Center for Health Statistics [Lepkowski et al. (2006)]. The project team developed response propensity models to predict whether each case would result in a completed screener or interview. Using the models, the segments (secondary sampling units) were stratified on the number of incompletes and the response propensity of the remaining active cases. For each of these dimensions, segments (clusters of households) were subsampled from "high," "medium-high," "medium-low," and "low" strata to reduce travel costs. Subsampling rates varied by stratum to favor segments likely to yield more completed cases for lower cost.

2.4 2006 General Social Survey (GSS)

The most recent round of the General Social Survey (GSS), periodically conducted by NORC for the National Science Foundation and other sponsors, began in 2006. Built into the design, household level nonrespondents were subsampled at a rate of 45% across the board. While there was no unique best sampling rate, 45% was chosen as providing a good balance between the unweighted number of completes and the weighted response rates.

3. Review of Theory and General Principles

According to Kish (1965), double sampling works well when the first phase cost of data collection is dramatically less than the second phase cost. Otherwise, the extra complexities added to operationalizing the design and calculating weights may not be worth the cost savings.

Kish' rule of thumb states that second phase data collection should be at least ten times that of the per-case first phase cost in order to be considered economical.

The implicit assumption is that the second phase data collection approach is fundamentally different than that of the first phase. In practice, sometimes subsampling of nonrespondents is done when data collection turns out to be more difficult or more costly than anticipated. Perhaps data collection must terminate early to stay within budget or to boost a weighted response rate. Application of subsampling methodology controls nonresponse bias much better than simply terminating data collection when the early, easier cases are complete. That is, rather than being a planned design feature, double sampling can be used as a late-game approach to save the budget or weighted response rate while attempting to control nonresponse bias. Though data collection modes are often no different between the two phases, it may just be that the second phase cases are more aggressively pursued.

Elliott et al. (2000) suggest that subsampling will save resources whenever 1) the per-callback or per-interview cost increases, or 2) the probability of obtaining a successful interview decreases, with each attempt. For relatively constant costs across attempts, cost savings are likely to be small or, if the variance of the variable of interest increases with later interviews, subsampling is less desirable. On the other hand, related decreases in variance makes subsampling more effective. Several proposed subsampling strategies follow.

3.1 Hansen-Hurwitz Method

The basic strategy as presented by Hanson and Hurwitz (1946) is to first determine the sample needed to achieve the desired precision level, assuming no nonresponse. Then, if the cost structure and expected response rates for each phase are known, solve for the initial sample size n and subsampling rate f that minimize cost subject to the desired precision level.

First, we present some useful notation. Let

N = total number of units in the population

n = total number of units in the initial sample

n_1 = number of first phase respondents

$n_2 = n - n_1$ = number of first phase nonrespondents

n_2^* = number of first phase nonrespondents selected for second phase data collection

n_2' = number of second phase respondents

$f = \frac{n_2^*}{n_2}$ = subsampling rate

$r_1 = \frac{n_1}{n}$ = rate of responding in first phase

$r_2 = \frac{n'_2}{n_2}$ = rate of responding in second phase

y_i = value of survey variable Y for unit i

$\bar{y}_1$ = mean of survey variable Y among first phase respondents

$\bar{y}_2$ = mean of survey variable Y among second phase respondents

σ^2 = population variance of survey variable Y

The double sample estimate of the population mean $\bar{Y}$ is

$$\hat{\bar{Y}} = (n_1 \bar{y}_1 + n_2 \bar{y}_2) / n.$$

Note that this estimator is the Hurvitz-Thompson estimator where the phase 1 cases have a base weight that is the reciprocal of the initial sample selection probabilities, and the phase 2 cases have a weight in which the base weight is adjusted for subsampling and for nonresponse among all phase 2 cases.

Suppose that ε^2 is the desired variance level. Then, under simple random sampling with no nonresponse, we can solve for the effective sample size, $\hat{n}$, where

$$\hat{n} = \frac{N\sigma^2}{\sigma^2 + \varepsilon^2 \left(\frac{N-1}{N} \right)}.$$

Now, if we want the double sampling estimator to have the same variance, ε^2 , we solve for the initial sample size n and the subsampling rate f , given the anticipated completion rates, r_1 and r_2 . As pointed out when the authors derived the estimator, the number of respondents needed in each phase to achieve the desired precision target is not unique.

However, suppose we know in advance the per-unit cost structure, ignoring fixed costs that do not vary with sample size. Then with costs given by

$$C = c_0 n + c_1 n_1 + c_2 n'_2, \text{ where}$$

c_0 = the per-unit cost for initial contact attempts

c_1 = the per-unit costs for first phase completes, and

c_2 = the per-unit costs for second phase completes

minimized for the desired variance level, the optimal initial sample size is

$$n = \hat{n} [1 + (f - 1)Q],$$

and the optimal subsampling rate is

$$f = \sqrt{\frac{c_0 + c_1 r_1}{c_2 r_1}}, \quad (1)$$

where $Q = N r_1$ is the proportion of population units that would not have responded in phase 1 if a census had been attempted with the same level of effort.

In practice, the Hanson-Hurwitz method is not used much. Groves (1989) discusses the problems with this method: 1) the method takes into account sampling error only, not other sources of error; 2) the completion rate in phase 2 is assumed to be high; 3) mode effects between phases are ignored; 4) no distinction is made between noncontacts and refusals; 5) completion rates and cost structures must be known in advance. Many of these same drawbacks are shared by other methods in the literature.

3.2 Deming Method

Deming (1953) points out that nonresponse bias is serious enough in most surveys to warrant careful planning of the number of call attempts at the design stage. The number of call attempts must be balanced with cost issues, however. Deming's goal is to minimize cost for a specified mean squared error, or vice versa. In Deming's approach, all sample cases are attempted once. Then subsampling occurs before the first callback attempt, and only the subsample is pursued for subsequent callback attempts. The Deming approach is to determine variance, nonresponse bias, and cost, and from that to determine the number of callback attempts. The subsampling rate is a by-product of this process.

If we view phase 1 of double sampling as the first attempt by Deming's method, and treat phase 2 as the first callback attempt, Deming's method with one "callback" is the same as double sampling.

The mean squared error of the estimator takes the form

$$MSE = A + \frac{B}{n} + \frac{C}{nf}, \quad (2)$$

with a cost function of the form

$$Cost = Dn + Enf,$$

then for any initial sample size n , Deming's optimal subsampling rate is

$$f = \sqrt{\frac{CD}{BE}}. \quad (3)$$

Notice that the subsampling rate depends on the ratio of the costs D/E , not their absolute individual values.

The challenge to using this method is in defining the MSE function. The mean and variance of the characteristic of interest is assumed to differ for each attempt, which is why subsequent attempts reduce the nonresponse bias. However, the means and variances for each attempt, or estimates of them, are needed in advance for the MSE function. As Groves (1989) also notes, the method assumes cases are equally likely to respond on each attempt, which often is not true.

3.3 Elliott-Little-Lewitzky Method

Elliott et al. (2000) present a framework that allows for different response propensities for each callback attempt with given nonzero costs related to refusals. They propose an efficiency ratio as the cost under the subsampling approach to the cost under the full-callback approach, assuming equal variances. Suppose subsampling is to occur at the m^{th} callback attempt, and subsampled cases will be subjected to a fixed number of subsequent callback attempts. The strategy is to determine the value of m with a subsampling rate f that sufficiently minimizes the efficiency ratio under 1. In general, m is typically a relatively early or middle callback attempt for which the proportion of remaining interviews needed is not large and the proportion of expected costs remaining is small.

4. Subsampling Rates for Alternative Constraints

Although most survey designs have precision requirements for desired analyses at their core, the requirements may be expressed contractually as sample size or response rate requirements. Cost may not be an issue to the sponsoring agency with a fixed price contract, while it is very much an issue to the contractor; in contrast, cost may be more of an issue to the sponsoring agency than the contractor under a cost reimbursable-type contract. In this section we look at alternative constraints and the impact on subsampling rates.

4.1 Required Completes

As discussed earlier, subsampling of nonrespondents may be part of the initial design, or it may be an end game strategy to control costs after the initial sample has been selected. In the latter case, there are fewer opportunities to optimize. Suppose, for example, that the number of completed cases is specified in advance. Suppose, further, that the initial sample size n has already been fixed. In the Hansen-Hurwitz scenario where completion rates are fixed, the subsampling rate is completely determined by the relationship

$$n_{spec} = nr_1 + n(1 - r_1)fr_2, \quad (4)$$

where n_{spec} is the specified number of completes.

Under Hansen-Hurwitz assumptions, meeting a sample size requirement optimally must be considered at the design stage (or for later batches using parameters determined in the early batches). To minimize cost subject to the sample size constraint, we note that the cost function is linear in n . The subsampling rate f is determined by n as shown in (4) above, but we have the added constraints that $0 \leq f \leq 1$, which determines a range for possible values of n . If $c_2 > c_1$, then the cost is

minimized when n is at the maximum of its range, $\frac{n_{spec}}{r_1}$,

and the subsampling rate f is zero. In other words, if cost is the only consideration, not response rate, and if phase 1 cases are less expensive than phase 2 cases, then simply enlarge the initial sample to complete n_{spec} cases in the first phase; subsampling should not be necessary. On the other hand, if $c_2 < c_1$, then the total cost is minimized

when n is at the minimum of its range, $\frac{n_{spec}}{r_1 + (1 - r_1)r_2}$, and

the subsampling rate f is 1. That is, select n to be the target number of completes, n_{spec} , divided by the weighted response rate (equation 5 below) and retain all first phase nonrespondents for second phase data collection. Suppose $c_2 = c_1$, then any value of n within this range will do, provided f is determined by (4) above.

4.2 Response Rates Constraint

If the contractual requirement is to achieve a specified (weighted) response rate, then in the Hansen-Hurwitz scenario, the subsampling rate is irrelevant. It can be shown that the weighted response rate is a function of r_1 and r_2 only:

$$\text{Weighted response rate} = r_1 + (1 - r_1)r_2. \quad (5)$$

From this equation it can be seen that the weighted response rate from a double sample will be larger than r_1 , the response rate without subsampling. If r_1 is large or r_2 is small, then subsampling is likely to help only a little. The biggest gains from subsampling occur when r_1 is small and r_2 is large.

The subsampling rate affects the response rate only if the sampling rate changes the funds available for the subsample and, in turn, the methodological approach and completion rate for the subsample. That is, the subsampling rate affects the overall weighted response rate only if the subsampling rate affects the value of r_2 .

Under Deming's method, for example, the subsampling rate is tied to the number of callback attempts. Under the

Elliott-Little-Lewitzky method, if we think of all call attempts prior to the m^{th} attempt as phase 1, and all subsequent call attempts up to K as phase 2, then the subsampling rate, which is tied to cost and the value of m , is also related to r_1 and r_2 because the completion rates depend on the number of attempts in each phase. The challenge is to have effective models relating cost and response propensity.

4.3 Weighting Effect, Sample Size, Cost Constraints

Subsampling nonrespondents introduces more variability in the weights, which increases the design effect and reduces the effective sample size. Suppose the goal is to reduce costs by a certain percentage while keeping the weighting effect below a certain level (or maintaining an effective sample size above a certain level). A two-step procedure is described here that takes both constraints into account. This method allows for multiple types of outcomes and different costs associated with each type of outcome.

Suppose there are J possible final outcomes and that there may be different costs associated with each outcome type. In this paper, we will assume four types of outcomes, each with a different associated cost: 1) phase 1 complete, 2) phase 1 final norespondent (e.g., hostile refusal or noncontact), 3) phase 2 complete, and 4) phase 2 nonrespondent. Other outcomes are possible, such as ineligible, or dealing with noncontacts and hostile refusals separately, but we use these four categories to simplify the algebra. The cost function without subsampling is given by

$$C_1 = n \sum_{j=1}^J c_j p_j, \quad (6)$$

where p_j is the proportion of cases from the initial sample of n that have outcome j , and c_j is the per-case cost associated with that outcome. This cost function assumes all cases get full treatment through phase 2 if not already finalized in phase 1. (Note that if the only cases finalized in the first phase were the completes, then we would have $p_1 = r_1$, $p_2 = 0$, and $p_3 = (1 - r_1)r_2$, leading us back to the familiar Hansen-Hurwitz notation.)

Now suppose that some outcomes in the first phase are subsampled before phase 2 treatment, and all such classes are subsampled at the same rate f . The total number of completes will be reduced unless we increase the initial sample size by a factor of

$$M = (p_1 + p_3)/(p_1 + fp_3), \quad (7)$$

the number of completes with full treatment and no subsampling divided by the number of completes with subsampling. At the same time, we want the total cost to be reduced by, say, a factor of X . So the cost of the subsampled design divided by the cost of the full treatment design should be less than or equal to X . That is,

$$\frac{C_2}{C_1} \leq X, \quad (8)$$

where

$$C_2 = Mn[(c_1 p_1 + c_2 p_2) + f(c_3 p_3 + c_4 p_4)].$$

The inequality above can be solved for an inequality in f , determining an acceptable range of f that meets the cost constraint.

The second step is to find an acceptable range of subsampling rates that does not increase the weighting effect beyond, say, W . To make things simpler, we assume that all cases have equal base weights, and for all practical purposes, we can assume that the base weights are scaled to 1. The weighting effect is approximated by 1 plus the relative variance of the weights. We assume here that the phase 1 completed cases retain the base weight, and that the weights for phase 2 completed cases are adjusted for subsampling. Deviating from the Hansen-Hurwitz scheme, we assume that all completes are adjusted for nonresponse; further, we make the simplifying assumption that all completes get the same nonresponse adjustment factor. Then, the final weights for phase 1 completes are $1/(p_1 + p_3)$ and for the phase 2 completes are $1/[f(p_1 + p_3)]$. It can be shown that the mean weight is $1/(p_1 + fp_3)$, and that the weighting effect is

$$WEFF = 1 + (p_1 p_3 / f) [(1 - f)/(p_1 + p_3)]^2. \quad (9)$$

The fact that we increase the initial sample size by a factor to compensate for subsampling does not affect the relative variance of the weights. So, applying a constraint on the weighting effect, we set $WEFF \leq W$ and solve for f . The equality is a quadratic function of f with two possible solutions that define a range of subsampling rates f that meet the constraint on the weighting effect. It is not necessarily the case that either or both solutions to the quadratic equation will be between zero and one. Values of f between zero and one are acceptable subsampling rates. This range can then be combined with the acceptable range for the cost reduction. Note that it is possible that no value of f or that a range of values satisfies both constraints.

5.0 Comparing Main and Followup Sample Responses

The 2003 Survey of Small Business Finances (SSBF) was established to collect information from the owners of a nationally representative sample of up to 5,000 business enterprises. Data were gathered from small businesses concerning their financial relationships, credit experiences, lending terms and conditions, income and balance sheet information, the location and types of financial institutions used, and other firm characteristics.

Targeted were headquarter locations of nongovernmental, nondepository, nonagricultural for-profit businesses with fewer than 500 employees. These firms also had to be in business in December 2003 under one or more of their current owners as well as at the time of data collection.

A stratified systematic sample of 37,600 businesses was selected from the Dun's Market Identifiers™ (DMI) file, a business database maintained by the Dun & Bradstreet Corporation (D&B). The 72 strata were defined by the cross-classification of business size, census division, and urban/rural status.

Data collection had two stages: screening and main interview. The screening was designed to verify the name of the business owner and the physical address of the business, screen the business for eligibility to participate in the main interview, identify the business's legal form of organization, and record the fiscal year end date. All sample firms were eligible for the screener.

The initial contact with respondents was a mailing containing materials explaining the purpose of the survey and encouraging participation. Within a few days of receiving the mailing, businesses were called and asked to complete the screener.

The sample was ultimately fielded in four batches, with each batch subject to screening followed by main study interviewing of eligible firms. For both screening and main interviewing of the first three batches, attempted contact was made with all firms during a first phase. For the second phase, nonrespondents were subsampled and recontact attempts were made. Each phase consisted of a series of call attempts, where the attempts followed a pre-determined schedule designed to increase the likelihood of contact until interviews or appointments were achieved. Batch 4 was purposefully added late in the study to compensate for lower than anticipated response rates. There was no subsampling for phase 2 of batch 4.

In this paper we illustrate the various ways of determining subsampling rates by using the 5,666 screener interviews from batch 2 of the study. Batch 2 was selected because the first and second phases were relatively smooth and

free of last-minute tinkering (expanded time periods or increased incentives) to boost response rates. The discussion here is also simplified due to the fact that all sample firms were eligible for screening.

Once the call design for the phase 1 screening was complete, main study eligibility had been determined for $r_1 = 50\%$ of the Batch 2 cases; i.e. $n_1 = 2,838$. Screener nonrespondents eligible for subsampling were identified from the remaining 2,828 cases. Businesses with which no human contact was ever established during phase 1 and finalized nonrespondents, such as language barriers and hostile refusals were excluded from phase 2 subsampling. Using a subsampling rate of $f = 60\%$, $n_2^* = 1,099$ of the 2,198 cases eligible for phase 2 subsampling were selected. This phase yielded $n_2' = 359$ completes with $r_2 = 33\%$. Follow-up for noncontacts was a separate process altogether.

If the screening interview were conducted today, the portion of the costs that depend on sample size, as in Hansen and Hurwitz, can be summarized as

$Cost = \$0.98n + \$17.48n_1 + \$26.03n_2'$, where

$c_0 = \$0.98$ per case ($n=5,666$) costs for materials and labor related to the advanced mailout

$c_1 = \$17.48$ per case ($n_1=2,838$) costs for phone charges and calling center labor (using regular interviewers)

$c_2 = \$26.03$ per case ($n_2' = 359$) costs for phone charges and calling center labor (using experienced refusal converters)

5.1 Hansen-Hurwitz Method, Minimize Cost

If we assume that $n = 5,666$ had been obtained according to the Hansen-Hurwitz approach to achieve the variance requirement, then the subsampling rate as determined by equation (1) would be 86.4%.

5.2 Hansen-Hurwitz Method, Required Completes

If our per-unit first and second costs are equal and a specified number of completed screeners are required, then the subsampling rate should be determined by equation (4). Figure 1 shows subsampling rates for various values of required completed screeners assuming an initial sample size of 5,666 cases, with first and second phase completion rates equal 50% and 33%, respectively. So, for example if we were hoping for 3200 completed screeners, which was our actual count, a subsampling rate of 40% would be indicated.

Again using the above assumptions for completion rates, if the goal had been to minimize costs and meet a

specified number of completes without regard to variance considerations or response rates, then we would have been better off taking a larger initial sample and not subsampling at all. In fact, this is indicated because $c_2 > c_1$.

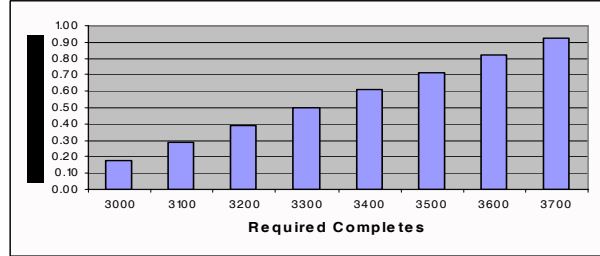


Figure 1: Phase 2 Subsampling Rates for Sample Size Requirements

5.3 Weighting Effect, Sample Size, and Cost

Suppose our goal had been to reduce costs at least 20% and increase the weighting effect by no more than 10%. For this illustration we assume that all cases had equal base weights, and that the weighting effect is solely attributed to subsampling and nonresponse adjustments.

The Hansen-Hurwitz cost structure above is not ideal for this setup since costs associated with nonrespondents have been transferred to the screener completes. Instead, we will assume the following hypothetical costs associated with each outcome:

$$\begin{aligned} c_1 &= \$5, \\ c_2 &= \$2, \\ c_3 &= \$25, \\ c_4 &= \$20. \end{aligned}$$

If there had been no subsampling, we estimate the proportions of the sample we would have observed in each outcome to be

$$\begin{aligned} p_1 &= .50, \\ p_2 &= .11, \\ p_3 &= .13, \\ p_4 &= .26. \end{aligned}$$

With subsampling, we increase the initial sample by M as defined in (7), and we define the cost ratio $\frac{Cost_2}{Cost_1} \leq .8$

using equation (8). So, solving the inequality, we have $f \leq .7988$. That is, any subsampling rate less than or equal to 79% will reduce costs by at least 20%, even with the increased initial sample size.

Now we solve (9) for values of f that satisfy the constraint that the WEFF must be no more than 1.1. The two values of f that solve the equality are .466 and 2.144. Since f is restricted to be between 0 and 1, the values of f that meet the WEFF criterion are between .47 and 1. Combining this with the cost criterion, we see that f must be in the range [.47, .79] to meet both constraints.

Incidentally, if we had applied the nonresponse adjustments to only the phase 2 completes in defining (9), it is unlikely there would have been values of f less than 1 that kept the WEFF within range, given that r_1 is substantially larger than r_2 .

5.4 Deming Method

The cost function for the Hansen-Hurwitz method above can be rewritten algebraically into Deming's structure as

$$Cost = 9.72n + 4.29nf.$$

The ratio that contributes to the subsampling rate is $\frac{9.72}{4.29} = 2.27$. The other ratio that contributes to the

subsampling rate, $\frac{C}{B}$ comes from the MSE function in (2).

The subsampling rate is the square root of the product of these ratios as in equation (3). Figure 2 shows different subsampling rates for various values of the ratio $\frac{C}{B}$.

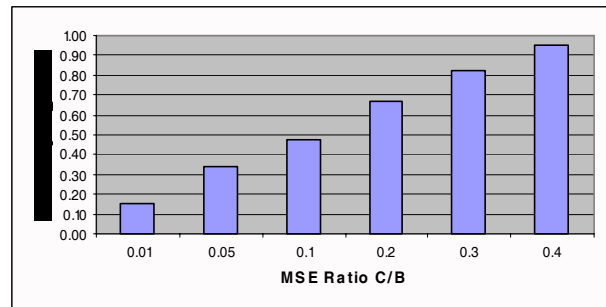


Figure 2: Subsampling Rates for Various Ratios from the MSE Function

6. Discussion

The illustrations in the previous section are limited by the production data retained from the 2003 SSBF. It would be good to track and retain completion rates and costs at

each attempt, enabling us to try to quantify the impact of changing the attempt at which subsampling is performed as well as the subsampling rate as in the Elliott-Little-Lewitzky method. The subtleties of subsampling nonrespondents are in the interactions between subsampling and redeploying the funds to boost response rates for the subsampled cases. Most of the methods presented here are too simple to capture these subtleties.

There are other methods for dealing with nonresponse and nonresponse bias that are similar to the methods presented here without actually subsampling nonrespondents. The focus here, however, is on subsampling nonrespondents and determining the rate at which to subsample.

Several of the methods presented are variations on the traditional cost/error models that lead to “optimal” solutions. Fellegi and Sunter (1974) and Groves (1989) discuss the limitations of cost/error models. The short summary is that the solutions are “optimal” only in a very narrow sense. Furthermore, one must take into account the variance and bias resulting from the methods used [Oh and Scheuren (1983)]. For the practitioner, the methods described here are intended as guidelines for establishing a range of reasonable options for determining subsampling rates. The choice of method(s) will depend on the information available and the study constraints.

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