An Experimental Implementation of a Dual Frame Telephone Sample Design

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1. Introduction

Early sample designs for surveys of the U.S. telephone household population used telephone directories and other listings of telephone numbers as sampling frames. Leuthold and Scheele (1971), in surveys of the state of Missouri, however, found that Blacks, persons in urban areas, and younger persons tended to have unlisted numbers. Later, Rich (1977), for surveys in California, found that younger and lower income persons tended to have unlisted numbers. Random digit dialing (RDD) expanded coverage of telephone surveys to all telephone households, whether or not their numbers were listed (e.g., Glasser and Metzger 1972). Some RDD methods select numbers at random (i.e., in one stage equal probability designs) from among working area codes and prefixes covering an area, but this is a rather inefficient way to contact the telephone household population.[1] With such a design in a national survey less than 25 percent of all sampled numbers are residential (Groves and Kahn 1979). Two stage RDD designs (e.g., Sudman 1973; Waksberg 1978) have been proposed to improve the efficiency of the sample. One, the Waksberg-Mitofsky design, screens of banks of 100 consecutive numbers in the first stage, selecting banks with probabilities proportionate to the number of residential numbers in the bank. In U.S. national samples, over 60 percent of telephone numbers in these banks are residential (Groves, 1978).

The two stage RDD design has clear advantages over directory-based samples in terms of coverage rates and over one stage RDD designs in terms of cost. But the two stage RDD design still suffers two important deficiencies. First, the cost of screening sample telephone numbers to identify residences remains a source of administrative inefficiency. Even with the two stage design, 40 percent of the sample numbers within selected banks of telephone numbers are ineligible for interviewing, but the only way to determine their status is by calling them. Many nonworking numbers provide ringing tones when dialed, and thus cannot be distinguished from unanswered residential numbers. Further, to maintain equal probabilities of selection, the two stage design requires a new selection from the same 100-bank for each nonworking number encountered. Time used to determine the working status of a nonworking selection is lost for determining the status of its replacement and then obtaining if appropriate, an interview. This problem is more acute for studies with shorter survey periods. The second important deficiency is that telephone surveys attempted without prior contact with the sample households tend to achieve lower response rates than those of comparable personal visit interviews (e.g., Groves and Kahn 1979; Alexander *et al.* 1986). While some have speculated that this is a property of the telephone as a medium of communication, others have noted that the conditions prior to the contact are different for the two modes. Specifically, the absence of an advance letter is thought by some to lower response rates. Indeed, advance letters have been found to increase response rates in samples of directory numbers (e.g., Dillman, Gallegos, and Frey 1976).

Dual frame sample designs, originally investigated by Hartley (1962), are appropriate for situations in which the target population densely populates one incomplete frame but forms only a minority of elements in another complete frame. In telephone sampling, files based on directories have fewer nonresidential numbers than RDD generated numbers, but not all residential telephone numbers appear in the directory based file. On the other hand, among the full set of numbers generated from area codes and prefixes, only a minority are residential numbers, even though all residential telephone numbers are included. Dual frame designs selecting telephone numbers from both the complete and incomplete frames can reduce screening costs relative to samples selecting numbers only from the complete frame.

Dual frame designs can also introduce more efficient sample designs in the incomplete frame than in the complete frame. In this case, the high eligibility rate and listings of individual numbers in the directory frame encourage stratified element sampling. In contrast, the two stage cluster design used in the complete RDD frame generally suffers some inflation in sampling variance due to the homogeneity of characteristics of households in the same telephone 100-bank (the sample cluster).

The purpose of the paper is to compare the variance and bias properties of a dual frame telephone sample with those of a single frame RDD design of equal cost. It extends the use of dual frame designs beyond concerns with sampling variance and cost alone. Alternative allocations of the sample to the two frames are examined in an effort to reduce nonresponse error, as well as sampling error, for fixed input of resources available for the survey.

In the next section an error and cost model is presented for a dual frame telephone sample design which uses list frame and RDD frame selections. Section 3 describes properties of the directory or list frame with findings from several studies, describes the effects on response rates and costs of an advance letter to list frame households, and reports the findings of two implementations of the dual frame design. Section 4 uses these results to simulate alternative dual frame designs, examine allocations to the two frames which minimize total survey error, and compare their error levels to that of a two-stage RDD design costing the same amount. The paper concludes in section 5 with a discussion of limitations of the current research and a set of unanswered questions about dual frame telephone samples.

2. Error and Cost Models for Dual Frame Telephone Samples

We restrict our attention to an estimator of the telephone household population mean. Following Hartley (1962) and Casady, Snowden, and Sirken (1981), consider a post-stratified estimator, which mixes the results from each of the two frames to obtain an estimate for the total population. Cases selected from the RDD frame that happen to be elements of the list frame are separated in the estimator from those RDD cases that do not appear on the list frame. In particular, the estimator of the mean is

$$\bar{y} = p_{r1}\bar{y}_{r1} + (1 - p_{r1})[\theta\bar{y}_{r2} + (1 - \theta)\bar{y}_d]. \quad (1)$$

The sample mean of cases from the RDD frame that are also elements of the list frame, $\bar{y}_{r2}$, is combined with the mean of list frame cases, $\bar{y}_d$, through the arbitrary mixing parameter, θ. The list frame estimate formed by mixing RDD and list frame cases is then combined with the estimate for the unlisted population, $\bar{y}_{r1}$, through the proportionality factor, p_{r1}, the proportion of the telephone population not listed.

Lepkowski and Groves (1986) give the mean squared error of this estimator. The mean square error is a function of sample designs and sizes in the two frames, various cross-products of biases among the unlisted cases, the listed cases from the RDD design, and those from the list frame sample, the variance of the estimated proportion unlisted, and the difference between the point estimates for listed and unlisted numbers. In this paper we restrict the bias terms to those arising from nonresponse error.

The costs of the dual frame survey can be divided into four categories: a) costs of sample number acquisition, b) costs of

Table 1. Dual Frame Telephone Survey Cost Model

Cost Component	Expression
Total Cost =	$T =$
Cost of primary selection and screening for RDD	$F_r\left[P_r + \frac{m_r}{w_{rm}} G_r\right] + S_r$
+ Cost of List sample	$+ F_d[S_d + N_d P_d] + \frac{m_d}{w_d} G_d$
+ Cost of RDD data collection	$+ \frac{F_r m_r}{w_{rm}} [I\ t_{im} + C\ t_{cm}]$
	$+ \frac{m_r n_r}{w_{rn}} G_r$
	$+ m_r R_r n_r \left[\begin{array}{l} I(t_{i,nw}D_{nw} + t_{i,ni}D_{ni} + t_{i,int}(D_{int} - 1) + t_{i,int,r}) \\ + C(t_{c,nw}D_{nw} + t_{c,ni}D_{ni} + t_{c,int}(D_{int} - 1) + t_{c,int,r}) \end{array}\right]$
+ Cost of List data collection	$+ W_d R_d m_d \left[\begin{array}{c} I(t_{i,nw}D_{nw} + t_{i,ni}D_{ni} \\ + t_{i,int}(D_{int} - 1) + t_{i,int,d}) \\ + C(t_{c,nw}D_{nw} + t_{c,ni}D_{ni} \\ + t_{c,int}(D_{int} - 1) + t_{c,int,d}) \end{array}\right]$
+ Cost of selection weight construction	$+ F_d[S_d + N_d P_d] + (1 - P_{ri})(100 m_r) C_d$
+ Costs of advance letter	$+ \$.52[m_d/W_d]$

administering the sample and completing interviews, c) costs of building the selection weights used in the survey statistics, and d) costs of mailing the advance letters to the list frame cases. The full cost model appears in Table 1; terms in the model are defined in Table 2. The costs remaining for an RDD design (with no list supplement) are merely those in Table 1 reflecting RDD frame costs.

The costs of the RDD frame must reflect the acquisition of the tape file containing working area codes and prefixes as well as the computer generation of the primary and secondary numbers. Both the RDD and the list frame acquisition costs reflect the practice of drawing subsamples over time from a master sample for different surveys. Thus, each survey can be considered as incurring only a fraction (F_r, for the RDD frame, and F_d, for the list frame) of the acquisition costs.

Sample administration costs include interviewer salary and telephone connect charges required to make initial contact with the sample household and total costs of interviewing. For each RDD sample number a check of the list frame must be made to determine whether it could have been sampled from that frame as well. This is the cost of selection weight construction in Table 1. This cost component would not be required for use of the RDD or list frames alone but is an added cost for using the dual frame design. Finally, the costs of the advance letter involves the generation of letters and envelopes using mail-merging software, the signing of the letters, assembling envelopes, and mailing.

3. Empirical Data on Dual Frame Design Characteristics

A series of studies conducted between 1984 and 1986 at the Survey Research Center provide information on the properties of dual frame designs. Some of these studies examined properties of the list frame for the national telephone household population, and others, the state of Michigan telephone household population. Dual frame designs were tested in surveys of Michigan, using a two stage RDD design and a systematic element sample from the list frame.[2] The two stage RDD design was based on 300 clusters from which 354 interviews were taken. Stratification of the first stage sample was based on geographical region. The sample from the list frame was a systematic selection yielding 399 interviews, from a list sorted by region, zipcode, and street.

3.1 Characteristics of the List Frame

The list frame used in this investigation is a computerized version of current telephone directories constructed and updated by the Metromail Corporation of Lincoln, Nebraska. The list is reported to contain the listings of most recent directories (within one month of publication), to exclude nonresidential numbers, and to include geographical data useful for stratification in sample designs.

There are two properties of the list that are important to the potential cost advantages of a dual frame design: a) the proportion of numbers on the list that are working residential numbers, and b) the proportion of all residential numbers that are on the list. The first describes how much screening will be required for locating an eligible sample number; the second describes the coverage rate of the frame for the full telephone household population. In one test of the dual frame design in the state of Michigan, 88 percent of numbers (standard error = 1.5) on the list were working residential numbers. This can be compared to 59 percent of the second stage numbers (standard error = 2.2) in the two stage RDD design that were working residential numbers for the state of Michigan sample. The result demonstrated the greater efficiency of the directory frame for locating residences.

Table 2. Cost Parameters, Error Parameters, and Values Used for the Parameters to Determine an Optimal Allocation Between the Two Frames

	Description	Value Used in Investigation
Cost Model Parameters		
F_r	Fraction of total uses of the RDD primary sample represented by this study	.33
F_d	Fraction of total uses of the List sample represented by this study	.33
P_r	Fixed costs for acquiring RDD frame	$499
P_d	Per number cost for accessing List frame	$.00038
m_r	Desired number of primary stage working household numbers from RDD frame	...*
m_d	Number of sample numbers purchased from list frame	...*
N_d	Total number of listings on list frame	2,500,000
n_r	Number of second stage working household numbers per primary stage cluster in RDD frame	6.49
S_r	Salary costs for data processing of RDD frame	$60
S_d	Salary costs for data processing of List sample	$60
R_r	Proportion of households yielding an interview in RDD clusters	.616
R_d	Proportion of households yielding an interview in List sample	.694
w_{rm}	Proportion of primary numbers in RDD frame that are working household numbers	0.283
w_d	Proportion of list frame numbers that are working household numbers	0.884
w_{rn}	Proportion of secondary numbers in RDD frame that are working household numbers	0.593
G_r	Cost to generate by computer a number from the RDD frame	$0.05
G_d	Cost to select a number from the List frame	$0.0375
t_{im}	Interviewer minutes required to determine status of a primary number	12
$t_{i,nw}$	Average minutes of interviewer time for calls to nonworking numbers	6

Table 2 (continued)

	Description	Value Used in Investigation
Cost Model Parameters		
$t_{i,ni}$	Average minutes of interviewer time for calls to noninterview cases	7
$t_{i,int}$	Average minutes of interviewer time for calls to interview cases, prior to interview call	7
t_{cm}	Minutes of telephone connect time required to check status of a primary number	3.6
$t_{c,nw}$	Minutes of telephone connect time for nonworking numbers	1
$t_{c,ni}$	Average minutes of connect time for calls to noninterview cases	2
$t_{c,int}$	Average minutes of connect time for calls to interview cases, prior to interview call	4
I	Cost per minute for interviewer salary	$0.083
C	Cost per minute of telephone connect time	$0.30
$t_{i,int,r}$	Length in interviewer minutes of completed interview for RDD cases	29.4
$t_{i,int,d}$	Length in interviewer minutes of completed interview for List cases	29.6
$t_{c,int,r}$	Connect minutes for completed interview for RDD cases	23.4
$t_{c,int,d}$	Connect minutes for completed interview for List cases	23.6
$D_{nw,r}$	Number of calls on nonworking numbers per interview obtained for RDD cases	1.85
$D_{nw,d}$	Number of calls on nonworking numbers per interview obtained for List cases	.366
$D_{ni,r}$	Number of calls on noninterview numbers per interview obtained for RDD cases	5.27
$D_{ni,d}$	Number of calls on noninterview numbers per interview obtained for List cases	4.00
$D_{int,r}$	Number of calls on interviewed cases per interview obtained for RDD cases	3.59
$D_{int,d}$	Number of calls on interviewed cases per interview obtained for List cases	3.47
P_r	Proportion of all numbers in RDD clusters which are listed	.42
C_d	Cost per number in RDD clusters matched to listed number	$.055

By matching several sets of two stage RDD sample numbers to the list frame, we estimated the percentage of all residential numbers that were on the list. This analysis was done both for national samples and state of Michigan samples. Table 3 shows that over five different national studies the percentage of contacted RDD sample households on the list is about 69 percent, varying between 68 and 71 over the five studies. The proportion of sample RDD numbers that were not contacted in the studies, but were found on the list was about 66 percent. It is unknown what proportion of these noncontacted numbers are working residential numbers. In a state of Michigan sample 61 percent of the households were on the list. This rate reflects the relatively low rate of listing in the large metropolitan area of Detroit, a result that is repeated in other large cities. The low rate of list frame coverage implies great risk in using a single frame survey from telephone directories in a national or Michigan sample. The rate also portends likely loss of precision in dual frame samples with very high allocations of the sample to the list frame.

3.2 Results of the Dual Frame Implementation

Two dual frame telephone surveys were conducted in the

Table 3. Percentage of RDD Sample Numbers on List Frame By Status of Number for Five National Studies

Survey	Status: Contacted Households	Status: Noncontacted Numbers
Crime Victimization	69.5%	75.0%
January Survey of Consumer Attitudes	67.8	66.7
February Survey of Consumer Attitudes	69.1	62.5
March Survey of Consumer Attitudes	67.8	66.7
April Survey of Consumer Attitudes	70.8	57.1
Mean Over Five Surveys	69.0	65.6

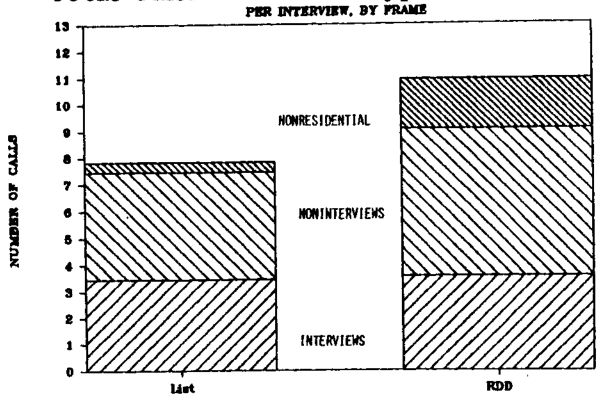
Table 4. Percentage Respondingand Standard Error Among Letter and Full RDD Groups

Group	Proportion Responding
Advance Letter	72.6% (2.6)
Full RDD	61.6 (2.1)
Difference	11.0 (4.1)

FIGURE 1

Total Calls to Various Types of Numbers

PER INTERVIEW, BY FRAME



state of Michigan, each measuring the effect of sending an advance letter. In both, advance letters were sent to a randomly identified subsample from the list frame. The first study obtained a 6.7 percentage point increase in response rate with the advance letter; the second, a 5.7 percentage point increase. Over the two studies the advance letter increased the response rate by 6.2 percentage points (standard error = 3.3 percentage points). Further, as Traugott, Groves, and Lepkowski (1986) note, the response rate gains were found disproportionately in those subgroups that displayed poor cooperation in previous RDD surveys (Cannell *et al.* 1985). These include the elderly and low education groups, which suggests a reduction in nonresponse bias for statistics varying across age and education groups.

The beneficial effects of the advance letter can be obtained, obviously, only for those cases on the list, which have addresses for mailing. In addition, however, the dual frame design is affected by any differences in cooperation between those households whose numbers are listed and those unlisted. It was found that persons with listed numbers are more likely to cooperate than those with unlisted numbers. Among RDD sample cases in the dual frame test which were listed, about 66 percent provided an interview; among those not on the list, only 53 percent. The difference of 13 percentage points has a standard error of 4.9.

Table 4 presents the overall comparison of the list frame survey with advance letters and the full RDD survey. These figures are affected both by the letter effect among the list cases and the more difficult to interview unlisted cases in the RDD survey. The table shows an overall 11 percentage point increase (standard error = 4.1) for the list frame cases with advanced letters versus the full RDD sample cases.

These response rate differences have both cost and error implications for the survey. On the cost side, with higher cooperation rates, less intensive refusal conversion efforts are required to achieve desired response rates. One indirect measure of costs of data collection is the number of dialings required to obtain one interview. The list frame cases with advance letters required on the average 7.8 dialings on sample numbers for every one interview obtained (standard error = .6). The comparable figure for the RDD sample is 11.0 (standard error = .61). The histogram in Figure 1 shows that the difference arises both because of higher noninterviews but also because of the lower eligibility rate among RDD sample numbers.

On the error side, the higher response rates bring into the respondent pool different kinds of persons. The effect on estimates of these higher response rates can be assessed by comparing the point estimates of list frame cases without the letter to those with the letter. The dual frame design also achieves increased precision because of the stratified element design for the list frame and because of the poststratification inherent in the estimator.

4. Determining Optimal Allocations to the List

Using the cost and error models and data obtained from the experimental implementation of the dual frame design, the quality of estimates of means and proportions from a dual frame design was evaluated. Alternative allocations of the sample to the directory frame (from 0 to 100 percent directory) were simulated for a survey costing $100,000, and the results were compared to an RDD design of the same cost.

Two error estimators were used in the simulations. The first treated sampling variance as the only source of error, while the second included a nonresponse bias component as well as sampling variance. In the absence of validating data on the entire sample, no direct estimate of the nonreponse bias terms were available. Instead, a component measuring "relative change in nonresponse bias" can be estimated from the results of the dual frame tests as $\bar{y}_{2,\mathrm{ltr}} - \bar{y}_{2,\mathrm{noltr}}$, where $\bar{y}_{2,\mathrm{ltr}}$ is the mean for interviews from sample cases of the list frame which were sent an advance letter, and $\bar{y}_{2,\mathrm{noltr}}$ is the mean for interviews from sample cases of the list frame which were not sent an advance letter. In effect, this formulation of the bias sets the bias of the list sample at 0.0,and lets the bias of the listed and unlisted domain estimates of the RDD sample be equal. This estimator for the nonresponse bias is obviously an incomplete representation of this error source. It might be best thought of as the relative difference in bias attributable to the advance letter. We use it to illustrate that very different conclusions about the relative quality of the dual frame approach are possible when bias terms are considered.

Parameters used in the cost and error models are those appearing in Table 2. These are based on the initial experimental tests of the dual frame method for the Michigan surveys. Careful examination of the cost model and various parameter values suggest that the larger the proportion of interviews taken from the list frame sample the larger the achieved sample size. This reflects the cheaper price of obtaining interviews from list frame cases with advanced letters. For example, for a $100,000 total budget and the cost and error models described previously, the sample size increases from about 4,300 in the all RDD case to about 5,000 with the entire sample allocated to the list frame. Other things being equal, this will lower sampling variances of the mean with higher allocations to the list. However, other things are not equal. While increasing the allocation to the list increases the sample size, the design effect[3] of the dual frame design also increases with increasing allocation to the list frame. These two results thus counteract one another in terms of sampling variance.

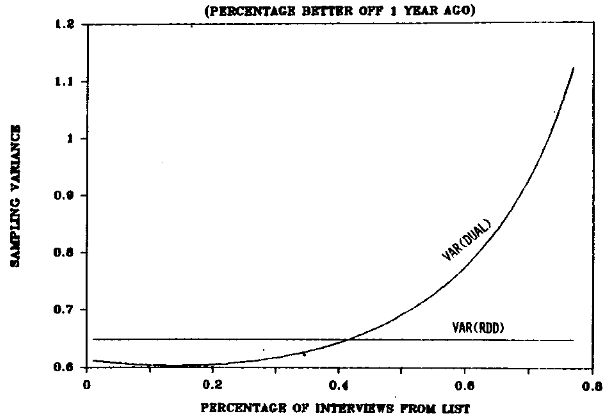
It is important to note that **even with our restrictive model for relative nonresponse bias**, both the RDD and the dual frame estimator are subject to nonresponse bias. The RDD estimator is subject to nonresponse bias because no cases receive the letter. The dual frame estimator is subject to nonresponse bias because, for the mean of the population of listed numbers, it uses a combination of estimates from the list frame sample (sent advance letters) and from the RDD sample cases who happen to be on the list (not sent advance letters). The mixing parameter used for the dual frame estimator reflects both differing variances and nonresponse bias (following Lepkowski and Groves 1986).

Figures 2 to 5 present the results of simulating alternative allocations to the list frame in a dual frame design. Figures 2 and 4 compare the sampling variance of the dual frame estimator with that of the RDD estimator from the two survey designs each costing $100,000. Figures 3 and 5 include the relative bias, as conceptualized previously. The first two figures apply to a statistic that appears relatively immune to the effects of the advance letter. That is, the estimated proportion of respondents who report that their financial condition was better one year ago is similar among those receiving the advance letter as among those not receiving the advance letter. Figure 2 shows that the optimal allocation for the dual frame design is about 17 percent of the interviews from the list sample and 83 percent from the RDD sample.

FIGURE 2

SAMPLING VARIANCE BY ALLOCATION TO LIST

(PERCENTAGE BETTER OFF 1 YEAR AGO)

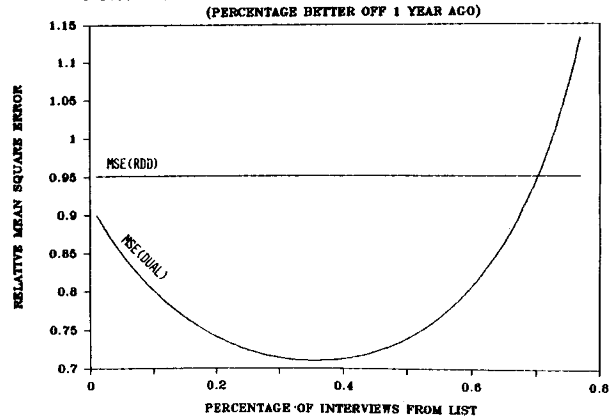


When the relative nonresponse bias term is added to the simulation (in Figure 3) the optimal allocation increases to between 30 and 40 percent from the list. That is, when both relative nonresponse bias and sampling variance are considered, larger portions of the sample should be drawn from the list frame. This follows because the list frame is both cheaper and offers lower nonresponse bias.

FIGURE 3

RELATIVE MSE BY ALLOCATION TO LIST

(PERCENTAGE BETTER OFF 1 YEAR AGO)



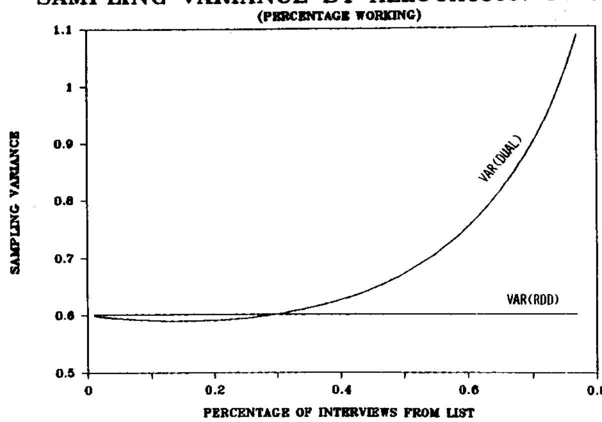
How much is really gained by the dual frame design for the estimated percentage reporting that they were better off financially one year ago? If we concern ourselves merely with sampling error, we can reduce sampling variance by about 14 percent with the dual frame over the RDD design (i.e., a gain of 7 percent in standard errors). Including nonresponse bias, as reflected in (3), we can reduce the mean squared error by about 25 percent, with the optimal allocation (i.e., a reduction of 13 percent in root mean squared error). If the design allocates more to the list frame than the optimal proportion, both sampling variance and mean squared error rapidly increases. Note that, in both figures, the slope of the error curve sharply increases for allocations of more than 60 percent to the list. This reflects the loss in sampling variance due to undersampling of the unlisted domain.

Figures 4 and 5 concern a different statistic, the percentage of respondents who report that they are currently working. In terms of sampling variance the optimal allocation to the list is approximately 15 percent but the level of sampling error is almost identical to that of the RDD design. A radically different result appears in Figure 5, however, because the relative bias estimate is very large for this statistic. Many more people who are not working cooperated with the survey request among those who received the letter

FIGURE 4

SAMPLING VARIANCE BY ALLOCATION TO LIST

(PERCENTAGE WORKING)

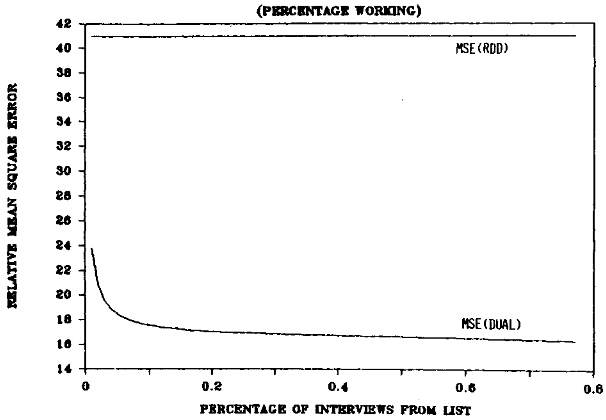


than among those who did not. The result is that dual frame estimator achieves radically lower mean squared error for the entire range of allocations. Fully 80 percent of the interviews might be allocated to the list frame and a reduction of over 50 percent in mean squared error is achieved.

The contrast between Figures 3 and 5 is to be expected in any survey measuring statistics that are differentially susceptible to nonresponse bias. In this case, the nonresponse differences appear to the center on the elderly and low education groups. The researcher faced with different optimal allocations implied by Figures 2 to 5 must judge the importance of sampling variance versus bias and assess the relative importance of the different statistics being estimated.

FIGURE 5

RELATIVE MSE BY ALLOCATION TO LIST



5. Summary and Conclusions

We have demonstrated significant gains in response rates for dual frame telephone surveys using the list frame with advance letters. However, these results should be interpreted carefully, because of several features of the implementations described here. First, these results are based on surveys conducted by The University of Michigan in the state of Michigan. The previous research on advance letters has observed variation in effects depending on the affiliation of the survey and the survey population (Brunner and Carroll 1969). Second, examination of the demographic characteristics of respondents suggests that the letter successfully encourages cooperation among those sample persons previously found to be resistant to telephone survey requests (e.g., the elderly). Third, using a measure of relative mean squared error, the optimal allocation to the list may be sensitive to the success of the letter at reducing nonresponse error. This will vary across statistics in the same survey. Our results show optimal allocations between 35 and 80 percent to the list. The reader should be cautioned that the proportionate gains in mean squared error is a function of both the relative nonresponse bias and the nonresponse bias shared by both the dual frame and the RDD estimate. We were not able to measure that shared bias, in the absence of validating data. In addition, the importance of nonresponse error relative to sampling variance is larger in higher budget surveys (with large samples) than in low budget surveys. The total survey costs of $100,000 used in the simulations limit the inference from this paper.

Finally, as with many dual frame solutions the design evaluated here offers another advantage, a built-in experimental feature. The RDD cases which happen to be listed in the directory do not receive an advance letter. The list frame sample cases do. Two point estimates of the list frame population statistic are available, and the effect of the letter is measurable in each survey. This permits assessment of the importance of the higher response rate to the values of survey statistic.

In the past decade there have been many attempts to alter telephone survey designs in order to improve their nonresponse error characteristics or to reduce their costs. The dual frame methodology offers some promise of doing both of these things. Several features of the design, however, require further investigation. They include examining the cost and error characteristics of the design for national surveys, by different survey organizations, and across different subpopulations, as well as experimentation with sending advance letters to some of the RDD cases which happen to appear on the list. The initial results suggest further testing of the methodology is merited.

Footnotes

[1] Telephone numbers in North America (e.g., 313-764-4424) have three components: A three digit area code (e.g., 313), followed by a three digit prefix (e.g, 764), followed by a four digit suffix (e.g., 4424).

[2] In both frames equal allocations to three regional strata within the state were used, producing an nonepsem design. To simplify the presentation, this paper presents weighted estimates; the results are those to be expected from an epsem design of the state of Michigan.

[3] The design effect is the ratio of the sampling variance under the complex design to that expected from a simple random sample of the same size.

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