PLANNING FOR THE EVALUATION OF CENSUS COVERAGE ESTIMATES FOR THE 1990 CENSUS

Mary H. Mulry and David Bateman*, U.S. Bureau of the Census
Mary H. Mulry, Bureau of the Census, Washington, D.C. 20233

1. Introduction

Coverage of the 1990 Census will be evaluated by two different methodologies. A post enumeration survey (PES) in conjunction with a dual system estimation model will be the primary source of coverage error measurement. A second methodology will employ demographic analysis techniques to produce estimates of census coverage error at the national level. The purpose of this paper is to document a program that has been established to evaluate the former program, i.e. the PES methodology. This evaluation will then be utilized to assist the Secretary of Commerce in deciding whether the results of the PES coverage measurement activities should be used to adjust the 1990 Census count.

In 1980, adjustment of the Census was also an issue. However, there was no program to evaluate the undercount estimates. The methodology for the evaluation has been developed within the last few years (Hogan and Wolter, 1988, Mulry and Spencer, 1988). The 1990 PES evaluation program will consist of two general groups of studies. The first group of studies will provide direct measures of error in the PES due to several error components. These errors combine in the dual system estimator model to cause differences from population counts that would be attained under an error-free program. The difference between the PES dual system estimate (DSE) and the error-free count is referred to as the total error. We will introduce a program to provide estimates of this total error. This total error estimate can then be used as part of a statistical model used in the statistical adjustment process.

The second group of studies will be conducted to provide supplementary evaluative information about the PES data. While this information will not provide direct estimates of error that can be used to measure total error, it will provide information that can be added to the body of knowledge that will be used to determine whether the PES information is sufficiently accurate to use as an adjustment mechanism. These studies are relatively easy and inexpensive to conduct and often are a by-product of the first group of studies.

The evaluation of the total error in the PES estimates is described in Section 2. Section 3 contains discussions of the estimation of the components of error and supplementary analyses. Section 4 describes the census adjustment decision issues relevant to the evaluation of the PES estimates.

2. Total Error In The Estimates

We have designed the program scientifically with an emphasis on the results being reproducible. We evaluate both the components of error and the total error in the PES estimates for two reasons. The evaluations of the components of error assess how well the assumptions underlying the PES methodology hold in the application. The components of error are response correlation bias, matching error, quality of the reported Census Day address, fabrication in the P sample, error in the E sample, error in balancing the estimates of the gross overcount and the gross undercount, missing data, and sampling variance.

The evaluation of the total error assesses the overall accuracy of the PES estimates of population size and census coverage error. A synthesis of the component errors, even though they each may be very small, provides estimates of the bias and variance. There are several steps in assessing the combined effect of all the errors on the PES estimate of the undercount rate. First, the estimates of the mean and variance of the distributions of the component errors are based on the conclusions drawn from the various projects. These estimates are used in the model for total error described in Mulry and Spencer (1988). Next, the simulation method produces an estimate of the bias and variance of the estimated undercount rate.

Sensitivity analysis incorporates the error component due to missing data. We study the effect of the imputation for missing data in combination with the other sources of error by computing the bias of the estimated undercount rate under the preferred imputation model. Finally, we compute the bias of the undercount rate under several other imputation models which are reasonable alternatives. The upper and lower bounds of the bias and the variance estimates are combined to produce prediction intervals for the undercount rate.

The 95% prediction interval has the form

$$(\hat{U} + B_L - 2\sigma,\ \hat{U} + B_H + 2\sigma)$$

where $\hat{U}$ is the undercount rate, B_L is the lower bound of the bias estimates for all components of nonsampling error, B_H is the upper bound of the bias estimates, and σ is the standard error.

We will develop these prediction intervals for 13 evaluation poststrata and for age, race, and sex groups at the national level. The program has been designed to provide good estimates of the components of error at the level of the 13 evaluation poststrata. Any development of error estimates below this level of geography will require making distributional assumptions.

3. Component Error Analyses

3.1 Quality of Census Day Address

Some of the respondents in the P sample have moved between Census Day and their PES interview. Respondents sometimes forget to report that they moved in spite of the probes on the questionnaire. This type of error may cause the matching operation to search the census in an area other than where the respondent was enumerated. This may lead to assigning

a nonmatch status to respondents who actually were enumerated.

3.1.1 Error Estimation

Two projects, the Evaluation Follow-up and the Revisit, will provide estimates of the error due to misreporting of Census Day address. One of the two goals of the Evaluation Follow-up and the Revisit is to identify movers who did not report themselves as movers in the PES interview and follow-up. The other goal is to determine how well the PES follow-up worked. The field work is scheduled for February, 1991.

The Evaluation Follow-up will use the PES follow-up questionnaire and more highly skilled interviewers to measure address reporting error and the error in the number of people matching a census enumeration due to address reporting error. The Evaluation Follow-up cases will include only nonmatch P-sample people who were not included in the production PES Follow-up. These P-sample people did not report that they were movers and will be sent for a follow-up to see if they report better Census Day addresses that allow a change in their match status. A sample of the matches also will be interviewed as a control group. The proportion who change their mind and report a new address will be used to measure the validity of the reporting in the Evaluation Follow-up.

The Revisit will use a more probing questionnaire and more highly skilled interviewers to evaluate the information collected during the PES follow-up. The Revisit will interview a sample of the P-sample nonmatches who were included in the PES follow-up. The information collected during the Revisit interview will be used to attempt to match these people. The results will provide an estimate of the address reporting error and the error in the number of people matching a census enumeration due to address reporting error. The sample for the Revisit includes both whole household nonmatches and partial household nonmatches.

3.1.2 Supplementary Information

Another analysis considers the effect of the variation in the percentage of the movers who match a census enumeration on the distribution of the dual system estimates. The study examines the tabulations of the estimated percentage of the movers who match a corresponding census enumeration for each stratum. We investigate the percentage of the movers and its relation to the estimated coverage error.

3.2 P-Sample Fabrication Error

Interviewers may fabricate people in P-sample housing units. The quality assurance of the P-sample interviewing detects fabrication and corrects it. A P-sample questionnaire fails quality control when any of the information required for matching is incorrect. The roster of names, ages, and Census Day address are all verified during the interview for quality control. When a set of interviews done by one interviewer fails the quality control sample check, all the recent work by the interviewer undergoes a quality control check. When the quality control specialist discovers a fabricated household, the real residents of the household are interviewed. The real residents are then matched to the census.

3.2.1 Error Estimation

Three analyses address the effect of any uncorrected fabrication that remains in the data set in spite of the quality control operation. One analysis uses data from the quality control for the interviewing to estimate the error in the estimate of the number of P-sample people matched due to fabrication.

In addition, some of the people included in the Evaluation Follow-up and the Revisit will prove to have been fabricated. These results will also produce an estimate of the number of people fabricated in the P sample.

3.2.2 Supplementary Information

Another analysis examines whether any of the P-sample interviewers have submitted fabricated interviews by investigating whether their data at the block level differs substantially from the other blocks in their PES stratum. This is accomplished by examining the nature of the nonmatch rates for each interviewer. For example, the percentage of people who do not match a census enumeration and the percentage of households where none of the residents match a census enumeration for an interviewer provide information about the quality of the interviewer's work, particularly when compared to other interviewers in the stratum.

3.3 Matching Error

Matching error in this discussion refers to errors that occur in the operation where the P sample is matched to the original enumeration. Therefore, matching error does not encompass response errors that arise in the data collection. Although other types of errors may result in an inaccurate assignment of a P-sample respondent's census enumeration status, or match status, these sources are evaluated in other studies.

3.3.1 Error Estimation

Two analyses investigate the error in the estimate of the number of P-sample people matched to the census due to processing error. The Matching Error Study measures the processing error in the assignment of census enumeration status to the P-sample and E-sample cases. These are errors that occur even when the people are real and their Census Day address is reported correctly. The study produces estimates of matching bias and variance.

The study uses a sub-sample of approximately 900 PES block clusters. The number of blocks selected for each evaluation stratum is different because the number of blocks in the PES sample in each stratum varies and the size of the blocks in each stratum varies. The sub-sample will be used to measure errors in the P sample and the E sample.

A team of professionals specially trained in matching will conduct a dependent re-match of a sample of

blocks, with the option of field work when clarification is needed. "Dependent" means that the matchers will have access to the match codes assigned by the PES production matching. The re-match is designed to estimate the net error rate in the assignment of enumeration status in the P sample and the E sample using the best personnel available. If a systematic matching bias is present, it will become evident.

3.3.2 Supplementary Information

Another analysis relies on the data collected in the quality control of the matching operation to evaluate the matching error. As part of the quality control for the matching operation, each PES block is matched by two different clerks. Their match codes are compared, and discrepancies are resolved by higher level technicians. This data set provides insight as to the nature of the errors in the matching operation.

3.4 E-Sample Error

Some enumerations may have been entered in the census as the result of mistakes. The following types of enumerations are erroneous:

(1) People duplicated,
(2) Enumerations of fictitious people,
(3) People who died before Census Day,
(4) People who were born after Census Day,
(5) People enumerated outside the search area where they were living on Census Day.

An estimate of the number of erroneous enumerations is part of the PES estimation of population size and census coverage error. The E sample provides for an estimate of the number of erroneous enumerations. This project will focus on errors in classifying an enumeration in the E sample as correct or erroneous. In other words, the concern is for errors in measuring census error.

3.4.1 Error Estimation

Three analyses investigate errors in classifying the enumeration status of E-sample people. One analysis uses the results of the Matching Error Study to estimate the error. The re-match assesses errors in the assignment of both enumeration statuses, correct and erroneous, during the processing. The focus is on the errors in the identification of duplicated and fictitious enumerations. The Matching Error Study estimates the error rate in the identification of duplicated and fictitious enumerations, as well as those born after Census Day and those who died before Census Day.

Another source of information about E-sample error is the Revisit of a sub-sample of the E-sample cases that were included in the PES follow-up. The questionnaire will have more probes, and the interviewers will be more highly skilled than those for the PES follow-up. These data will provide an estimate of the error in the estimate of the number of erroneous enumerations.

3.4.2 Supplementary Information

Another part of the analyses assessing errors in measuring erroneous enumerations consists of reviewing the crosstabulations of E-sample data. This review provides evidence as to whether a particular type of error in classifying enumeration status is present in the data. One example of the crosstabulations to be reviewed is the distribution of the erroneous enumerations by age group. This examination will assess the accuracy of the identification of duplicate enumerations due to violations of the census residency rules by highly-mobile segments of the population. The distributions by type of erroneous enumeration, fictitious or duplicate, also will provide information. Any discontinuities in the distribution which can not be explained will be an indication of the presence of misclassification of enumeration statuses.

3.5 Balancing The Estimates of Gross Undercount and Gross Overcount

Both the E sample and the P sample measure enumeration errors in the census. The E sample measures the gross overcount in the form of erroneous enumerations. The P sample measures the gross undercount in the form of those not enumerated. Ideally, the entire census would be searched before a P-sample person was declared to be not enumerated. Ideally, the entire country would be searched to determine if an E-sample enumeration is duplicate or fictitious. Of course, such extensive searches are simply not feasible in the performance of the PES. These searches must be limited in a reasonable manner. The way chosen has to preserve the net error although the measured gross overcount and the measured gross undercount may increase due to limiting the search area. The gross overcount and the gross undercount have to balance to equal the net coverage error.

Balancing is not a major issue for the design of the 1990 PES. The design calls for overlapping the P sample and the E sample. The same blocks are included in the P sample as in the E sample. The P-sample search area is, by definition, the proper search area. The E-sample search area is chosen to be consistent with the P-sample search area. An inspection will determine whether the search areas for the E sample and the P sample are drawn properly and consistent as designed.

Although we do not plan a direct estimate of this error, supplementary information is obtained in an inspection that assures that balancing is not an issue in the performance of the PES, as designed. To verify that the geocoding is performed consistently, the estimated percentage of the E-sample housing units geocoded outside the search area, will be examined for each stratum. A large percentage of the E-sample housing units found outside the search area may indicate that the addresses are not geocoded consistently in the census and the P sample although the same system is used.

3.6 Evidence of Correlation Bias

The dual system estimation used for the PES estimates is based on three independence assumptions: causality,

homogeneity, and autonomy. Basically these assumptions say, respectively, that inclusion in the P sample and the census are independent, that everyone has the same probability of inclusion, and that everyone acts on their own as to whether they are included in the P sample population or the census. The violation of any of these three assumptions may cause the estimate of the proportion of the population enumerated in the census, and thereby the estimates of the population, to be biased. Such a bias is known as a correlation bias.

The PES has been designed to avoid introducing correlation bias. The PES interviewing is not performed until after the closeout of the nonresponse follow-up for the census. There are different field offices for the census and the PES. For estimation, the sample persons are post-stratified into race, sex, age, and geographic groups which are believed to be homogeneous with respect to inclusion probabilities. Since the PES and census are conducted on a household basis, there is some lack of autonomy as to whether a person is included in the census or PES. However, the bias caused by this is negligible although there is an increase in variance.

The focus of this project is on evaluating whether the homogeneity assumption holds. Some individuals are believed to have very low probabilities of inclusion in the census or the PES. If the post stratification does not account for all the heterogeneity of inclusions probabilities in the population, then a bias may be present.

3.6.1 Error Estimation

The correlation bias is difficult to estimate. We are going to use two methods for assessing correlation bias. One approach is to compare DSEs and demographic analysis estimates of population size and use differences between the two sets of estimates to make inferences about the magnitude of correlation bias; see Ericksen and Kadane (1985, p.103). In this approach we need to be wary of the errors in the demographic analysis estimates.

Demographic analysis as a tool for census evaluation involves first developing estimates for the population in various categories, such as age, race, and sex group, at Census Day by the combination of estimates based on various types of demographic data. The estimates for the groups are then added to yield an estimate for the nation as a whole.

The data used for demographic analysis estimates are drawn from sources essentially independent of the census being evaluated. They include: birth, death, and immigration statistics; sex ratios, life tables, etc.; historical series of census data; and data from errors. The overall accuracy of the method depends on the quality of the demographic data and corrections (Fay et.al, 1988).

The second approach uses a conditional logistic estimation procedure (Alho, 1990) to obtain estimates of the probabilities of inclusion in the census and the P sample. This method allows analysis of dual system data using individual level covariate information, as opposed to requiring completely independent source of data. Having estimated the inclusion probabilities, we can estimate the correlation. Using the estimated correlation, we obtain an estimate of τ, the correlation bias factor.

We use this modeling approach in two ways. First we obtain the inclusion probabilities for each of the PES post strata and the PES evaluation post strata. In these applications, we use the post stratification variables themselves as the explanatory variables. We use the estimated inclusion probabilities to estimate the correlation for the 13 evaluation post strata. For a consistency check, we also model the inclusion probabilities for the same groups that demographic analysis uses at the national level. In this model, the explanatory variables are the race, sex, and age groupings used in demographic analysis.

The second application of the model examines the inclusion probabilities within the PES post strata. The PES post strata are believed to be homogeneous with respect to inclusion probabilities. This method will examine the variability of the inclusion probabilities within PES post strata. The explanatory variables include household size, the geographic Federal Information Processing System (FIPS) code, and actual age (as opposed to ten-year age group). Other variables relevant to inclusion may be examined.

3.6.2 Supplementary Information

Each P-sample field manager will attend a debriefing to discuss the effectiveness of the execution of the plans for keeping the census and the P-sample separate. In addition, some of the PES interviewers and crew leaders will attend a debriefing to discuss the implementation of the PES. These reports include data such as the number of enumerations added to the census after PES interviewing has begun.

A comparison of the results of some census operations will provide evidence about the validity of the assumption of causal independence. The number of people added to the census after the beginning of P-sample interviewing will be tabulated for PES blocks and for comparable blocks not in the PES sample. The study performs both comparisons between two comparable blocks and between the distributions of all the blocks.

3.7 Missing Data

Missing data occur in the P sample and the E sample in more than one way. The interviewer may be unable to obtain an interview during the P-sample interviewing or during the PES follow-up of the P sample and E sample. A P-sample or E-sample questionnaire may not have all the information required for the estimation. Even with all the information requested on the questionnaires, the circumstances may be so unclear that the enumeration status can not be resolved.

Three analyses investigate the distribution of the missing data and determine whether the error due to missing data causes a significant distortion of the distribution of the PES estimates. The PES production specifies a preferred method of imputation for unresolved P-sample and E-sample enumeration statuses prior to the implementation of the PES.

3.7.1 Error Estimation

We examine the effect of missing data on the PES estimates by a sensitivity analysis and do not make a direct estimate of the error component. The sensitivity analysis investigates the uncertainty caused by the imputation through examining the range of estimates of the population size under different assumptions about the missing data. The range of the alternative estimates indicates the sensitivity of the PES estimates to the chosen method of imputation. For example, a narrow range implies that the estimates are robust, and the missing data causes little uncertainty in the estimates. Alternative treatments of the missing data are suggested by problems that arise during the collection and processing of the PES and census data. Examples include alternative treatments of proxy data, movers, and E-sample follow-up cases for which the person in question was not known by the respondent.

Another analysis examines data collected during the Revisit Survey of a sample of persons with an unresolved match status and households that were unable to be interviewed in the PES. We expect that a questionnaire with more probes in combination with more highly skilled interviewers yields better information from these difficult cases. We intend to develop an alternative imputation model using the cases we can resolve.

3.7.2 Supplementary Information

A third analysis considers the possible effects of missing data on the estimated distribution of population among different places. The study will examine the tabulations of the estimated percentage of the population with unresolved enumeration status for each PES stratum. We will evaluate the uniformity of the percentage of unresolved cases and the relationship with estimated coverage error.

3.8 Sampling Error

The PES estimates are subject to sampling error. The analysis assesses the amount of sampling error in the estimates of census coverage error based on the PES estimates of the population. The evaluation is based on the variance and coefficient of variation. The distributions of the variances and coefficients of variation of the original and smoothed adjustment factors are compared.

4. Adjustment Issues

4.1 Synthetic Estimation Assumption

Synthetic estimation assumes that the probability of being missed by the census is constant for each person within a post-strata. The coverage error may vary substantially within the PES stratum although the strata were drawn so as to be homogeneous with respect to expected coverage error. This project verifies that the assumption underlying a synthetic estimation of census coverage error is valid.

We will investigate whether the variables used in the regression smoothing of the adjustment factors are homogeneous within post strata. These census characteristics are considered to be highly correlated with coverage error. The underlying assumption is that if the highly correlated variables are homogeneous, then the undercount is also.

4.2 Decision Process

Currently there is a special advisory panel composed of eight members who will review the undercount estimates and the evaluation results. They will individually make a recommendation to the Secretary of Commerce about whether to adjust the census. The Director of the Census Bureau also will make recommendations. The Secretary then makes the decision on whether to adjust the Census.

References

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*This paper reports the general results of research undertaken by Census Bureau staff. The views expressed are attributable to the authors and do not necessarily reflect those of the Census Bureau.