ISSUES ON PROCESSING ERRORS IN ESTABLISHMENT SURVEYS

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1. INTRODUCTION

The Subcommittee on Measurement of Quality in Establishment Surveys of the Federal Committee on Statistical Methodology in the Office of Management and Budget is preparing a report entitled "Measurement of Quality in Establishment Surveys" which documents common problems and practices of Federal Government agencies which conduct surveys of establishments. This paper elaborates on a section of the report which discusses processing errors. The subcommittee reviewed the survey design practices of nine agencies in the conduct of 55 establishment data collection programs (not a probability sample). Information was obtained concerning activities conducted in these programs to measure and control processing errors. This information is discussed in the report of the subcommittee and summarized here.

Processing error is the error in final survey results arising from the faulty implementation of correctly planned survey designs. This includes problems in translating specifications into operational procedures and problems in following or conforming to these procedures. Most processing errors occur in data for individual units, although errors can also be introduced in tabulations and estimates.

The examples used in the discussion of processing errors are drawn from the economic censuses conducted by the U.S. Bureau of the Census every five years. The censuses are conducted by mail using questionnaires designed for specific standard industrial classifications (SIC). Data collected include employment, payroll, sales or receipts, and operating expenses. The basic units for which data are collected are individual establishments. Questionnaires are mailed in January following the reference year for which data are requested, with mail and telephone followups for nonrespondents. Data collection continues through approximately July. Data are keyed and edited with telephone callbacks for edit failures. Data are then tabulated by geography and SIC.

2. SOURCES OF PROCESSING ERROR

Instead of compiling a lengthy listing of processing errors, we will categorize the major sources of such errors as follows preparation of questionnaires, the data collection process, clerical handling of the forms, and processing of the data by clerks, analysts, and computers. Basically, these categories cover any processing problems from the printing of the questionnaires to the publication of survey results. Some processing errors affect the quality of the survey results directly (keying errors, for example), while others have indirect effects (poor printing on mailing labels, for example, which could lead to increased nonresponse). Generally, it is difficult to completely separate the effects of processing errors from the effects of nonresponse, responseerrors, and coverage problems. Moreover, the categories of processing errors used here are not intended to be mutually exclusive since interactions between processing activities can cause more errors. For convenience in the discussion it is assumed here that the sample design is correct and the both the questions being asked of respondents and their responses are correct for the purposes of the survey.

Questionnaires

Even after a draft questionnaire has been carefully field tested, errors can creep in during the final preparation and printing. For example, arrows indicating skip patterns or boxes for checking the appropriate response may be dropped; typographical errors may occur; or question and answer boxes may be poorly arranged, any of which can make it difficult for the respondent or interviewer to complete the form. Printing errors such as pale or smeared type may also decrease the response rate. These types of problems occur most often when a large number of similar forms must be prepared and printed at the same time, such as for the economic censuses for which a basic questionnaire is tailored to each of several hundred SIC categories. A few people must proofread and review a large number of questionnaires in a short time, leading to reviewer fatigue and errors. Any of the problems mentioned here can result in erroneous or missing data.

Data Collection Process

Many processing errors can occur during the actual collection of data from respondents whether the data are collected by mail, telephone, or personal visit. For example, errors in the preparation of mailing lists may lead to the wrong type of form being mailed to a respondent, or a telephone interviewer may not follow the questions on the questionnaire correctly. Even when data collection procedures are carefully spelled out, the following types of errors can occur: for mail surveys the form may be sent to the wrong location, or the form may be sent to an in appropriate person within the company. This may be lead to poor quality responses or nonresponses. For telephone or personal visit surveys the wrong unit may be called or visited; data may be collected from an inappropriate respondent; the interviewer may lead the respondent to a particular answer; the interviewer may second guess or assume answers; a question may be skipped; or the interviewer may probe in an inappropriate manner or may fail

*This paper reports research undertaken by a member of the Census Bureau's staff. The views expressed are attributable to the author and do not necessarily reflect those of the Census Bureau.

to probe.

In the case of the economic censuses a form is mailed to a company based on the SIC code for each establishment. If we have the wrong SIC code, an inappropriate form will be mailed and the form may then be discarded by the company as not applicable. Or the respondent may make an honest effort to respond on the form anyway without giving enough information to assign the correct SIC. So if the problem is not corrected, we will end up with no data for the correct SIC and possibly erroneous data for a wrong SIC.

The special difficulty associated with data collection errors is that the results are usually indistinguishable from nonresponse and response errors. The agency sponsoring a survey will not be able to distinguish a nonrespondent who chose not to respond from a nonrespondent who didn't receive a form because it was sent to the wrong location. Similarly, the survey taker can't separate true response error (that is, the respondent providing erroneous data) from erroneous data caused by an interviewer asking the wrong question. Because of this, the processing errors that occur during contacts with respondents are usually treated as though they were nonresponse or response errors and the steps taken to reduce response errors (such as computer assisted telephone interviewing) can also reduce these processing errors.

Clerical Handling of Forms

Many opportunities for mistakes that can affect the quality of survey data arise in the handling of the questionnaire forms. Before mailing, questionnaires may get sorted by company, SIC, geography, and zip code; and forms and instructions must be folded and stuffed into envelopes. Errors in these activities lead to nonresponse problems (which were discussed in detail in a previous section). After mail returns, envelopes are opened, and forms are checked in (clerically, by keying, or by bar code reading) and sorted. During all the shuffling, forms or instructions can be left out of a mailing piece; forms or parts of forms can get lost or damaged; and forms can be checked in more than once. These mistakes lead to nonresponse, duplicate response (from unnecessary nonresponse followup), lost data, and data stored under the wrong unit identifier.

The economic census processing includes several stages of clerical handling of the forms. The forms must be preprinted with addresses by form type, then sorted by identification number to collect all forms for one company together. When the forms are mailed back they are removed from envelopes, checked in by bar code reader, sorted by form type for keying, and resorted by identification number for later operations. These sorts offer ample opportunity for accidents such as separating (and losing) the back pages of a form from the front, or placing a form in the wrong order with the result that it can't be found when it is needed later.

Data Processing by Analysts and Clerks

Clerical and professional staffs are responsible for many activities that provide opportunities for mistakes that will affect the quality of the survey data. Many business survey questionnaires include questions requesting verbal responses, such as those used for classification of the establishment by SIC or type of business, which are subsequently coded by clerks. Most large establishment surveys have survey data entered into a computer by keying, and keyed data are edited in several ways. Records are reviewed for missing or inconsistent data; tabulated survey results are reviewed for possible errors; and data are sometimes imputed by analysts using information from callbacks to respondents or from other sources. Each of these activities provides opportunity for errors. Keying errors, in particular, affect survey results directly and can be very difficult to detect. Coding errors, such as assigning the wrong SIC, will not alter the accuracy of data on an individual record, but will cause inaccuracies in survey estimates. Analyst review of tabulations is a subjective activity at best and errors can occur either by overlooking erroneous results or by overediting results that were correct to begin with. Editing and imputation by analysts are also subjective activities with the same potential problems, with the addition of response errors (caused by interviewer errors) if contacts are made with respondents during editing. Analyst review of data for individual respondents is employed by many government surveys of establishments, in contrast to household surveys for which such review is uncommon. This comes from the larger influence on survey results that larger establishments have, thus requiring careful review of data for these larger establishments whereas in a household survey, all households are equally important for survey results, making review by analysts not cost effective for improving data quality. This is the case for the economic censuses for which many activities are conducted primarily for the largest establishments. In particular, callbacks for missing or inconsistent receipts data are made for the very large establishments, because the accuracy of the total receipts tabulation is most affected by their data. Very small companies, however, are unlikely to be contacted regarding edit failures, with very little effect in the tabulations if errors are not corrected.

The economic censuses use prior information about an establishment and a combination of prior and current information about industries as a whole for editing data from an individual establishment. For example, the ratio of payroll to receipts for an establishment is compared to an acceptable range for the ratio for the type of business. If the establishment's ratio falls outside the range, the data may be corrected (based on a callback if the establishment is large). For the most part, this editing leads to improvements in tabulations, but it is possible that for an individual establishment, the original data were correct and the edited version was wrong.

Data Processing by Computer

Many establishment surveys use computers for much of the processing, including editing,

imputation, tabulation or computation of estimates, and preparation of survey results for publication. Usually survey requirements are translated into specifications for use in the development of computer programs. Both the initial specifications and the resulting programs can alter the original survey plans, thereby leading to error in individual data records and final results. For example, many surveys use computer programs to perform extensive editing and imputation of individual records. Many ratios, such as payroll to employment, are computed and compared to industry standards. The sheer volume of computations to be programmed suggests that some ratios will be programmed incorrectly or some parameters for these ratios will be built into the programs incorrectly. Even the final tabulations of a census can be programmed incorrectly for example, aggregating data for the wrong establishments in a publication cell.

3. CONTROL OF PROCESSING ERROR

Various methods are employed in establishment surveys to control the effects of processing errors on survey results. The most common are standard quality control procedures. Acceptance sampling and process control methods are available for such well-defined and easily measured processes as envelope stuffing, clerical coding, and data keying. The economic census processing includes quality control for all major keying operations. More subjective processes, such as analyst review of edit failures, do not lend themselves easily to standard quality control methods. However, the processing of surveys is often designed to allow later processing stages to correct errors made in earlier stages. For example, in the processing of the economic censuses, the changes made during the analyst review of failed edit cases are reviewed by sending these cases through the computer edit program that failed the cases originally. While this is not a precise measure of the quality of the analyst review stage, it does serve to limit the errors introduced at this stage of processing.

Two other control procedures are commonly employed to control processing errors in establishment surveys. Interviewers in telephone surveys are usually monitored at least in a supervisory capacity and occasionally in a systematic quality control scheme. This serves to ensure that interviewers follow the prescribed procedures. Also, computer programs are commonly tested using test files (simulating problems in actual data files) to detect and correct most programming errors. Another technique sometimes used to control computer program errors is the review of the programming code by the staff that wrote the specifications.

4. MEASUREMENT OF PROCESSING ERROR

Indirect Techniques

Most large surveys requiring large processing staffs keep performance statistics during processing for supervisory or management purposes. For example, data keying error rates, usually produced from quality control checks, serve as a supervisory tool with keyers showing high error rates being retrained or removed from the operation. Edit failure rates produced during computer editing of survey data provide indications of the expected workload for analysts reviewing the rejected cases. Similarly, the rates of SIC reclassification provide estimates of the workload for other processes. These performance statistics indirectly measure the effects of processing errors on survey data. For the most part, performance statistics provide a count of errors rather than a measure of the effect of errors on data accuracy. For example, quality control procedures can provide an estimate of the percentage of data fields keyed in error, but do not measure the size of the errors included in the total value for a particular data item.

Direct Techniques

The effect of processing errors on data quality for establishment surveys is rarely measured directly. The opportunity for direct measurement is reduced by the fact that the effects of processing errors are mixed in with response, nonresponse, and coverage errors and cannot be measured separately. For example, in the case of nonresponse errors, it would be impractical to try to measure refusals to respond separately from nonresponse caused by forms mailed to the wrong address. Some special evaluation projects, however, have measured processing errors directly. For example, in the 1982 Economic Censuses, a study was conducted to measure the effect of each processing stage on census data by following the data values for a sample of establishments through the processing. (See U.S. Bureau of the Census, 1987.)

5. SUMMARY PROFILE

The results of the review, by the Subcommittee on Measurement of Quality in Establishment Surveys of 55 federal survey programs, of practices used to control processing errors are summarized in figures 1 and 2 (see reference Subcommittee..., 1988). Standard quality control procedures (process control or acceptance sampling) for data keying and the use of test files for computer programs were the most commonly used controls for the surveys reviewed by the Subcommittee. This is to be expected since keying is one of the easiest survey operations for which statistical quality control can be used, and the use of test files is common for programming in any context. About half of the surveys used quality control procedures for other activities, including printing, forms check-in, coding, and editing. It would be more appropriate for all surveys to use standard quality control procedures for any operations that are repetitive or follow specific guidelines or rules since the use of quality control can greatly reduce errors in these operations. In addition, any clerical operation that can be automated should be, since the opportunity for clerical error is then eliminated, such as automated check-in of forms used by more than half of the surveys.

About half of the surveys produce keying error rates, edit failure rates and imputation

rates which provide indirect measures of processing errors. A few surveys also produce coding error rates and reclassification rates. Almost all of these rates are produced for internal use only however. Some of these rates can be produced as routine output from quality control procedures, so if more surveys employ quality control techniques, more will obtain indirect measures of processing errors. Only one survey reported ever attempting to measure processing error directly. No indirect measures besides those included in the tables were reported. In summary, survey sponsors and survey takers reviewed by the subcommittee are getting relatively little information about their processing errors.

REFERENCES

Subcommittee on Measurement of Quality in Establishments Surveys, Federal Committee on Statistical Methodology, 1988. Measurement of Quality in Establishment Surveys. Washington, D.C.: Office of Management and Budget.

U.S. Bureau of the Census, 1987. 1982 Economic Censuses and Census of Government Evaluation Studies. Washington, D.C.: U.S. Department of Commerce.

Figure 1

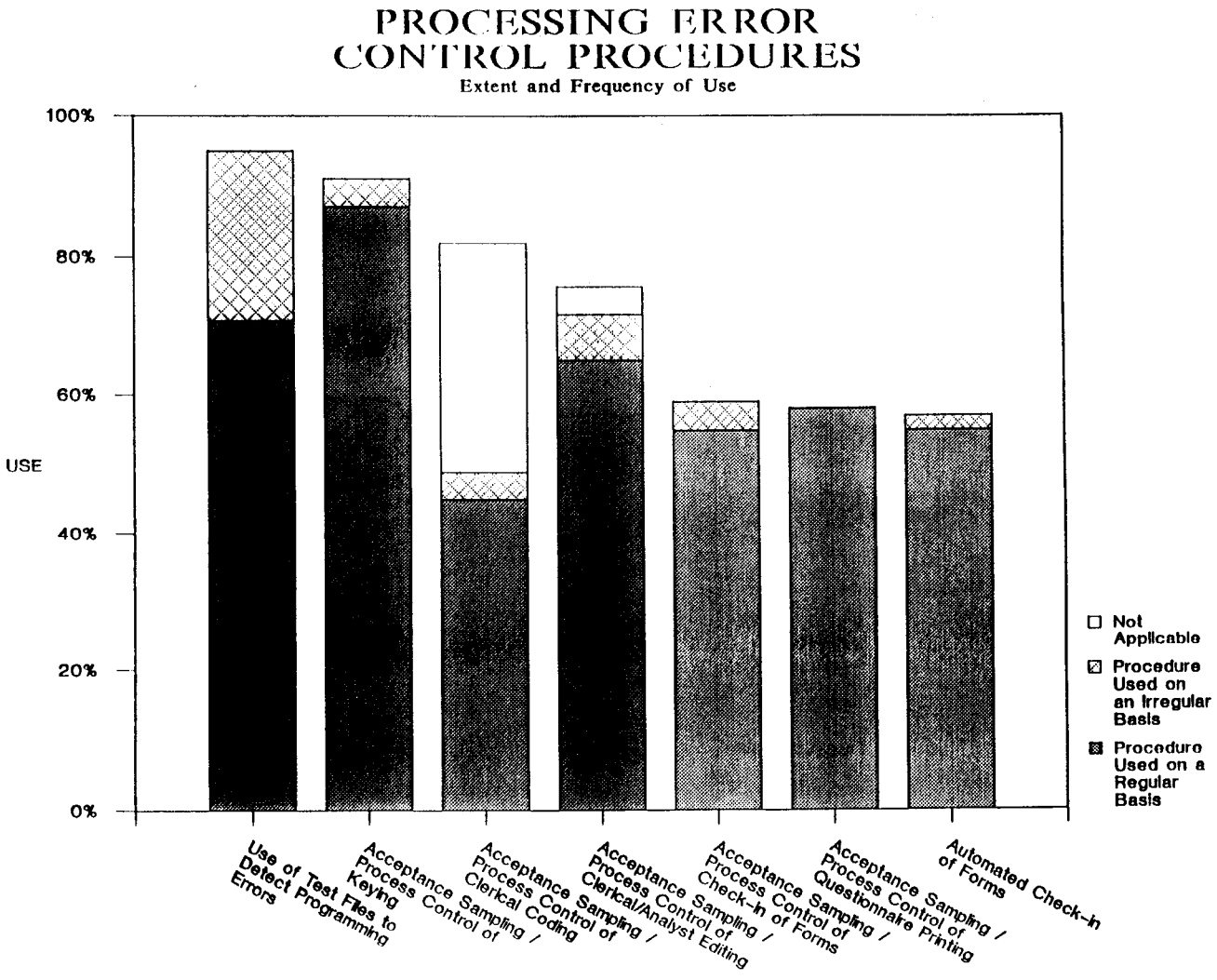

Figure 2

PROCESSING ERROR MEASUREMENT TECHNIQUES

Frequency and Application of Use