Reducing Nonsampling Error in the Bureau of Labor Statistics Occupational Compensation Surveys

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The Bureau of Labor Statistics (BLS) Occupational Compensation Surveys Program (OCSP) collects wage and salary data for 46 specific occupations and skill levels within those occupations. OCSP collects these data from private firms and State and local government offices, known as "establishments." The sample of establishments is taken from a sampling frame designed to represent a universe of non-farm private and State and local government establishments of 50 or more employees.[1] Because the Occupational Compensation surveys are designed to be locally as well as nationally representative, one can make inferences about the wage rates and earnings of workers in these specific occupations and labor markets.

In making inferences about any population based on a sample, one must take into account the degree to which estimates can be expected to differ from the true (population) values. This difference is called "total error," which is made up of two components: sampling and nonsampling error.[2] Sampling error is the error that arises from surveying less than the entire population. Nonsampling error includes all types of survey measurement error other than sampling error. Nonsampling error arises from sources throughout the planning and operations of a survey; each method and operation in a sample survey is a potential contributor to nonsampling error. The purpose of this paper is to identify the types of nonsampling error that can occur in the Occupational Compensation surveys and to describe OCSP methods to reduce nonsampling error.

Types of nonsampling error can be categorized into the following groups:

- specification errors,
- coverage errors,
- nonresponse errors,
- response (or measurement) errors,
- processing errors, and
- interpretation errors.

Specification error occurs when the data targeted for collection may not fully satisfy the objectives of the survey. Coverage error exists because some establishments are not included in the sampling frame. Nonresponse error occurs because some establishments refuse to participate in the survey. Measurement error arises during the data collection process; the wording of the collection instrument, errors made by the interviewer, errors made by the respondent, and the mode of data collection all contribute to measurement error. Processing error includes errors arising from clerical handling of the forms, data keying and other processing by analysts and clerks, and computer processing.[3] Finally, the way the data are interpreted by the end users can be considered a form of nonsampling error.[4]

There are many methods to reduce nonsampling error, for example, survey planners train their interviewers to word questions so that the information collected is of high quality and free from any influence the interviewer might exert on the respondent. They also train them in methods which increase response rates.[5] The OCSP employs

[1] The Occupational Compensation Surveys cover the 48 contiguous United States. For further information about the Occupational Compensation Surveys scope and methodology, see the Bureau of Labor Statistics Handbook of Methods, Bulletin 2414, Washington, DC, September 1992, pp. 42-67.

[2] For more discussion of the components of total error, see Groves, Robert M., Survey Errors and Survey Costs, Wiley Series in Probability and Mathematical Statistics, John Wiley and Sons, New York, 1989, p. 8.

[3] Specification, coverage, response, nonresponse, and processing error are defined and discussed in "Quality in Establishment Surveys," Statistical Policy Working Paper 15, prepared by the Subcommittee on Measurement of Quality in Establishment Surveys Federal Committee on Statistical Methodology, United States Office of Management and Budget, July 1988.

[4] Biemer, P.P., "Statistical Evaluation of Content Error" in Evaluating Censuses of Population and Housing, U.S. Bureau of the Census, Statistical Training Document, ISP-TR-5, 1985, Washington, DC, pp.65-6.

[5] Groves, Robert M., Survey Errors and Survey Costs, Wiley Series in Probability and Mathematical Statistics, John Wiley and Sons, New York, 1989, p. 4.

nonsampling error reduction methods in each step of the data collection and publication process. They are described in the sections below, in sequential order of their occurrence.

Specification of survey variables

Specification error occurs in the planning stage of a survey if variables targeted for collection do not meet the needs of the data users and do not fulfill the objectives of the survey. Data needs also change over time; for example, researchers may need appropriate data to study the economic impacts of emerging technologies and labor markets. OCSP reduces specification error by keeping in touch with data user interests and working toward meeting those needs.

OCSP pursues information on user interests from a variety of sources internal and external to the Bureau of Labor Statistics. For example, OCSP conducted test surveys to study the feasibility of collecting non-wage cash payments (bonuses) along with the regularly collected occupational wage data.[6] OCSP tracks of all of its data requests to see what types of data are most requested, including those types which they currently do not collect. The Bureau of Labor Statistics Office of Compensation and Working Conditions Quality Council has a Customer Needs Identification Team, whose title describes their work.

BLS hosts a number of user conferences to garner information from the general data user community. The Labor Research Advisory Council, consisting of representatives of labor unions, and the Business Research Advisory Council, consisting of professionals in labor and industrial relations, compensation, and human resources from large corporations, employer associations, and State and local governments, each meet two times per year to discuss emerging trends and data needs. These sources of information on data user needs help OCSP to revise its data collection objectives. In doing so, they help OCSP maintain the value of the database and reduce specification error.

Development of the sampling frame

[6] For more information see Dietz, Elizabeth, "Measuring Employee Bonuses: A Review of Test Surveys," Compensation and Working Conditions, Bureau of Labor Statistics, May 1994, pp. 13-19.

Deficiencies in the sampling frame can contribute to nonsampling error. Ideally, the target population and the sampled population should coincide. An incomplete or out-of-date sampling frame, deficiencies in administrative records, and processing errors are some of the things that can cause the sampling frame to fall short of the target population. The sources of the sampling frame should be current and include as many of the types of units targeted for the survey as possible. In producing a sampling frame from any list of establishments, errors can occur if:

- a proper establishment is omitted;
- an improper establishment is included;
- establishments are misclassified; or
- establishments are duplicated.

In an establishment based survey such as the OCSP, several sources are available for a sampling frame such as telephone listings, Unemployment Insurance (UI) records, business directories, and memberships in industry associations. OCSP compiles its universe data base (UDB), or sampling frame, from State Unemployment Insurance records for the 48 contiguous United States. The universe of State Unemployment Insurance records is a relatively complete and current source of business names and addresses. OCSP updates the universe database quarterly and extracts a new sample frame from this database for each full locality survey. Then OCSP refines the universe, removing all establishments that are out of scope, out of business, duplicated, or miscoded by State. When possible, field economists visit local Chambers of Commerce to identify new larger-sized firms moving into survey areas.

During this refinement process, OCSP reconfigures UI reporting units so that they conform to the establishment definition for the survey. During refinement, UI reporting units are sometimes combined or separated to conform to the OCSP establishment definition.

To make the most efficient use of survey dollars, OCSP seeks to maximize sample overlap from year to year. In doing so, it is important to recognize previous universe members. Because reporting changes for a particular unit may prevent it from being recognized as a prior reporting unit during an automated update process, a list of possible deaths (drops) from the previous universe is compared to a list of possible births (additions) for the current universe. This comparison is referred to as the "hand-match"

phase of refinement and ultimately helps in maintaining sample overlap.

The data collection process

Misunderstanding of survey questions could happen in any survey, but the complexity of the OCSP data objectives makes this a particular challenge. OCSP collects earnings data for a selected list of specific occupations. Field economists analyze the occupations found at survey establishments to see if they match the job descriptions in the OCSP occupational list. The OCSP occupational descriptions are based on duties and responsibilities; there are separate descriptions for each occupation and skill level within each occupation. Once a match has been made, the field economist collects wage rates, hours worked per week, and the number employed in each OCSP "matched" occupation.

It is a detailed, difficult, analytic process to match company jobs to OCSP's occupational descriptions. Establishment respondents may have their own perceptions of which jobs match OCSP definitions. The OCSP field economist must clearly convey information about OCSP job descriptions to receive specific, adequate information to determine a match between an company job and an OCSP job description. Field economists must carefully adhere to OCSP job matching criteria because inconsistent job matching practices will affect estimates.

OCSP requires that all field economists be certified in data collection procedures to insure that they make the best occupational matches possible. Certification requires that the field economist complete several performance-enrichment steps. The field economist must complete readings, training seminars, tests, and on-the-job training. Then they must demonstrate competency in independently organizing and completing at least six (6) establishment interviews. During these trials, regional survey managers observe field economists performing establishment interviews and give them feedback to improve their performance.

Wage data collected by personal visit are considered by collection and review staff to be more accurate and complete than data collected by mail or telephone interview.[7] Considering the relative

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[7] For information on OCSP test studies of telephone interview data quality compared to personal interview data quality, see James, Penny

complexity of the OCSP survey questions, data collection by personal visit has its advantages. "To the extent that a question requires deep cognitive processing, the quickened pace of telephone interviewing may induce superficial responses."[8] It is too costly, however, to make personal visits to all survey sample members. OCSP conducts personal interviews for all first-round surveys on a two- or three-year survey cycle. Interim surveys, those in the second and third years, are largely conducted by telephone or in some cases by mail.

Logistics is another reason why personal interview is preferred over other methods. Much of the survey wage data may be found in company personnel records. It is often helpful for the field economist to be present to review these records rather than to try to decipher the company's data over the telephone. Sometimes different types of information are kept in different locations, and with the field economist present, it is more likely that the respondent will follow through in locating the records during that visit. Company records, however, can be inaccurate. This is a source of nonsampling error that is hard to avoid, but it can be reduced if the field economist knows the company or industry well enough to ask the respondent to check further into the suspected incorrect data.

OCSP also employs several data collection policies to insure against built-in biases and to reduce nonsampling error in the data collection process. The field economist is not allowed to accept a response, for example, that "everyone received a five-percent raise" since the last interview. Even if all employees received a certain percentage above last year's wages, this doesn't account for possible increases in skill levels that accompanied the wage increases or for such salary changes as those dictated by length-of-service adjustments. OCSP requires that each occupation in each establishment be examined.

Micro-data review

Nonresponse error. Some establishments in the survey may not be reached during the collection period or respondents may refuse to respond to all or part of the questionnaire. During the first set of data processing edits, OCSP reweights the collected sample

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L., "Occupational Wage Survey Telephone Collection Study," unpublished, October 1992.
[8] Groves, Robert M., Survey Errors and Survey Costs, Wiley Series in Probability and Mathematical Statistics, John Wiley and Sons, New York, 1989, p. 514.

units within each sampling stratum to adjust for these nonresponding sample units.[9] Nationally, data were not available from 11.8 percent of the sample establishments, and an additional 6.8 percent of the sample establishments were either out-of-business or outside the scope of the survey. OCSP publishes locality nonresponse statistics in each of its locality bulletins and national nonresponse statistics in its national bulletins.

The nonresponse adjustment is designed to correct for response bias, but cannot always correct for it completely. The only data available are those of the respondents; when the data are reweighted, this reflects only the data of respondents. Since respondents may have different characteristics than nonrespondents, the sample may be weighted differently than it would be if it were to reflect the entire population.

If an establishment reports wage rates for less than 70 percent of its matchable workers, it is considered a nonresponding unit. If a unit reports wage data for 70 percent or more of all matchable workers, the missing data are considered "ignorable nonresponse," and no adjustment is made. Response bias can be considered a relatively minor problem, because pay data were unavailable for less than 2 percent of all matchable employees. Despite this, OCSP is considering approaches to reduce response bias through item imputation. (See section on "future directions.")

OCSP also makes efforts to reduce the number of refusals from the start. OCSP sends a letter announcing the upcoming survey and requesting the establishment's participation. If survey participation is refused, OCSP sends follow-up letters or makes a personal visit to persuade establishment officials to reconsider. OCSP trains its field economists in various sales techniques to foster participation. Field economists promote the wide variety of BLS data available as one of the selling points.

Data Access and Validation. OCSP has employed the Data Access and Validation (DAV) computer system, which automatically produces edit reports on questionable data. This helps the reviewer locate variable nonsampling error which originated in transcription, data entry, keying, coding, editing, and computer programming. DAV analyzes all

schedules[10] for internal or within-schedule consistency and also for external consistency.[11] Reviewers investigate these edit reports and make changes where necessary.

The DAV edit reports also help the reviewer locate nonsampling error originating from interviewer or respondent bias or cognitive problems with the questionnaire. Examples of this include out-of-range earnings, hours, and employment counts. For full and interim surveys in which the establishment has been interviewed by OCSP in the previous year, DAV edit reports compare employment counts, hours worked, and average wage rates for each occupation to those of the previous year. Depending on the metropolitan area being surveyed, about one-third to one-half of all establishment records require some form of data correction.

After any necessary DAV edit corrections have been made, every schedule is completely reviewed by an OCSP certified reviewer (see below). Often, the same individuals who reviewed the DAV results of a set of schedules review those same schedules by hand. The reviewers discuss the errors with the field economist for the purpose of continually improving their interview performance. This is one method of process improvement "feedback."

Reviewer certification. Every data reviewer must be certified. The review certification program includes a seminar on review procedures and guidelines. Also, a five-member panel reviews examples of the reviewers' completed work to assess whether their work shows good judgment and adherence to schedule review guidelines, thereby warranting their qualification for certification.

Structured schedule review. OCSP has developed a checklist for reviewers to follow as a means of standardizing review practices across all regions and among reviewers within regions. This has the effect of keeping the field economist to a standard set of procedures, thus standardizing the review function.

Sample Reconciliation. This process involves reconciling collected data with the sample to assure that all sample units are accounted for during collection. The database system developed for this purpose is called RECON. RECON helps monitor

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[9] No adjustment is necessary for establishments that dropped out of the sample because they were out-of-business or outside the scope of the survey. Also, no adjustments are made for seasonal businesses.

[10] Survey results for each establishment is known as a "schedule."
[11] Consistency between one schedule and all others.

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discrepancies between sampled and reported information, monitor the number of unusable schedules to assess the need for supplemental sample units, and perform automated nonresponse adjustment.

Macro-data review

Weighted schedule review. Once the data have been reweighted to adjust for nonresponse, OCSP runs a computer edit review of the aggregated, weighted data under an interactive computer system called "Variance Estimation and Photocomposition" (VEP). The reviewers look for outliers, or anomalies, and other data interrelationships in relation to those of the entire local area. The VEP report shows the change in the aggregate wage rates and occupational employment counts since the most recent locality survey. It also shows the percent impact each firm has on the aggregate data for each occupation in the locality. Data failing basic variance parameter requirements will be suppressed from publication.

Review of preliminary and final tables. OCSP performs preliminary and final table reviews to reduce processing error. After preliminary tables have been checked for consistency, final tables are checked for content, making sure that: BLS upholds its pledge of confidentiality; BLS statistical standards are met; data from dominant companies have been suppressed from publication; and data failing other publication criteria are suppressed.

Process Improvement Programs

Quality Assurance Program. To maintain each field economist's data collection expertise after the field economist receives data collection certification and on-the-job training, the regional offices conduct quality assurance reinterviews. The number of quality assurance reinterviews per field economist depends on the experience level of the field economist.

Each quality assurance reinterview is a complete reinterview. A highly experienced field economist or a survey manager conducts the reinterview. The reinterviewer compares the results of the reinterview with the results of the original interview and discusses the results with the original field economist. The reinterviewer reconciles any discrepancies with the original field economist and, on the basis of the reconciliation, corrects the original data in the parent survey. The original field economist

receives additional training for those errors that are consistently found.

Job Match Validation Program. The Job Match Validation (JMV) Program helps OCSP to measure and control nonsampling errors that occur during job matching. The JMV Program is a reliable quality measure of the initial job matching by field economists. The procedures of the program are designed to identify reasons and sources of the observed job matching differences/errors and to provide immediate feedback to field economists on the observed quality of their job matching efforts.

The JMV reviewer examines all reported information given for an establishment. On the basis of the examination, the JMV reviewer recontacts the respondent to verify only those job matches that are suspected of error. The JMV reviewer recontacts the establishment (the majority through telephone contact) to insure that the accuracy of the job match decisions reflect the OCSP occupation definitions, on the basis of duties and responsibilities of the job. The JMV reviewer discusses the results of the reinterview with the original collecting field economist and integrates any discrepancies into the parent survey data. The JMV results are tabulated, analyzed, and used to train data collection staff and to improve the OCSP data collection process. In the past, JMV results have been used to improve the OCSP field economist training program and to revise the job descriptions. Among OCSP areas surveyed, the JMV process typically results in data changes for less than ten percent of all sampled job match decisions. JMV results are published in the applicable locality bulletins.

National Audit Program. Because of workload and budgetary restrictions, not all OCSP surveys are studied in the JMV Program. In the absence of any reinterview surveys being conducted in those areas where JMV is impractical, the National Audit Program was constructed. The National Audit Program is less rigorous than the JMV Program and concentrates on actual data points collected, instead of actual decisions made by the collecting field economist. The overall utility of the National Audit Program results is limited.

Job Maintenance Team. This National-office team reviews all correspondence between field economists and reviewers regarding questions or need for clarification on job matches. The information is consolidated into a question-and-answer booklet which is supplementary to the job descriptions, and often

leads to changes in job descriptions or training programs. This team also conducts field research to determine when a job description has become obsolete or should be changed to better fit the job market.

Future Directions

Effectiveness of methods. OCSP data are subject to quality control measures at every step of production, from survey planning, to data collection, to publication. What have the results of these efforts been? OCSP nonsampling errors are expected to be relatively low due to high response rates, the extensive and continuous training of field economists, careful screening of data at several levels of review, periodic evaluations of job definition suitability, and thorough field testing of new or revised job definitions. To date, however, there has been no empirical study to measure the effectiveness of these methods to reduce nonsampling error in the OCSP data. As Groves notes, "reduction and measurement are preferable to either singly because measurement evaluates how successfully error was reduced."[12] To this end, OCSP is beginning to develop methods to measure review effectiveness using on-line information at each step of data processing and review. Programs will be developed to pull DAV and VEP on-line data to assess data quality throughout the review process.

OCSP is developing methods to build in checks to the data processing systems, as in their new PC laptop version of DAV. This system will have checks for data accuracy built in to the data entry system.

OCSP is also developing methods to check their data against that of other data sources. For instance, OCSP currently performs an on-going correlational analysis of regional refusal rates of the Current Population Survey as compared to OCSP data. This helps determine the number of refusals which can be attributed to OCSP's unique methodologies and which can be attributed solely to regional differences.

The future of the OCSP Process Improvement Team. In the next year, resources will be added in order to conduct more comprehensive and rigorous process evaluation and measurement studies. One of the goals of the team is to expand process improvement

study from data collection only to sample frame refinement, data collection, and micro-data and macro-data review. In addition, the team is planning to convert the cases done under National Audit to the JMV process.

The development of an expert job matching system. BLS is currently developing an expert system to aid in job matching. Expert systems are computer software "heuristics," or rules of thumb, which mimic human decision-making processes. Expert systems are especially adapted for mapping out decision making processes when large amounts of specialized knowledge are required, as is the case with OCSP job matching.[13] BLS cognitive researchers are working with OCSP field economists (job matching experts) and data review staff to encode their expertise into rules in the expert system. The expert system will be loaded into laptop computers and will consist of a series of questions to prompt the field economist about the establishment and specific positions at that establishment to determine the most likely OCSP matches.

The expert job matching system will assist field economists and review staff by providing a consistent set of decision criteria by which all job matches are made. This may lead to lower variation in reported wage data. It can also streamline the review process by reducing the number of errors entered into the system. The expert system can provide field economists-in-training a useful training tool, guiding them through a series of job-match decisions with help screens and automated exercises.

Reducing nonresponse bias through imputation. OCSP hopes to reduce nonresponse bias by imputing data for establishments reporting wages for some matched occupations but refusing to report wages of others. SMG is currently considering various approaches to item imputation, such as the "hot deck" method. Missing wage data may be imputed based on locality, industry, and size of establishments similar to those refusing to report the data.

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[12] Groves, Robert M., Survey Errors and Survey Costs, Wiley Series in Probability and Mathematical Statistics, John Wiley and Sons, New York, 1989, pp. 4-5.

[13] For more information on expert systems, see, Peter Jackson, Introduction to Expert Systems, Second Ed. (Reading, MA: Addison-Wesley Publishing Company, 1990); Eugene Charniak and Drew McDermott, Introduction to Artificial Intelligence (Reading, MA: Addison-Wesley Publishing Company, 1985), pp. 437-40; John R. Anderson, Cognitive Psychology and Its Implications (New York: W.H. Freeman and Company, 1990); and Richard V. Kelly, Jr., Practical Knowledge Engineering (Bedford, MA: Digital Press, 1991).