DEPENDENT VERSUS INDEPENDENT VERIFICATION

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Introduction

Human error is a part of any human process. To prevent a deterioration in quality, verification schemes have long been used as a means of checking on the truth or accuracy of the various elements that make up that process.

This paper discusses one such verification process, that being the verification of the coding of Industry and Occupation responses obtained in the Current Population Survey (CPS), a survey carried out monthly to primarily obtain estimates of labor force characteristics of our changing population. More precisely, the paper will compare and discuss two verification schemes, a dependent scheme and an independent scheme, which were carried out simultaneously for a period of ten months on the CPS Industry and Occupation coding operation. Based on the analysis of these two schemes, it was concluded that the independent is the better verification scheme to use on the CPS Industry and Occupation data. Consideration was given to timing, bias, record keeping, costs, etc., in attempting to arrive at the optimum scheme. Before dependent and independent verification can be discussed, each term should be defined:

Dependent Verification - A "verifier" reviews an Occupation or Industry code previously assigned by a producer -- with the verifier having complete knowledge of the producer-assigned code.

<u>Independent Verification</u> - At least one other person assigns an Occupation or Industry code without prior knowledge of what was done by the producer and the outcomes are compared.

Until recent years, most quality control programs used the dependent verification process for inspection. The verifier could be influenced by the work of the original producer; thus, many times the verifier failed to identify a substantial proportion of defective items. The corrector of rejected work could also be influenced by work initially done by the producer as well as changes made by the verifier. In most theoretical plans that were dependent in nature, the assumption was made that inspection was carried out with little or no error. A review of data from several coding operations has shown this assumption to be invalid.

In quality programs where it was suspected that dependent inspection might fail to uncover a substantial proportion of defectives, independent verification has been used. Two schemes that have been used are: (1) three independent codings with majority rule, and (2) two independent codings with adjudication of differences. With the majority rule device, three sets of independently produced items were compared and the code assigned by two out of three coders was considered the correct code. Studies indicate that when a particular item was assigned a code independently by three equally qualified coders, it was highly unlikely that codes in agreement were incorrect. $\underline{1}/$

In the two-way system, an independently precoded item was matched to the production coder entry, and agreements were accepted as correct. Disagreements were sent to an adjudicator who decided whether the precoder was incorrect, the coder was incorrect, or both were incorrect. This latter plan is not discussed within the context of this paper.

The attached chart shows some of the advantages and disadvantages that should be considered in selecting either a dependent or an independent verification scheme.

Background

The Census Bureau has conducted the CPS monthly since 1942. The Industry and Occupation (I&O) data is collected to reflect employment trends, unemployment rates, occupation mobility and other labor force data for the various industries and occupations throughout the country.

Labor force questions are asked with reference to the week containing the 12th day of the month. Hence, the survey is conducted during the week following the week containing this 12th day. Results of the survey for a particular month must be released to the public on the first Friday of the following month. This time-frame allows eight working days to assign approximately 75,000 I&O codes, with small amounts of the work early in the period and large amounts late in the period. This coding is performed at the Census Bureau's Jeffersonville, Indiana facility.

Below is a facsimile of the I&O questions on the CPS questionnaire from which the basic I&O information for an individual is obtained. This information, along with the type of ownership of the industry, listings of the large companies for the individual's geographic location, and the respondent's age, sex and education provide the basis for assigning the I&O codes.

23. C 23 A.	ESCRIPTION OF JOB OR BUSINESS For whan did work? (Name of company, basiness, organization of other amployer)
238.	When kind of business or industry is this? (For example: TV and radio m(g., resail choir cours, State Labor Dept., fam.
23C.	Most kind of work was doing? (For example - alactical engineer, asack clork, typics, former.)
23D.	What were "a most important activities or dution" (For example: opper, beeps account books, files, solls cars.

^{1/} U. S. Bureau of the Census, <u>United States</u> <u>Censuses of Population and Housing, 1960:</u> <u>Quality Control of Preparatory Operations,</u> <u>Microfilming, and Coding</u>, Washington, D. C., <u>1965</u>, p. 33.

Historically, there has been some type of industry coding at the Census Bureau since the 1850 Decennial Census. A method of occupation coding was introduced in the 1910 Decennial Census. The three-digit industry and the three-digit occupation codes currently used by the Bureau have been in use since 1960, with additional codes being added for the 1970 Census. Before the 1960 Decennial Census, dependent verification was used to control the quality of the I&O coding at the Bureau. Then, prior to the 1960 Decennial Census, a study was conducted to determine the number of coders required to successfully employ an independent system. This study, in which five different people coded the same items, showed that a three-way match provided the correct code with sufficient accuracy when the three persons were equally qualified.2/

Thus, for the first time in I&O coding, an independent plan with a three-way match was employed in the 1960 Census. Subsequently, independent plans were used for the 1970 Decennial Census, the 1970 Current Employment Survey, and the 1973-1974 Consumer Expenditure Survey. Estimated error rates on these surveys ranged from 2.7 percent to 8.9 percent. However, these error rates cannot be realistically compared to CPS or to each other as each coding requirement and group of coders differed.

CPS Verification Plans

From August 1942 to September 1975 the CPS I&O coding was verified on a dependent basis. In 1967 the coding operation was transferred from Washington to the Census Processing Office in Jeffersonville, Indiana. From this point until the independent plan was instituted, the qualification level was 1.0 percent on a code-pair basis with no verification of documents containing referral codes. A referral code occurs whenever specified in the coding manual or whenever a coder decides that he/she cannot give the item a specific code. Referrals are forwarded to a specialized group of coders. The observed error rates during this time were consistently less than 1.0 percent. Based on a review of data from the 1973-1974 Consumer Expenditure Survey, this error rate would have been estimated at 1.0 to 2.0 percent on an individual code basis.

A small pilot study was carried out to develop and test the necessary computer programs and to determine the costs of the clerical operations for an independent verification scheme. Although the test did not contain a representative sample of the qualified CPS I&O coders and did not contain any documents that were referred, the test did give some feeling for costs of an independent verification program and some idea of the size of the error rates for production coders. This study showed the error rate level to be around 3.0 percent, which was higher than the dependently derived error rate of 1.0 percent stated above. In late 1974, personnel from several divisions within the Bureau jointly designed an independent verification system for the industry and occupation coding operation. Because of the short timeframe allowed by the constraints of the CPS operation, the verification was designed as a postsurvey operation. Therefore, the verification plan is necessarily a process control type plan rather than a lot acceptance sampling plan.

With this plan, feedback of errors cannot be given during a particular month of coding but rather it is given prior to the CPS coding for the next month. It was felt that this would not be a drawback because the majority of the coders had been coding industry and occupation for several years. Rapid feedback is of primary importance when a coder initially begins an operation.

Rather than concentrate on the feedback tool, it was felt that the entire training package should be reviewed and revised. A larger test deck of responses with their respective codes was devised for use in training new coders and those coders that require retraining. A review was made of the training instructions and coding instructions to determine what revisions might be made to eliminate ambiguity in these materials. Because many of the current coders had been on the job for several years, it was felt that they had probably attained their accuracy level and the greatest impact could be made on any newly hired coders.

The independent verification plan was designed as follows: a 10 percent sample of each coder's work is systematically selected throughout the coding operation. These CPS documents are kept separate from all other documents. Also included in the sample are 10 percent of the referral cases. As soon as enough sample documents have been accumulated, these documents are sent to microfilming operations as a unique work unit. Such work units are identified by a range of identification numbers set aside for the QC sample documents.

Following production microfilming, the QC sample work units are microfilmed again. Paper copies are generated from the microfilm with the coded areas masked so that the subsequent coding can be done independently. Each work unit is coded twice by the regular CPS coders with care taken that no coder codes the same document twice.

The two independent codings are done on FOSDICreadable sheets that are microfilmed and read via FOSDIC equipment (the Census Bureau's film optical reading equipment). A computer match by document serial number and person number is made and the particular codes are matched. If there is a three-way agreement in code, the code is considered correct and no error is assigned. Similarly, if all three codes differ, the response is said to be vague, no code is said to be better than another and no error is assigned. However, when two of the codes agree and a third code disagrees, the two codes in agreement are said to be correct and an error is assigned to

^{2/} This study, conducted in 1959, was not published and is only in tabular form.

the person assigning the differing code (including referrals).

Coders are considered to be qualified as long as their error rates remain less than 7.5 percent, and their work is verified only via the independent system. When a coder becomes disqualified, in addition to the independent verification, dependent verification is performed in the nonsample work to assure that no poor quality work is released. As soon as the error rate is brought back within reasonable limits, the dependent verification is dropped.

Another change made in the new system is the definition of an item of error: each three-digit occupation code and each three-digit industry code is unique. In the past system, because of the relationship between some codes (e.g., a fireman for the railroad industry receives the occupation code 456, while a fireman in the mining industry receives an occupation code of 452), the two three-digit codes were linked and the unit item was defined to be the entire six-digit industry and occupation code. This was changed because it was felt that, in some cases, errors could be camouflaged by the use of the six-digit definition. It should be noted that this change should only serve to decrease the effective error rate.

The early results of the independent plan show the error rate to be considerably higher than shown by the dependent plan (6 percent versus less than 1 percent). While the error rate is 4.5 percent when the coder assigns a code, the coders are erroneously referring items approximately 15 percent of the time. While this error does not directly give an erroneous code, it does cause increased burden upon the referralists, and was therefore defined as an error. At the present time, approximately 13 percent of the I&O items are referred, of which one-seventh should not have been.

One feature of the independent plan is the utilization of the Bureau's FOSDIC and computer facilities for matching purposes. The FOSDIC equipment has a very low misread rate and the computer no-match rate is low (1.5 percent). Though there are no estimates for a manual matching operation, it is expected to be low also. Utilization of the computer also allows the compilation of numerous summary tables for use in decision-making. This tabular capability also allows the pinpointing of problem codes.

It is felt that the inclusion of the referral cases provides a more complete evaluation of a coder's error rate. No provision is made for estimating the quality of the codes assigned by the referral pool; however, early results show that when the production coder gives a referral as a minority code, the referral pool assigns the same code as the two independent coders 75 percent of the time.

Contrary to expectations, the classification of a minority referral as an error has not decreased the referral rate; in fact, the referral rate for

documents has increased from the 20 percent level to around 25 percent. Thus, the desired decrease in referral rate has not occurred; this problem has not been fully dealt with and no reasons for the increase in referral rate come readily to mind.

Concurrent Verification

For a period of ten months, the industry and occupation coding operation for CPS was verified via both the dependent and the independent schemes. An initial 10 percent sample was selected for independent verification and dependent sample verification was performed on the remaining work. Records were maintained for each method of verification for the coders.

The average error rate for the dependent plan was 1.2 percent, while for the independent scheme it was 6.0 percent. These two error rates are significantly different at the 99 percent confidence level. A correlation coefficient was calculated to determine if there was a relationship between the two overall error rate estimates for a particular coder; it was found to be low (0.56). This can be partially ascribed to the difference in unit item definition for the two verification schemes and the exclusion of referral cases in the dependent scheme.

The error rate estimates for the independent plan, while somewhat higher than anticipated, were more in line with past experience. With the complexity and ambiguity within the I&O coding operation, it seems unrealistic that the error rate could have been below the 2 percent level. Therefore, it was decided that the independent verification plan gave a more credible estimate.

As the verification plans were utilized in a live, working operation rather than an evaluative atmosphere, no precise estimate of bias was derived. It was assumed that the dependent plan gave a downwardly biased estimate of the production coder error rate.

In regard to consistency, while the error rates for an individual coder fluctuated with the dependent verification scheme, "poor" coders consistently had high error rates and "good" coders consistently had low error rates in the independent scheme, however variable.

The costs for the independent verification plan were higher than for the dependent plan as the dependent plan was an integral part of the ongoing coding operation and had been for many years. However, it is felt that after the independent operation becomes smooth running, the costs for the independent operation, while probably still exceeding those of a dependent operation, will become more acceptable. Also, the institution of the use of the computer increased the cost.

Problems

The delay in the feedback of types of errors and error rates is an undesirable feature of the present independent verification plan for CPS. Due to the short processing time-frame there is no practical method of speeding up the timeliness of the feedback of results. The importance of timeliness of feedback must be weighed against the importance of accuracy and completeness of feedback.

A second problem arises in that, although coders are required to reach a qualification error level, the process control plan for qualified coders could permit a coder to perform substandard work for two months before an action is taken. However, due to the unreliability of the dependent plan, it would seem that little if any quality is lost due to independent verification.

During dependent verification the estimated coding error rates would have ranged between 1 and 2 percent on an individual code base. In independent verification this estimated error rate is approximately 5 percent on an individual code base. This is probably a result of the unreliability of dependent verification. Additionally, independent verification provides a measure of the percentage of codes incorrectly referred. There is no practical way to do this using a dependent plan.

Probably the most serious problem associated with independent verification is the increased cost. The hours expended to accomplish the independent verification increase the total hours expended by 30 percent. Due to the importance of the figures that are published, a reliable estimate of the outgoing error rate may justify this expense. In other surveys where the significance of the I&O statistics is secondary these costs may not be justified. One possible solution to this problem could be a reduction of the I&O coding sample.

Conclusions

While the independent verification plan as incorporated in the coding operation may be more expensive, more disruptive, and less timely than the old dependent plan, the new plan, as designed, gives a more credible estimate of the coders' error rates, gives a less biased estimate, and gives an estimate which is more consistent with those derived in other industry and occupation coding operations.

Further research is needed in verification plans for all coding operations, not just for CPS. Feedback is essential to any coding operation and the problems are intensified in a postoperation such as the independent QC scheme for CPS. Research is needed to derive new or better methods for giving information back to coders concerning errors found in the work. Notification of errors is a natural aid in the constant education process.

Another area where research is needed is in the area of the referrals. Specifically, research is desired in deriving a method of evaluating the referral pool, a specialized group. Since the referral cases are necessarily ambiguous and difficult to code, the setting of quality standards should also be studied.

In conclusion, past experience at the Census Bureau has shown that independent verification is a more reliable and realistic estimator of quality. Although operationally less efficient, more work is necessary to develop an independent verification scheme that is practical to carry out and less costly to maintain. The independent verification plan utilized for CPS industry and occupation coding is the Bureau's first step in such an effort.

Advantages/Disadvantages of an Independent Verification Plan Versus a Dependent Verification Plan

Item	Independent Plan	Dependent Plan
Bias	 Objective Verification Usually less biased since no one person's work is dependent upon another. 	 Subjective Verification History of some collusion Rectifier of rejected work units has history of missing many original errors.
Timeliness	Usually time consumingUsually disruptive to process	Usually quickerNot disruptive to process
Recordkeeping	 Usually more people upon whom records must be kept. 	 Requires little work if handled clerically.
Costs	 Usually more costly 	• Usually less costly
Overall Summary	 More expensive, more disruptive, and more time consuming; however, Less variable est. of errors Less biased; more credible 	 Less expensive, less disruptive, and less time consuming; however, More variable est. of errors More biased; less credible

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