

## MEASUREMENT OF DIFFERENT DESIGN EFFECTS

Shail Butani, Bureau of Labor Statistics; Lawrence Cahoon, Robert Fay, Donna Kostanich, Bureau of the Census  
Shail Butani, 2 Massachusetts Ave., NE Room 4985, Washington, D.C. 20212

Key Words: Ratio Adjustment, Compositing, Seasonal Adjustment

### I. Introduction

The Current Population Survey (CPS), the monthly labor force survey that the U.S. Bureau of the Census conducts for the U.S. Bureau of Labor Statistics (BLS), uses state probability samples (state-based design) totaling about 60,000 households. In January 1994, CPS interviewers began collecting data in an entirely computer-assisted environment, using a new questionnaire. Before introducing the new data collection method, the Census Bureau and BLS tested it on a separate national probability sample of 12,000 households. The results of this parallel survey (PS), which ran from July 1992 through December 1993, indicated that the CPS annual average unemployment rate would have been 0.45 percentage point higher in 1993 had the new data collection method been used. For a general discussion of the results, see the February 1994 *Employment and Earnings* (Bureau of Labor Statistics, 1994, Vol. 41, No. 2); for a more detailed discussion, see Polivka (1994).

The above difference of 0.45, however, provides an estimate of only the overall effect on a 1993 annual average basis. In this paper, we discuss the measurement of design differences between the PS and the CPS in January 1994 and subsequent months to better understand the transition effects that were not accounted for. We concentrate our analysis on the effects of: 1) differences in the proportion of households interviewed from centralized facilities; 2) use of 1990-based population controls, adjusted for census undercount, rather than 1980-based controls formerly used; 3) differences in ratio adjustment methods; 4) use of composite estimation to reduce variance; 5) seasonal adjustment; and 6) 1990-based population controls on variances.

In this paper, we first give a brief background on the redesign of the CPS; discuss the design differences between PS and CPS; present estimates of various design differences; compare the expected estimates to actual estimates for the early months of 1994, where possible; summarize our results; and state a topic for immediate future research. Due to space limitations, we give only estimates of effects for design differences on the national unemployment rate. For estimates of differences in design effects on several demographic groups and on employment-to-population ratio and civilian labor force estimates, see Kostanich and Cahoon (1994).

### II. Redesign of the CPS

The main objective of the CPS is to provide a "reliable" monthly estimate of the unemployment rate for the nation. Other goals include producing national monthly estimates on the number of persons employed, unemployed, and not in the labor force by various demographic groups and some sub-national estimates for regions and states. The CPS began in 1940. The questionnaire has remained essentially unchanged since the last redesign in 1967. The current design was undertaken to reflect changes which have taken place in the workforce and structure of American society, as well as to take advantage of changes and improvements in survey methods, such as computer-assisted data collection and questionnaire design that utilizes the theories of cognitive psychology. Further discussion of the questionnaire and mode of collection changes incorporated into the CPS in January 1994 can be found in three articles of the September 1993, *Monthly Labor Review*, "Overhauling the Current Population Survey."

### III. Design Differences Between CPS and PS

**General**--The sample design of the PS was based on the National Crime Victimization Survey. Like the CPS, the PS was a multistage probability sample in which large metropolitan areas are selected with certainty, and smaller primary sampling units are selected with probability proportional to size within strata. For the PS, strata were defined within the four regions, unlike the CPS strata that are defined within state. The sample size of the PS is about one-fifth (12,000 households) the size of the CPS. The reference period for the PS was the same as that of the CPS, that is, the week containing the 12th of the month and the data collection occurred the same week as the CPS. In the CPS, the households are interviewed for 4 consecutive months, drop out of the sample for the next 8 months, and are interviewed again for 4 consecutive months. Although the PS had the same rotation pattern as the CPS, it did not completely achieve this pattern until September 1993 due to the short phase-in period (Miller 1994). Consequently, we could not measure month-in-sample effect in the PS. In the following paragraphs, we state the design differences which we were able to measure and Table 1 highlights these differences.

**Centralization**--During the testing period, data for approximately 18 percent of the PS sample was collected from one of the two centralized facilities located in Hagerstown, Maryland, and Tucson, Arizona, as compared to 9 percent for the CPS. All

**data collected from the centralized facilities is through computer assisted telephone interviewing (CATI).** In January 1994, the new CPS was to have only 12.5 percent of the sample collected from the centralized facilities. As described below, test results indicated that centralization yields a higher unemployment rate. Thus, we measured what the effect would have been if we had only 12.5 percent of the PS sample interviewed from centralized facilities rather than 18 percent, as was the case with the PS. Current plans are to increase the centrally interviewed sample for the new CPS to about 18 percent during May and June of 1994.

Even though centralized interviewing has been used in the CPS since January 1989, it was only at the end of 1993 that some statistical evidence regarding the effect of only centralization became available. This is because in the old CPS the old paper and pencil questionnaire was just not administered from a centralized location, it was converted to and administered by a computerized version. In addition, the wording of the lead-in question "What were you doing most of last week?" was modified. In the facilities, the interviewers were instructed to offer only the response option "working or something else?". In the field, the interviewers were instructed to vary the response options "working or something else?", "keeping house or something else?", and "going to school or something else?"; according to the appearance, age, and sex of the respondent (Rothgeb 1994). In the old CPS, therefore, it was not possible to distinguish between the effect of centralization, computerization, and questionnaire.

In order to minimize any potential effects on official CPS estimates, the percent of sample cases interviewed from centralized facilities was purposely kept small. Over a period of 5 years, the percent of the CPS sample interviewed from centralized facilities gradually increased to the 9 percent level used in the 1993 CPS. An evaluation was conducted by randomly assigning sample housing units to test and control panels. The test panels were eligible to be interviewed from centralized facilities while the control panels were not eligible for centralized facilities (i.e., they were to be interviewed in the field or otherwise referred to as decentralized interviewing). Findings based on CPS data collected between January 1991 through December 1992 showed that centralized interviewing with a modified lead-in question produced an unemployment rate 0.8 percentage point higher than for the control or decentralized group (Shoemaker 1993). This measure is a combined effect of centralization, computerization, and questionnaire.

Based on the above results, the possibility of a centralization effect existed. The PS was, therefore, designed to facilitate the comparison of centralized versus decentralized interviewing. In the PS, many of

the confounding effects were eliminated. First, the exact same questionnaire was administered by the field interviewers (decentralized interviewing) and interviewers at the centralized facilities. Second, the comparisons of results were based only on data for month-in-sample two through four and six through eight households because data for them in field are mainly collected through computer-assisted interviewing by telephone, as is done from the centralized facilities; whereas, the data for month-in-sample one and five households are usually collected by personal visits (always decentralized). Still, one big confounding effect remained. This effect concerns those households that were in the test panel to be interviewed from the facilities but were sent to be interviewed in the field because the interviewers from the centralized facilities were unable to reach the respondents or households that were without telephones (these are called "recycles").

The sample sizes to measure the centralization effect in the PS were extremely small. The sample size for the centralized facilities (test group) had about 5,500 housing units per month and the sample size in the field (control group) had only 600 housing units per month. Because of these small sample sizes, the variability was too large to draw any conclusions until the test was complete in December 1993. In the PS, the unemployment rate for the test group (centralized facilities) was 1.1 percentage point higher than for the control group. This difference is marginally significant at the 90 percent confidence level (Kostanich 1994).

**1990 Population Controls**--In both the CPS and the PS, a second-stage ratio adjustment procedure was used. This procedure substantially reduces the variability of the estimates which are correlated with the population--particularly estimates of employment and civilian labor force. Additionally, the adjustment partially corrects for undercoverage for certain demographic groups, most notably black males. Under this procedure, the sample weights are adjusted to ensure that sample-based estimates of population match independent population controls for various groups of population described in the next paragraph. The overall difference in the unemployment rate between CPS and PS of 0.45 percentage point used independent population controls as projected forward from the 1980 decennial census. Beginning with the January 1994 CPS estimates, however, the independent population controls are projected from the 1990 decennial census, adjusted for undercount by the Post Enumeration Survey (PES). This effect was an important one to measure because of the differential change in the size of the population of various demographic groups.

**Differences in second-stage ratio adjustment**--The CPS population estimates are consistent with

independent sets of controls for: 1) 50 States and the District of Columbia; 2) 14 Hispanic and 5 non-Hispanic age-sex groups; and 3) 66 white, 42 black, and 10 other race-age-sex groups. As mentioned under general design differences, the PS was a national sample. It was, therefore, not possible to apply the controls at the state level. Additionally, the smaller sample size of the PS resulted in 559 national post-stratification cells (control categories 2 and 3) as compared to 600 for CPS. We examined the effect due to the lack of state controls and fewer national post-stratification cells on the estimates.

**Composite estimation**--In the CPS estimation process, a last step before seasonal adjustment is the use of a composite estimation procedure. The main reason for applying this procedure is to further reduce the variance, especially on estimates of month-to-month change. This reduction is achieved by taking advantage of the seventy-five percent overlap in the sample from one month to the next.

Additionally, the current composite estimator adjusts for month-in-sample bias of the old CPS. In the old CPS, the expected value of an estimate of the unemployment rate is higher for new participants (month-in-sample one) than the average unemployment rate for the entire sample. Similarly, those reentering the survey, month-in-sample five, have a higher unemployment rate than the average of participants for month-in-sample six, seven, and eight. It has been shown (Bailar 1975) that slight changes in the questionnaire can lead to significantly different month-in-sample bias. Because many changes were made to the questionnaire, the month-in-sample bias of the new CPS is likely to be different than the old CPS. It will, however, take a few years to determine the pattern of bias for the new CPS.

Because the composite estimator differentially weights the month-in-sample data, it changes the expected value of estimates relative to uncomposited estimates (after post-stratification or the application of the second-stage ratio adjustment). Because all comparisons made between the CPS and the PS are based on uncomposited estimates, we also examined the effect of compositing. In the new CPS, the compositing started with June 1994 data.

**Seasonal adjustment**--Because most users are interested in comparing seasonally adjusted unemployment rates, we also applied the CPS seasonal adjustment procedures (described in the next paragraph) and factors to the composited estimates from the PS and CPS. Thus, the final comparison to assess transitional effects between the CPS and PS was based on composited and seasonally adjusted estimates.

A seasonally adjusted national unemployment rate for CPS is produced by aggregating 12 independently

adjusted series. The component series are: agricultural employment, nonagricultural employment, and unemployment by four sex-age groups (men 20 years and over, women 20 years and over, men 16 to 19 years, and women 16 to 19 years). Eight of these series are seasonally adjusted using multiplicative factors; the other four use additive factors. The four additive series are nonagricultural men and women of age 16 to 19 years, and unemployed men and women of age 16 to 19 years. The seasonal adjustment factors are generated using X-11 ARIMA software and are given in the January 1994 issue of *Employment and Earnings* (Bureau of Labor Statistics, Vol. 41, No. 1). Each of these 12 series is separately adjusted for seasonal variation, and the resulting estimates are then aggregated to derive seasonally adjusted totals. The seasonally adjusted figure for the labor force is a sum of eight seasonally adjusted civilian employment components and four seasonally adjusted unemployment components. The overall unemployment rate is derived by dividing the resulting estimate of total unemployment by the estimate of the labor force.

**Variances**--Our final step was to examine the effect on variances for 1994 CPS estimates. In general, a standard error of an estimated level increases as the size of the estimate increases. Because the 1990-based population controls tend to increase the level of estimates, we compared standard errors on estimates based on 1980 population controls with those based on 1990 population controls. We did not, however, examine the effect from the redesign on variances.

#### IV. Estimates of various design differences

**General**--The 1993 annual average estimate of national unemployment rate using 1980-based population controls for PS was 7.26 percent, while that for CPS was 6.81 percent. Both of these are uncomposited estimates. This is an increase of 0.45 percentage point (Bureau of Labor Statistics, 1994, *Employment and Earnings*, Vol. 41, No. 2; Polivka 1994) under the new methodology. The estimated standard error on this increase is 0.17.

**Centralization**--To derive an estimate of this effect, we reweighted the PS data to reflect the proportion of centralized interviewing that was to occur in the January 1994 CPS (12.5 percent). The reweighting of the PS involved adjusting base weights within test (eligible for centralized interviewing) and control (not eligible for centralized interviewing) panels, and then performing the usual post-stratification using 1990-based population controls. Annual average estimates for 1993 from the reweighted PS were compared to those from the CPS which also used 1990-based population controls.

The reweighted PS gives an estimated unemployment rate of 7.29 compared to the original estimate of 7.37.

The difference between these unemployment rates is close to being significant at the 90 percent confidence level. Thus, the expected effect of 12.5 percent centralized interviewing rather than 18 percent in January 1994 is to reduce the measured difference in the national unemployment rate by 0.08 percentage point. In May and June 1994, the proportion of interviewing from centralized facilities in CPS will increase to about the percent in PS. By the end of June, we expect the centralization effect for the new CPS to be the same as measured in the PS.

**1990 Population controls**--The 1990-based population controls, adjusted for undercount, were applied at the second-stage ratio adjustment step to the monthly CPS and PS data for 1993. The 1990-based CPS estimate was 6.90 percent, yielding an increase of 0.10 percentage point from the 1980-based CPS estimate (6.90 vs. 6.81, the difference rounded to 0.10). The 1990-based PS estimate is 7.37 percent. The overall increase between PS and CPS based on 1990 population controls is, therefore, 0.47 (7.37 minus 6.90) percentage point as compared to 0.45 using 1980 population controls. Again, all of these estimates are uncomposited. Additional information on the effect of 1990-based population controls is given in the February 1994 *Employment and Earnings* (Bureau of Labor Statistics, 1994, Vol. 41, No. 2).

**Second-stage ratio adjustment**--To measure the effect of not having state controls and fewer national age/sex/race, and age/sex/ethnicity controls in PS, we reweighted the CPS estimates using the PS post stratification controls. The 1993 annual average estimate of national unemployment rate based on 1990 population controls for reweighted CPS was 6.89 percent as compared to 6.90 percent for CPS. This estimated difference of + 0.01 percentage point, is not statistically significant.

**Compositing**--To estimate the effect of compositing on the national unemployment rate based on 1990 population controls, both the PS and CPS estimates were composited with two different initial months. In one case, we initialized the composite with October 1992 data, in the other, with February 1993 data. In both instances, the composited estimate from PS was 0.06 percentage point lower on a 1993 annual average basis. For CPS, however, the composited estimate was 0.02 and 0.03 percentage point higher on a 1993 annual average basis. In either case, the difference from compositing is not statistically significant. Because the PS sample did not achieve 100 percent true month-in-sample until September 1993, we could not say in December whether the compositing in the new CPS would have the effect similar to PS or to the old CPS. As mentioned above, it will take a few years to determine the month-in-sample bias of the new CPS. In any event, the composite estimate has very little effect on the expected value of the national monthly

unemployment rate. This was examined extensively under a variety of bias and percentage change assumptions (Cantwell and Ernst 1993).

**Seasonal Adjustment**--As part of our research, we applied the same seasonal adjustment methods and factors to both the CPS and PS estimates based on 1990 population controls for each month of January 1993 through December 1993 data. The estimates for January 1993 were uncomposited while those from February 1993 onwards were composited. Our results indicate that the monthly difference in the estimates of unemployment rate between PS and CPS, after applying the seasonal adjustments was about the same as before the seasonal adjustment. We support this by noting that the seasonal adjustment moved the two series in the same direction by about the same absolute amount. As with rotation group bias, it will take several years before the seasonal pattern of the new CPS is formed.

**Variations**--Finally, we compared the standard errors based on 1990 population controls with those based on 1980 population controls for the CPS. The 1980-based standard errors were estimated using generalized variance functions that were derived from 1987 CPS replicate variances. The 1990-based standard errors were estimated using replication from 1993 CPS data post-stratified with 1990-based population controls. For the national monthly unemployment rate, the estimated standard error is about 6 percent larger (0.116 vs. 0.110) when 1990-based population controls were used. As mentioned earlier, we did not measure the increase in variance from the redesign.

## V. Comparison of Estimated and Actual Effects

**1990-Based population controls**--In January 1994, we applied both the 1990-based and the 1980-based controls to the CPS second stage ratio adjustment process. The difference was, as expected, 0.10 percentage point higher with the 1990 controls. That is 7.34 percent with 1990 controls vs. 7.23 with 1980 controls (the difference rounded to 0.10). It should be noted both of these estimates are uncomposited and not seasonally adjusted.

**Compositing**--Although the composite estimation procedure officially started with June 1994 data, we examined this effect with February through April 1994 data. The composite estimate was 0.06 percentage point lower than the uncomposited estimate for February. Similarly, it was lower by 0.05 and 0.04 percentage point if we had started it, respectively, with March and April data. In all three instances, both the uncomposited and composited estimates, not seasonally adjusted, rounded to the same tenth of a percentage point. For example, in February, the uncomposited unemployment rate was 7.14 percent while the composited estimate was 7.08 percent. For June 1994,

the composited estimate was lower by 0.02 percentage point.

## VI. Summary

**January through April**--Assuming additivity of effects and no change in the economy, the expected overall increase in the national unemployment rate for January through April 1994 was 0.50 percentage point. The components are:

Redesign (PS90 - CPS90)	= + 0.47
Centralization (12.5 % vs. 18 % sample)	= - 0.08
1990 population controls (CPS90 - CPS80)	= + 0.10
Fewer post-stratification cells	= + 0.01
<b>Total</b>	<b>= + 0.50</b>

Because these estimates are uncomposited and all the comparisons are based on uncomposited data, we need not account for the effect of compositing at this time.

**June and beyond**--The composite estimation procedure resumed with June 1994 data. Since the remaining five percent of the sample cases were added in the centralized facilities in May and June, the centralization adjustment is not necessary. Thus, the expected overall increase in the national unemployment rate, again assuming no change in the economy, from June and beyond is expected to be 0.52 percentage point. The components are:

Redesign (PS90 - CPS90)	= + 0.47
1990 population controls (CPS90 - CPS80)	= + 0.10
Fewer post-stratification cells	= + 0.01
Compositing effect	= - 0.06
	to +0.02
<b>Total</b>	<b>= + 0.52</b>
	to +0.60

In summary, we expected the overall difference, which takes into account design differences including 1990-based population controls, to be about 0.5 percentage point between the "old" and "new" CPS.

## VII. Future Research

At present, our biggest area of concern is the appropriateness of current seasonal adjustment factors. In the near future, staff at BLS and the U.S. Bureau of the Census will be investigating and researching alternative approaches to seasonally adjust CPS data.

**Acknowledgement:** The authors gratefully acknowledge the contributions of the following people:

Athar Malik, who provided computer programming support; and Tamela Elliott, who typed the paper.

## References

- Bailar, B. (1975), The Effects of Rotation Group Bias on Estimates from Panel Surveys, *Journal of the American Statistical Association*, 70, 23-30.
- U.S. Bureau of Labor Statistics (1993), Overhauling the Current Population Survey, *The Monthly Labor Review*, Vol. 116, No. 9, Washington, D.C., U.S. Department of Labor.
- U.S. Bureau of Labor Statistics (1994), *Employment and Earnings*, Vol. 41, No. 1, Washington, D.C., U.S. Department of Labor.
- U.S. Bureau of Labor Statistics (1994), *Employment and Earnings*, Vol. 41, No. 2, Washington, D.C., U.S. Department of Labor.
- Cantwell, Patrick J. and Ernst, Lawrence R. (1993), Short-Term Changes to the CPS Composite Estimator in January 1994, *Proceedings of the Section on Survey Research Methods*, American Statistical Association.
- Kostanich, Donna L. (1994), Mode Effects Analysis - Highlights. Mode Effects Analysis CPS Overlap Analysis Team Technical Report 3. U.S. Bureau of the Census, Washington, D.C. (unpublished)
- Kostanich, Donna L. and Cahoon, Lawrence (1994), Effect of Design Differences Between the Parallel Survey and New CPS, *CPS Bridge Team Technical Report 3*, U.S. Bureau of Labor Statistics, Washington, D.C. (unpublished)
- Miller, Stephen M. (1994), What Would the Unemployment Rate Have Been Had the Redesign Current Population Survey Been in Place from September 1992 to December 1993?: A Measurement Error Analysis. *CPS Bridge Team Technical Report 1*. U.S. Bureau of Labor Statistics, Washington, D.C. (unpublished)
- Polivka, Anne E. (1994), Comparisons of Labor Force Estimates for the Parallel Survey and the Current CPS. *Overlap Analysis Team Technical Report 1*. U.S. Bureau of Labor Statistics, Washington, D.C. (unpublished)
- Rothgeb, Jennifer M. (1994), Revision to the CPS Questionnaire Effect on Data Quality, *CPS Overlap Analysis Team Technical Report 2*, U.S. Bureau of the Census, Washington, D.C. (unpublished)
- Shoemaker, Harland H. (1993), Results from the Current Population Survey CATI Phase-In Project, *Proceedings of the Section on Survey Research Methods*, American Statistical Association.
- Tiller, Richard and Welch, Michael (1994), Predicting The National Unemployment Rate That The Old CPS Would Have Produced, *CPS Bridge Team Technical Report 2*, U.S. Bureau of Labor Statistics, Washington, D.C. (unpublished)

**Table 1 Sample Design for CPS and PS**

Component	Old CPS-93	PS-93	New CPS-94	Estimated Effect (New CPS vs PS)
<b>General:</b>				
Sample size	60,000	12,000	60,000	
Primary strata	within state	within region	within state	
<b>Data Collection Procedures:</b>				
Centralization (CATI)	9% <sup>1</sup>	18%	Jan-April 12.5% May 16% June 18%	-.08 -.03 -.00
Decentralization	paper and pencil	CATI <sup>2</sup> & CAPI <sup>3</sup>	CATI & CAPI	
<b>Post-stratification:</b>				
Population controls	1980 census	1980 census	1990 census (PES adjusted)	+ .10
Number of controls	600 National 51 States	559 National No States	600 National 51 States	+0.01
<b>Composite estimation</b>			Jan-May-- uncomposited June-onward-- composited	-.06 to +0.02
<b>Seasonal adjustment</b>	12 series	12 series	12 series	None <sup>4</sup>

<sup>1</sup> Wording of the lead-in question was modified (See Rothgeb).

<sup>2</sup> CATI - Computer-Assisted Telephone Interviewing

<sup>3</sup> CAPI - Computer-Assisted Personal Interviewing

<sup>4</sup> Seasonal factors of the old CPS may not be appropriate.