THE EFFECT OF THE FIRST STAGE RATIO ADJUSTMENT ON THE CURRENT POPULATION SURVEY

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Key Words: ratio adjustment, multistage sample, Current Population Survey

Introduction[1]

The Current Population Survey (CPS) is the primary source of labor force statistics for the United States. It uses a complex weighting system to lower the variance and reduce coverage errors in the estimates. There are three stages of weighting in the CPS. The so-called first-stage ratio adjustment (or first-stage factor) is designed to account for racial differences between sample and non-sample non-self-representing (NSR) primary sampling units (PSU). An NSR PSU is a geographic area that is subject to sampling because the population there is small, relative to other areas in the same state. They are grouped with other, similar NSR PSUs into strata. One NSR PSU is selected from each stratum. Self-representing PSUs have a large population and are automatically included in the CPS sample -- each one is its own stratum. They are not included in the calculation of the first-stage ratio adjustment. The second-stage ratio adjustment adjusts the weights to match updated state population controls as well as a number of national age, race, sex, and ethnicity controls. The composite weighting takes advantage of the repeating sample inherent in the design of the CPS, using month-in-sample to more finely adjust the weighting and estimates. For more details on CPS weighting, see CPS Technical Paper 63, Chapter 10 and Appendix I.

The first-stage factor for the 1990 CPS design was calculated using population counts taken from the 1990 decennial census. These are counts of the total population aged sixteen and over (16+), divided into race cells of black and non-black. In 1996 recalculation of the first-stage factors was necessary for the states where sample PSUs were dropped due to budget reductions. This recalculation used the same 1990 census population estimates used previously. Hence, the first-stage factors currently used by CPS are calculated using population counts from 1990.

The first-stage weighting adjustment factor is calculated using the following formula:

$$FS_{sj} = \frac{\sum_{i=1}^{n} C_{sij}}{\sum_{k=1}^{m} [\frac{1}{\pi_{sk}}](C_{skj})}$$

Where:

FS_{sj} = the first-stage factor for state s and race cell j (j=Black, Non-black).

C_{sij} = 1990 16+ census population for NSR PSU i in state s, race cell j.

C_{skj} = the 1990 16+ census population for NSR sample PSU k in state s, race cell j.

π_{sk} = 1990 probability of selection for NSR sample PSU k in state s.

n = total number of sample and nonsample NSR PSUs in state s.

m = number of sample NSR PSUs in state s.

In 31 states and the District of Columbia the race cells are collapsed and the first-stage factors set to 1. The race cells are collapsed if any of the following conditions is true:

1. There are fewer than four NSR PSUs in a state,
2. One of the factors is greater than 1.3,
3. One of the factors is less than 1/1.3 = .769230,

[1]This paper reports the results of research and analysis undertaken by Census Bureau staff. It has undergone a more limited review by the Census Bureau than its official publications. This report is released to inform interested parties and to encourage discussion.

4. There are fewer than ten expected interviews per month in a race cell in the state.

In this paper I examine two possible modifications to the first-stage factor:

1. With the introduction of second-stage and composite weighting, it is possible that the first-stage factor is redundant; therefore, we could simply drop the first-stage factor altogether.

2. The first-stage factors could be recalculated, based upon more recent population estimates.

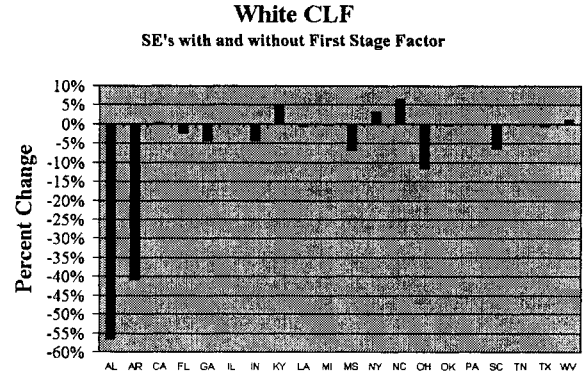
Variances with and without the First-Stage Factor

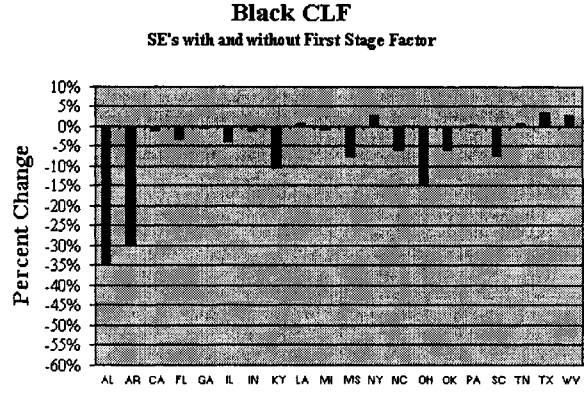
To look at whether the first-stage factor is giving its intended reduction in variance, I calculated the standard errors of some state-level estimates from CPS using VPLX, a variance estimation program developed at the Census Bureau by Robert Fay (1995). I used the modified half-sample method of calculating variances proposed by Kirk Wolter (1985) and extended by Robert Fay (1989). A limitation of this method is that the state sample size is not as large as the national sample sizes for which the method was originally designed. This might result in more variability among the standard errors. To overcome this limitation, I calculated standard errors for twelve distinct months, then looked at the mean of the differences between the separately calculated standard errors. For most of the states, the standard errors did not change very much when the first-stage factor was not used. There were some notable exceptions, however -- the loss in reliability appears to favor keeping the first-stage factor.

Using VPLX, I calculated the standard errors for civilian labor force (CLF) and unemployed (UE) for each state, both with and without the first-stage factor. Currently we calculate state standard errors for monthly estimates using the first and second stages of weighting, without using the composite estimator. My calculations ran the entire weighting process through the second-stage ratio adjustment, simply skipping the first-stage.

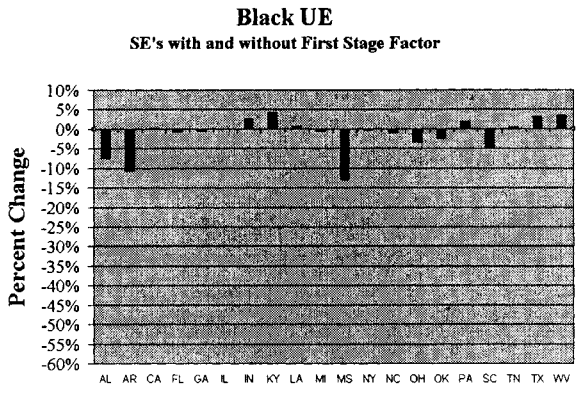
Since the first-stage factor adjusts for the black and non-black populations, it made sense to also look at the standard errors for the same characteristics for similar subpopulations. I did this for each month in 1997. I compared the standard errors that I had calculated with those already produced by subtracting my standard errors (without the factor) from previously calculated standard errors (with the factor) for corresponding estimates. **Negative numbers, therefore, favor keeping the first-stage factor** because the standard error without the first-stage factor is larger than the standard error with the factor; positive numbers or numbers close to zero favor getting rid of it. I also calculated the relative difference, dividing the difference in standard error by the original standard error, calculated with the first-stage factor.

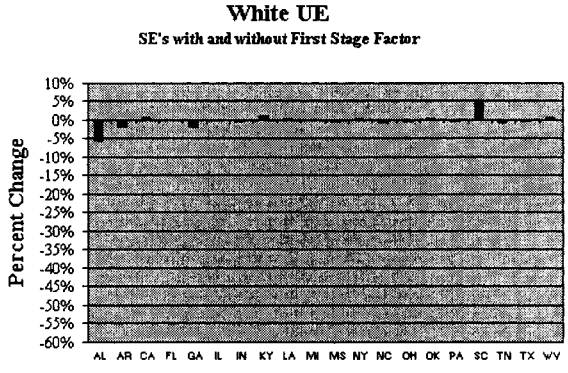
My results favor keeping the first-stage factor. Some standard errors actually decreased without the first-stage factor, but in some states standard errors increased substantially. For example, in Alabama, the standard error for the white population CLF increased 56 percent when the first-stage factor was omitted; for the black population, it went up 35 percent. By contrast, the greatest improvement in those categories was a decrease of only six percent.





The differences in standard errors for unemployed were not nearly so pronounced. The errors appeared to be adversely affected by the loss of the first-stage factor, but the largest difference was only 13 percent (Mississippi, Black population), as compared to the 56 percent difference mentioned above. Only one other difference was over 10 percent. (Charts on next page)





Because of the large increase in the standard errors for some states, the CPS needs to continue using the first-stage factor in addition to its other weighting adjustments.

Using New Population Estimates

Since the Population Division of the U.S. Census Bureau has begun releasing population estimates for each county in the nation annually, the first-stage factors could be recalculated annually or updated periodically. I did this using two types of population estimates from 1997. First, I used some estimates which roughly approximate the civilian noninstitutional population (CNP) age 16 and over. These estimates include the noninstitutional population and exclude military personnel living on military bases, but include military personnel living off-base. The CNP by definition excludes all military personnel. (The CNP is the target population for the CPS.) In addition, I also calculated the factors using updated total population 16+. I obtained these population estimates from the Population Division of the U.S. Census Bureau.

The factors for the non-black population show no major differences from the currently-used factors with either new set of population estimates. The largest difference between them and the factor we are currently using is less than 3 percent.

The factors for the black population, however, show more dramatic differences. Using 1997 total 16+ population estimates, there was only one major difference between the original and the new factors – in Pennsylvania. This was a result of a prison having been built in a sample NSR PSU in Pennsylvania. The resulting numbers would make it necessary to collapse the race cells for Pennsylvania, since the factor for the race cell is .6988, which is less than 1/1.3. With the CNP, because of the prison in Pennsylvania, the factor goes up to 1.471, which would also trigger collapsing -- but because the factor is above the limit, not below. (The factor we are currently using for Pennsylvania is 1.175.) Also using the CNP, the factor for California drops from .9282 to .6959 and the factor for Texas goes from 1.233 to 1.336, which are both outside of the acceptable range of 1/1.3 and 1.3. The factor in Illinois shows a twelve percent difference, but this is still within the acceptable range. The following table gives those states where the difference between **black** first-stage factors is more than 5%:

State	Current Factor	Factor based on 1997 Total 16+	Factor based on 1997 CNP
California	0.9282	0.984	0.6959
Florida	1.0778	1.0867	1.0156
Illinois	0.9667	0.9381	1.0908
Indiana	1.1672	1.177	1.2567
Pennsylvania	1.1754	0.6988	1.471
Texas	1.2328	1.2525	1.3363
West Virginia	1.2259	1.2012	1.1614

Using the method for calculating variances discussed earlier, I calculated the coefficients of variation (CVs) for monthly estimates in each state using first-stage factors for each of these scenarios:

1. CNP, removing the limits
2. CNP, collapsing when limits exceeded
3. Total population 16+, removing the limits
4. Total population 16+, collapsing when limits exceeded

I calculated these CVs for four attributes: black CLF and unemployed, and white CLF and unemployed. There are 23 states that either use the first-stage factor or would use it if the limits on the race cells were removed. So, for each set of population estimates there were four attributes

times 12 months times 23 states, or 1104 numbers for each set of estimates. I subtracted each of these CVs from those calculated using the old first-stage factors, and looked at the distribution of those numbers. Again, negative numbers favor keeping the status quo.

Mean Difference

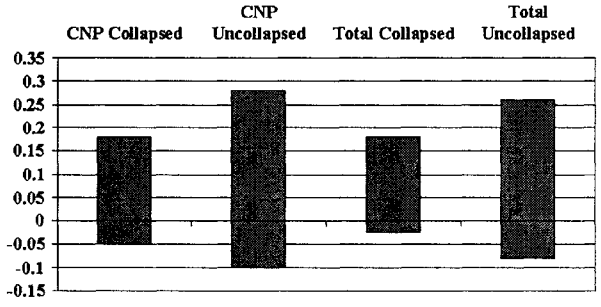
	Collapsed Race Cells	Uncollapsed Race Cells
1997 16+	0.203	0.345
1997 CNP 16+	0.192	0.340

Median Difference

	Collapsed Race Cells	Uncollapsed Race Cells
1997 16+	0.01	0.02
1997 CNP 16+	0.01	0.03

On average, then, the CVs are smaller when we use any set of updated population estimates. The interquartile ranges follow:

Interquartile Ranges



The interquartile ranges are skewed to the positive side as well. Note that the means are outside of the interquartile ranges, so there are clearly more or larger outliers to the positive side.

The uncollapsed race cells appear to improve the variance more than the decision on which set of population estimates to use. They introduce more variability, as well – which is to be expected, because that is why the limits were placed there in the first place.

There are three issues here:

1. Whether to use updated population estimates or the original census counts.

2. Whether to continue to use the total 16+ (either counts or estimates) or use estimates closer to the CNP 16+, which is the CPS target population.

3. Whether to use the same criteria to collapse race cells, specifically the 1.3 and 1/1.3 restriction.

Issue 1 – yes, we should be using updated population counts for the first-stage factor. Doing so will require extensive additions to the current CPS variance system, though, and may be difficult at this point in time. Also, if we use updated factors, then Issue 3 becomes very important.

Issue 2 -- There are large differences in the factors when we use the CNP 16+. If we are using counts from one population (Total 16+) to calculate estimates for a different population (CNP 16+), error is introduced into our estimates. Intuitively, if we can lower that error by using something closer to our target population, then we should probably do it. My research on this point, however, is inconclusive.

Issue 3 -- Only two states, Maryland and Hawaii, have fewer than four NSR PSUs (but not zero), so these are the only states affected by that restriction. States with no NSR PSUs have collapsed race cells as well. The restriction of ten expected interviews in each race cell in a state is a good one, for it eliminates states where the factor would have a large impact on the estimates. An area for further research might be to study this limit and see if it is indeed optimal. I have only considered the limits of 1.3 and 1/1.3.

The decision to remove the limits of 1.3 and 1/1.3 on the first-stage factor must be considered jointly with the decision on the population to be used in the calculations. Only one state, Pennsylvania, would be collapsed if we updated the factors using the total population 16+. However, if we use the CNP, then we lose the first-stage factor in Texas and California as well. We would not gain the first-stage factor in any state; all states previously containing collapsed race cells for this reason would still have collapsed race cells.

Conclusion

My research indicates that removing the first-stage factor from CPS is not feasible at this point because of the large increase in state variances for some labor force estimates in some states.

To improve the estimates using recent population estimates for the first-stage factors may be beneficial. Intuitively, the error will be lowered if we calculate weights based upon estimates closer to our target population. If we wish to use estimates that are closer to the CNP, then the changes in some estimates would be larger, but intuitively the errors would be lower. I believe we should use estimates closer to our target population, but my research on this point is inconclusive. It also appears that removing the limits of 1.3 and 1/1.3 on the first-stage factors may reduce the variance in some states.

Areas for Further Research

- The number of data points used and averaged could be expanded. Are twelve data points enough to make such a determination? An effort related to this might be checking to see how updated first-stage factors affect variance from one year to the next. In other words, calculate 1997 variances with 1996 population estimates which would be available, then see how it would change in 1998 when 1997 population estimates are used.

- National variances should be calculated for each of these different possibilities to ensure that the national reliability would not be adversely affected by a change.

- In addition to calculating the total variance for the states the Census Bureau calculates a within-PSU variance using a different method. Calculating these variances with the different first-stage factors would be useful in checking the results here. The first-stage factor is used to reduce between-PSU variance, which can be approximated by subtracting the within-PSU variance from the total variance. Is the improvement in variance part of the within-PSU variance or the between-PSU variance?

- Very little (if any) research has been done on the effect of non-sampling error on these estimates. No matter which set of population numbers we use, there will be some non-sampling error involved, whether from the age of the 1990 Census counts or the imperfections of the updated population estimates. Intuitively the updated population estimates should be better, but we have no research to back that up.

- As mentioned earlier, research could be done on the other factors which cause us to collapse the race cells in the first-stage factor, the number of NSR PSUs and the number of expected interviews in a race cell.

- Further research could be done on the limits of 1.3 and 1/1.3. In this paper I have considered them largely as a qualitative measure – it is possible that keeping the limits, but changing them (to, for instance, 1.5 and 1/1.5) would be beneficial to the reliability of the estimates.

Acknowledgements

I would like to thank Richard Griffiths for providing invaluable guidance in some of the statistical details of this research. I also need to thank Harland Shoemaker, who reviewed many drafts of this paper and never failed to provide useful, substantive comments.

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