The impact of Different Rotation Patterns on the Composite Estimator

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Abstract
One of key elements in the repeated sample design is the rotation pattern. High sampling overlap between periods reduces the sampling variance of estimates of period change and the degree of sample overlap between any two periods is determined by the rotation pattern design. Composite estimation is used in the rotation pattern design to reduce the variance of estimators. The aim of the paper is to determine an optimal rotation pattern by comparing the effect of different rotation patterns in terms of the variances, biases and mean square errors used as the performance criteria of monthly, month-to-month and year-to-year change of the composite estimators. The analysis based on the CPS data on different rotation patterns under study indicates that the variance, bias and the mean square error of the composite estimate under the 6-6-6 rotation pattern for all levels are lesser with small differences than those of estimates under any other rotation pattern. These differences compared to those under the 4-84 are so small that they do not strongly support the rotation pattern 6-6-6 performing better than any other specified rotation pattern, particularly, no better than the current 4-8-4 rotation pattern. This leads that 4-8-4 rotation pattern is preferable and can be retained.

Key Words: Current Population Survey, Rotation Pattern, Composite Estimator, Rotation Group Bias and Mean Square Error

1. Background

The Current Population Survey (CPS) is a monthly household survey conducted by the Bureau of the Census for the Bureau of Labor Statistics. Its primary purpose is to provide monthly labor force and related estimates for the total U.S. civilian noninstitutional population. The information on the employment status of respondents is collected by the interviewers from a sample of about 60,000 households located in 754 sample areas. Since its inception in 1940, the CPS has been the primary source of information on the unemployed, employed, and persons not in the labor force in the United States.

The CPS sample is a two-stage probability sample of housing units, covering the entire U.S. It is a rotation sample design. The sample is divided into eight subgroups called rotation groups. Eight panels or rotation groups, approximately equal in size, make up each monthly CPS sample. The sample for a month consists of eight rotation groups, divided in such a way that 1/8 of the sample is interviewed for the first time, 1/8 for the second time, …, and 1/8 for the eight time. The first interview is defined as the first month-in-sample (MIS 1), the second as the second month-in-sample (MIS 2), etc. The month-in-sample represents the number of months (including the current month) a rotation group in the sample. Sometimes the term 'time-in-sample' for 'month-in-sample' and are used through out the paper. A household whose address is selected for the sample is interviewed for four consecutive months, rotated out of the sample for eight months, and then interviewed for another four months before being retired from the sample. This is referred to as the 4-8-4 rotation pattern.

Labor force estimators used with the rotation designs are composite in nature and composite estimation can be used in a rotation design to decrease the variance of estimators of change in level. In order to take advantage of repeating sampling, they combine rotation group estimates obtained for the current month with those from prior months into a final estimator. In the previous study (Tagels and Cahoon), comparisons among different rotation patterns were made on the ratio estimator to determine the optimal rotation pattern, in this study we will concentrate our research on a composite estimator to determine the optimal rotation pattern for the CPS.

Rotation groups and their selection are discussed in Section 2. Section 3 discusses the sampling overlap and simulation of rotation patters. Section 4 discusses the ratio and the composite estimator, Section 5 discusses the variance and the covariance. The Biases of the composite estimators and their derivations are discussed in Section 6. A general discussion of results and Conclusion are included in Section 7.

2. **Rotation Patterns**

Rotation patterns in various types are used in many major household surveys. A general class of rotation patterns is defined by selecting units being included in the survey for ‘a’ consecutive months, removed for ‘b’ months and included again for an additional ‘a’ months. The pattern is repeated so that units are included for a total of ‘m’ occasions. These rotation schemes are denoted ‘a-b-a(m)’. The CPS uses 4-8-4(8) and Japan monthly labor force survey uses 2-10-2(4) rotation plans. Setting b=0 gives an in-for-m rotation pattern. The Canadian and Australian labor force surveys (LFS) use an in-for-6 and in-for-8 rotation patterns respectively. That is, Canadian includes selected units for six consecutive months and Australia to include them for eight consecutive months. British quarterly labor force survey uses 1-2-1(5) rotation plan.

Several considerations are taken into account in deciding upon a rotation scheme. High sampling overlap between consecutive periods reduces the sampling variance of estimates of change between periods and high sampling overlap between periods 12 months apart reduces the sampling variance of estimates of annual change.

The present 4-8-4 rotation pattern was chosen by CPS as optimal at a time when national estimates of month-to-month changes were the major goals of the CPS. However, since annual estimates become more reliable as there is less overlap among the monthly samples, it may be desirable to change the CPS rotation plan to one that has less month-to-month overlap, although some overlap is still necessary because national estimates of month-to-month change remain important. Since there is no year-to-year sampling overlap in Canadian and Australian LFSs and there is no month-to-month and year-to-year sampling overlap in British LFS, we will not consider the rotation patterns used by those countries in our study. In order to find a good rotation pattern, the rotation patterns 4-8-4(8), 3-9-3(6), 2-10-2(4), and 6-6-6(12) are taken into account as they give considerable overlap between samples a month-to month and a year to year, which improves the standard error of the estimates of change between these months. These rotation patterns are compared to each other by examining variances, biases of their composite estimators.

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3. **Data Simulation**

There are several ways we can simulate 3-9-3 rotation pattern data from 4-8-4 rotation data. For example, drop third and seventh month-in-sample's data and treat month-in-sample 1, 2, 4, 5, 6, 8 as month-in-sample 1, 2, 3, 4, 5, 6. Under the 3-9-3 rotation pattern a monthly sample of households is partitioned into 6 rotation groups and households in a particular group are interviewed for 3 months, dropped for 9 months and then interviewed for an additional 3 months. In simulating 2-10-2 rotation pattern data, drop third, fourth, seven and eighth month-in-sample's data and treat month-in-sample 1, 2, 5, 6 as 1, 2, 3, 4. Under the 2-10-2 rotation pattern a monthly sample of households is partitioned into 4 rotation groups and households in a particular group are interviewed for 2 months, dropped for 10 months and then interviewed for an additional 2 months. Similarly, under the 6-6-6 rotation pattern a monthly sample of households is partitioned into 6 rotation groups and households in a particular group are interviewed for 6 months, dropped for 6 months and then interviewed for an additional 6 months. All rotation patterns assume about the same sample size.

The 4-8-4 rotation pattern provides a 75 percent overlap in the sample each month and a 50 percent overlap in the sample each year for a given month. The 3-9-3 rotation pattern provides a 67 percent overlap in the sample each month and a 50 percent overlap in the sample each year for a given month. The 2-10-2 rotation pattern provides a 25 percent overlap in the sample each month and a 50 percent overlap in the sample each year for a given month. Similarly, the 6-6-6 rotation pattern provides a 83 percent overlap in the sample each month and a 50 percent overlap in the sample each year for a given month.

4. **Ratio and Composite Estimators**

For i=1,…,8, let $y_{h,i}$ be a labor force estimator of total unemployed for month h, computed using data from the i^{th} rotation group. That is, $y_{h,i}$ is eight times the sum of the sample weights, after raking, of respondents in the specified labor force category who completed their i^{th} interview in month h. Then the CPS ratio estimator for the labor force category is

$$y_h = \frac{1}{8}\sum_{i=1}^{8} y_{h,i} \tag{4.1}$$

The ratio estimator only uses data from the current month in estimation.

The CPS composite estimator for a given labor force characteristic is based on a weighted average of two estimators of the same characteristic: (1) the CPS ratio estimator and (2) the previous month's composite estimator plus an estimator of change from the preceding to the current month.

Because of the 4-8-4 rotation pattern, six of the eight rotation groups in the sample for month h-1 remain in sample for month h. Thus for i $\mathbf{i} \in \mathbf{S}$, where S={2,3,4,6,7,8}, positive correlation between $y_{h,i}$ and

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$y_{h-1,\mathbf{i}-1}$ serves to reduce the variance of estimates of change computed from these figures. So the change in the labor force characteristic since the previous month is estimated by

$$\Delta_h = \frac{1}{6}\sum_{i \in S}(y_{h,i} - y_{h-1,i-1})$$

In addition to the weighted average of the two estimates described above, the CPS composite estimate incorporates an adjustment that reduces variance while at the same time partially correcting for bias associated with month in sample. Results of past research have indicated that, for estimates of total unemployed, $E(y_{h,1})$ significantly exceeds $E(y_h)$ (Mansur and Shoemaker), and (Bailar). Early research indicates that adding a bias adjustment term that reduces both the variance of the composite estimator and the month in sample bias of CPS estimates (Breau and Ernst). The current bias adjustment term is based on the quantity

$$\beta_h = \frac{1}{8}(\sum_{i \notin S} y_{h,i} - \frac{1}{3}\sum_{i \in S} y_{h,i})$$

Which serves to reweight the estimates from the various rotation groups, assigning slightly more weight to data from persons completing their first or fifth interviews in month h. Note that if all the $y_{h,i}$'s had the same mean, β_h would have mean zero.

Incorporating both the weighted average and the bias adjustment term, the CPS composite estimator takes the form

$$\mathbf{y}''_h = (1-K)\mathbf{y}_h + K(\mathbf{y}''_{h-1} + \Delta_h) + A\hat{\beta}_h \qquad (4.2)$$

That is,

$$\begin{aligned} y''_h = \frac{1}{8}\{(1-K+A)(y_{h1}+y_5) + (1+K-\frac{A}{3})(y_{h2}+y_{h3}+ \\ y_{h4}+y_{h6}+y_{h7}+y_{h8})\} + K(y''_{h-1}+\frac{1}{6}(y_{h2}+y_{h3}+y_{h4}+ \qquad (4.3) \\ y_{h6}+y_{h7}+y_{h8}-(y_{h-1,1}+y_{h-1,2}+y_{h-1,3}+y_{h-1,5}+y_{h-1,6}+y_{h-1,7})) \end{aligned}$$

where A and K are constant coefficients between zero and one. The CPS composite estimator is often called an "AK estimator. Note that the coefficient K determines the weight, in the weighted average, of each of two estimators for the current month : (1) the current month's ratio estimator $\mathbf{y}_h$ (given a weight of 1-K) and (2) the sum of the previous month's composite estimator y'_h and an estimator Δ_h of the change since the previous month. The estimate of change is based on sample data common to months h and h-1. The coefficient A determines the weight of β_h, an adjustment term that reduces both the variance

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of the composite estimator and the bias associated with month in sample. Optimal values of the coefficients, however, depend on the correlation structure of the characteristic to be estimated. Research has shown that higher values of A and K result in more reliable estimates for employment level, because the ratio estimators for employment are more strongly correlated across time than those for unemployment. The composite weighting approach allows variation in compositing coefficients, thus improving the accuracy of labor force estimates. It is important to note that to determine appropriate values of K and A for CPS, minimize the mean square error of the resulting AK composite estimators. Currently, the estimator is applied with A=0.3 for unemployed and 0.4 for employed and K=0.4 for unemployed and 0.7 for employed.

5. Variance of Composite Estimator

Using five years (2007-2011) of CPS sample data, variance and covariance in this study are computed using a successive difference replication method. For each month, variances and covariances are estimated between all panels in sample for that month for the labor force (Unemployed) estimate.

The variance for the characteristic $\hat{\mathbf{y}}_0$ is:

$$\mathrm{Var}(\hat{\mathbf{y}}_0)=\frac{4}{160}\sum_{r=1}^{160}(\hat{\mathbf{y}}_r-\hat{\mathbf{y}}_0)^2 \qquad r=1,\ldots,160 \tag{5.1}$$

where $\hat{\mathbf{y}}_r$ is the rth replicate estimate and $\hat{\mathbf{y}}_0$ is the full sample estimate.

The replicate covariance estimates of each pair of months i and j is:

$$\mathrm{Cov}(\hat{\mathbf{y}}_i - \hat{\mathbf{y}}_j)=\frac{1}{160}\sum_{r=1}^{160}(\hat{\mathbf{y}}_{ir}-\hat{\mathbf{y}}_i)(\hat{\mathbf{y}}_{jr}-\hat{\mathbf{y}}_j) \tag{5.2}$$

where $\hat{\mathbf{y}}_{ir}$ is the rth replicate estimate and $\hat{\mathbf{y}}_i$ is the full sample estimate from month i.

The month-to-month change variance is:

$$\mathrm{Var}(\hat{\mathbf{y}}_1 - \hat{\mathbf{y}}_2)=\mathrm{Var}(\hat{\mathbf{y}}_1)+\mathrm{Var}(\hat{\mathbf{y}}_2)-2\rho^2\sqrt{\mathrm{Var}(\hat{\mathbf{y}}_1)*\mathrm{Var}(\hat{\mathbf{y}}_2)} \tag{5.3}$$

where $\hat{\mathbf{y}}_1$ is an estimate for month 1 and $\hat{\mathbf{y}}_2$ is an estimate for month 2. ρ is the correlation of the estimate between month 1 and month 2.

Note that var($\hat{\mathbf{y}}_1$) and var($\hat{\mathbf{y}}_2$) are approximately equal. That is, $\mathrm{var}(\hat{\mathbf{y}}) \approx \mathrm{var}(\hat{\mathbf{y}}_2)=\mathrm{var}(\hat{\mathbf{y}})$.

We write variance of change (5.3) as

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$$\mathrm{Var}(\hat{\mathbf{y}}_1 - \hat{\mathbf{y}}_2) = 2 * \mathrm{Var}(\hat{\mathbf{y}})(1-\rho^2) \qquad (5.4)$$

The aim of the paper is to determine which rotation pattern is preferable in reducing the variance of the composite estimator comparing to the variance of the ratio estimator. The preferable rotation pattern is one that has the smallest composite variance for the monthly, month-to-month and year-to-year change estimators among that of the specified rotation patterns (assuming same sample size in all rotation patterns). An early study shows that the variance of the composite estimator is generally less than the variance of the ratio estimator for estimating monthly level, month-to-month change and year-to-year change estimator (Huang and Ernst). Table 1 summarizes the effect of different rotation patterns by the given variable (Unemployed) and selected rotation patterns. The variance ratio (the ratio of the composite variance relative to the ratio estimate variance) is also given in the table.

In column 4 of Table 1, the variance ratio for monthly level is 0.97 under 4-8-4 rotation pattern, 0.98 under 3-9-3, 0.97 under 2-10-2 pattern and 0.95 under 6-6-6 rotation pattern. For the monthly level estimation, the reduction in the composite variance under the rotation pattern 6-6-6 (3.3 percent) is higher than that of other specified rotation patterns, but the optimum variance of 6-6-6 rotation pattern is very close to those variances of other rotation patterns, 3.2 percent for 4-8-4, 1.1 percent for 3-9-3, and 0.3 percent for 2-10-2.

Column 4 in Table 1 shows in general, increasing m (total number of months a unit is included in the survey) in the a-b-a(m=2a) rotation pattern decreases the variance of the monthly level estimates. For example, the rotation pattern 6-6-6(12) containing units that remain in the survey for a total of 12 months, time longer than units remain in the survey of any other rotation patterns has the lowest variance ratio. This leads the rotation pattern 6-6-6 performs best.

For month-to-month change estimation (in column 4 of Table 2), the variance reduction in composite estimate with respect to the ratio estimate under the 6-6-6 rotation pattern is much higher than that of any other specified rotation pattern. Column 4 in Table2 summarizes the effect of different rotation patterns for the month-to-month change estimates. The column shows that the month-to month overlap has tremendous effect on the rotation patterns. High sample overlap between consecutive periods reduces the sampling variance of estimates of change between periods. The 6-6-6 rotation pattern with a very high month-to-month sampling overlap (6.40 percent) provides the largest variance reduction and thus leads the rotation pattern to perform well.

Column 4 in Table 3 shows that for a year-to-year change, the 6-6-6 rotation pattern (7.2 percent) performs best and the second best performing rotation pattern is 3-9-3 (4.5 percent). The rotation pattern 6-6-6 in this case also performs well.

The small differences in variance reduction among rotation patterns are not enough evidence to say one rotation pattern performs better over any other selected rotation pattern, particularly the rotation pattern 6-6-6 over 4-8-4 rotation pattern.

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6. Rotation Group Bias

This section investigates biases of the composite estimator of different rotation patterns. Since all eight rotation groups are random samples of the population, they can be used to generate eight separate estimates of a population characteristic such as the number of unemployed. In principle, the estimates should differ only by a random error. In practice, though, the estimates from different rotation groups show sizable systematic differences. For example, several studies ((Mansur and Shoemaker), and (Bailar, 1975)) have found that the unemployment reported by the first rotation group tends to be about (8-10) percent higher than that reported by the full sample. Why responses vary with time is unknown. So for some characteristics, the estimates from the eight rotation groups relating to the same time-period do not have the same expected value. The most pronounced differences occurred between rotation groups in sample for the first time when compare to the average estimate from all rotation groups. Hence, it is worthwhile to investigate the bias and mean square error of the composite estimate under the 4-8-4 rotation plan and compare them with those of specified alternative rotation plans.

Let the population parameter μ_h, a true mean of a certain labor force (unemployed) characteristic in month h we want to estimate and let the ratio estimator for month h be denoted by $\mathbf{y}_h$, where $y_h = \frac{1}{8}\sum_{i=1}^{8} y_{hi}$ and y_{hi} is the contribution to the estimate for the rotation group which is in its i^{th} month in sample. If y_{hi} be the estimator of μ_h and if a_{hi} be the bias associated with the rotation group in its i^{th} time in the sample. Then,

$$a_{hi} = E(y_{hi}) - \mu_h \qquad (6.1)$$

Throughout this paper we will be assume that bias is independent of the month. That is,

$$a_{hi} = a_i \text{ for all h,}$$

These assumptions may not be completely valid (Bailar, 1979).

We have,

$$a_i = E(y_{hi}) - \mu_h \qquad (6.2)$$

Under this assumption, the expected values of the ratio estimator and composite estimator for level can be shown to be as follows:

For the 4-8-4 rotation pattern:

$$E(y_h) = E(\frac{1}{8}\sum_{i=1}^{8} y_{hi}) = \mu_h + \frac{1}{8}\sum_{\mathbf{i}=1}^{8} a_i\,, \qquad (6.3)$$

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The bias of the ratio estimator is $\sum_{i=1}^{8} a_i$. Note that with the assumption $a_{hi} = a_i$ for all h and based on the CPS data it can be seen that $\sum_{i=1}^{8} a_i$ =0. This leads to the ratio estimator is unbiased.

The expected value of the composite estimator defined in (4.3) for the 4-8-4 rotation pattern is

$$E(y''_h) = \mu_h + \frac{1}{8}\sum_{i=1}^{8} a_i + \frac{K}{6}(1-K)((a_4 + a_8) - (a_1 + a_5)) +$$
$$(\frac{A}{8}(1-K))((a_1 + a_5) - \frac{1}{3}(a_2 + a_3 + a_4 + a_6 + a_7 + a_8))$$

The bias of the composite estimate under 4-8-4 rotation pattern:

$$\text{Bias} = \frac{K}{6}(1-K)((a_4 + a_8) - (a_1 + a_5)) + (\frac{A}{8}(1-K))((a_1 + a_5) - \frac{1}{3}(a_2 + a_3 + a_4 + a_6 + a_7 + a_8)) \quad (6.4)$$

For the 3-9-3 rotation pattern:

$$E(y_h) = E(1/6\sum_{i=1}^{6} y_{hi}) = \mu_h + 1/6\sum_{i=1}^{6} a_i \ , \qquad (6.5)$$

$$E(y''_h) = \mu_h + (1/6)\sum_{i=1}^{6} a_i \ + (K/4(1-K))((a_3 + a_6) - (a_1 + a_4)) +$$
$$(A/6(1-K))((a1 + a_4) - 1/2(a_2 + a_3 + a_5 + a_6))$$

$$\text{Bias=}\begin{matrix} K/4(1-K)((a_3 + a_6) - (a_1 + a_4)) + (A/6(1-K))((a1 + a_4) \\ -1/2(a_2 + a_3 + a_5 + a_6)) \end{matrix} \qquad (6.6)$$

For the 2-10-2 rotation pattern:

$$E(y_h) = E((1/4)\sum_{i=1}^{4} y_{hi}) = \mu_h + (1/4)\sum_{i=1}^{4} a_i \ , \qquad (6.7)$$

$$E(y''_h) = \mu_h + (1/4)\sum_{i=1}^{4} a_i \ + (K/2(1-K))((a_2 + a_4) -$$
$$(a_1 + a_3)) + (A/4(1-K))((a_1 + a_3) - ((a_2 + a_4))$$

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$$\text{Bias} = \begin{matrix} K/2(1-K)((a_2+a_4)-(a_1+a_3)) + \\ (A/4(1-K))((a_1+a_3)-(a_2+a_4)) \end{matrix} \tag{6.8}$$

For the 6-6-6 rotation pattern:

$$E(y_h) = \mu_h + (1/12)\sum_{i=1}^{12} a_i \,, \tag{6.9}$$

$$E(y''_h) = \mu_h + (1/12)\sum_{i=1}^{12} a_i + (K/10(1-K))((a_6+a_{12})-(a_1+a_7)) +$$
$$(A/12(1-K))((a_1+a_7)-1/5(a_2+a_3+a_4+a_5+a_6+a_8+a_9+a_{10}+a_{11}+a_{12}))$$

$$\text{Bias}= \begin{matrix} (K/10(1-K))((a_6+a_{12})-(a_1+a_7)) + (A/12(1-K))((a_1+a_7) \\ -1/5(a_2+a_3+a_4+a_5+a_6+a_8+a_9+a_{10}+a_{11}+a_{12})) \end{matrix} \tag{6.10}$$

When estimating month-to-month change, though, the bias differences out so that

$E(y_h - y_{h-1}) = \mu_h - \mu_{h-1}$. That is, month-to-month change estimate is unbiased.

It can be shown that the corresponding expected value for year-to-year change is the same as for month-to-month change level.

6.1 Rotation Group Index

For the computational convenience, define the term 'rotation group index' which is the ratio of the expected value of the estimate based on the sample units in a particular month-in-sample group to the average of the expected value of the estimate from all eight groups combined, multiplied by 100 (Mansur and Harland). Let I_i be the rotation group index for its i^{th} month in sample, then

$$I_i = \frac{E(y_i)}{E(\sum_{i=1}^{8} y_i/8)} * 100, \quad i=1,\ldots, 8 \tag{6.11}$$

We estimate the bias a_i as follows:

For the 4-8-4 rotation pattern:

From (6.2), we have

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$$a_i = E(y_{hi}) - \mathbf{E}(\sum_{\mathbf{i}=1}^{8} \mathbf{y_i}/8) = \sum_{\mathbf{i}=1}^{8} \mathbf{y_i}/8)(\frac{E(y_{hi})}{\sum_{\mathbf{i}=1}^{8} \mathbf{y_i}/8)} - 1) \tag{6.12}$$

Using (6.11), the bias takes the form:

$$a_i = \sum_{j=1}^{8} \frac{\hat{y}_j}{8} \frac{(I_i - 100)}{100} \tag{6.13}$$

where, $\hat{y}_j$ = the average ratio estimate for its j^{th} month in sample for the given period. Note that the rotation group bias derived in this manner has the property that $\sum_{i=1}^{8} a_i = 0$

Thus, under the assumption that the bias a_{hi} for the i^{th} is constant over months, and $\sum_{i=1}^{8} a_i$ =0, (6.3) takes the form $E(y_h) = \mu_h + \frac{1}{8}\sum_{\mathbf{i}=1}^{8} a_i$ = μ_h. That is, under these assumptions, the ratio estimator of level is unbiased.

Similarly, for the 3-9-3 rotation pattern:

$$a_i = (\sum_{j=1}^{6} \hat{y}_j / 6)(I_i - 100)/100 \tag{4.17}$$

For the 2-10-2 rotation pattern:

$$a_i = (\sum_{j=1}^{4} \hat{y}_j / 4)(I_i - 100)/100 \tag{4.18}$$

For the 6-6-6 rotation pattern:

$$a_i = (\sum_{j=1}^{12} \hat{y}_j/12)(I_i - 100)/100 \tag{4.19}$$

Biases of composite estimators under different rotation patterns for estimating μ_h, are calculated and tabulated in Table 4. Results in column 3 of Table 4 show that biases of composite estimators under all rotation patterns are underestimates, and the absolute bias (973) under the 6-6-6 rotation pattern(column 4) is smaller than the bias of any other rotation pattern. Ratio of the mean square error (MSE) is also computed and tabulated in column 2 of Table 4. This shows that for the unemployed characteristic, the

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MSE ratio (the ratio of the MSEs of the composite and the ratio estimators) under the 6-6-6 rotation pattern is less than the MSE ratios of any other rotation patterns. Results indicate that the bias and the MSE ratio under the rotation pattern 6-6-6 are less than that of any other selected rotation patterns. Thus, from a bias and MSE standpoint, the 6-6-6 rotation pattern performs well.

7. Conclusions:

Our analysis indicates that the variance, bias and MSE of the characteristic (Unemployed) under the 6-6-6 rotation pattern are small for all three levels when compare to those under specified the rotation plans. This is due to the 6-6-6 rotation plan that has high sampling overlap between consecutive months and year-to- year change. The differences in the variance, bias and MSE are so small that do not give any strong indication to say one works better than other rotation pattern. Hence, the 4-8-4 rotation pattern is preferable to keep for the CPS.

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Table 1 : Variance Comparison of Monthly Estimates for Different Rotation Patterns

Rotation Pattern	Ratio Variance	Composite Variance	Variance Reduction
4-8-4	1.49E+10	1.44E+10	3.2%
3-9-3	1.65E+10	1.63E+10	1.1%
2-10-2	1.79E+10	1.79E+10	0.3%
6-6-6	1.75E+10	1.69E+10	3.3%

Table 2 : Variance Comparison of Month-to-Month Estimates for Different Rotation Patterns

Rotation Pattern	Ratio Variance	Composite Variance	Variance Reduction
4-8-4	6.27E+10	5.98E+10	4.7%
3-9-3	7.76E+10	7.43E+10	4.3%
2-10-2	1.19E+10	1.19E+10	0.10%
6-6-6	7.70E+10	7.21E+10	6.40%

Table 3 : Variance Comparison of Year-to-Year Change Estimates for Different Rotation Patterns

Rotation Pattern	Ratio Variance	Composite Variance	Variance Reduction
4-8-4	7.70E+10	7.39E+10	4.03%
3-9-3	1.11E+11	1.06E+11	4.50%
2-10-2	1.60E+11	1.56E+11	2.50%
6-6-6	9.84E+10	9.13E+10	7.22%

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Table 4: Bias Comparison of Rotation Patterns

Rotation Pattern	Mean Square Error	Bias	Absolute Bias
4-8-4	1.44E+10	-4910	4679
3-9-3	1.63E+10	-10158	3002
2-10-2	1.79E+10	-13399	4499
6-6-6	1.69E+10	-2193	973

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