COMPARISON OF AN ALTERNATIVE ESTIMATOR TO THE CURRENT COMPOSITE ESTIMATOR IN CPS [1/]

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I. Introduction

The Current Population Survey (CPS) is a household sample survey conducted monthly by the Bureau of the Census to provide estimates of employment, unemployment, and other characteristics of the non-institutionalized civilian population (5). The current survey is a rotation sample design which consists of a sample of eight rotation groups partitioned in such a manner that for any given month 1/8 of the sample is interviewed for the first time, 1/8 for the second time, ..., and 1/8 for the eighth time. Households in a rotation group are interviewed for 4 months, dropped for 8 months and then interviewed for an additional 4 months. It has been observed that the estimates from the 8 rotation groups for many characteristics relating to the same time period do not have the same expected value. The most pronounced differences occured between the rotation group in sample for the first time when compared with the average estimate from all 8 rotation groups. Bailar (1975) has investigated the effects of rotation group bias on ratio and composite estimates in CPS.

In this study, the efficiency and bias aspects of an alternative estimator--the AK composite estimator--are compared with the current composite estimator under the current sample rotation pattern, 4-8-4, and an alternative rotation pattern, 3-9-3. 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.

The AK composite estimator, first defined by Gurney and Daly (1965), is a generalization of the composite estimator currently being used. The AK composite estimator has the potential of assigning more weight to rotation groups which have been in sample for the 1st and 5th time, and less weight to the rest of the rotation groups than the corresponding weights in the current composite estimator. The estimator will be defined in the next section.

II. The Variance and Bias of AK Composite Estimator

The variance and bias of the AK composite estimator are studied under the current 4-8-4 rotation pattern and the alternative 3-9-3 rotation pattern with assumptions that will be given in this section.

II.A. The Variance of AK Composite Estimator under 4-8-4 and 3-9-3 Rotation Pattern

Let the parameter μ_h denote a mean or total of a certain labor force characteristic in month h. Under the 4-8-4 rotation pattern, let y_{hi} be the estimator of the μ_h based on the rotation group i (which is in its i-th time in the sample), i = 1, ..., 8. Assume the following:

(1) $V(y_{hi}) = \sigma^2$ for all h, i.

(2) Estimators derived from different rotation groups of a given month are uncorrelated; that is, $Cov(y_{hi}, y_{hj}) = 0$, $i \neq j = 1, \ldots, 8$.

(3) Estimators derived from the overlapping rotation groups are covariance stationary.

The simple estimator for estimating parameter μ_h based on all eight rotation groups is defined to be the simple average of estimates from the eight rotation groups; that is

$$y_h = (1/8)\sum_{i=1}^{8} y_{hi}, \text{ and } V(y_h) = \sigma^2/8. \quad (2.1)$$

The AK composite estimator is

$$y_h''' = (1/8)\{(1-K+A)(y_{h1} + y_{h5}) + (1-K-A/3)(y_{h2} + y_{h3} + y_{h4} + y_{h6} + y_{h7} + y_{h8})\} + K(y_{h-1}''' + d_{h,h-1}),\ 0 \leq A, K \leq 1 \quad (2.2)$$

where

$$d_{h,h-1} = (1/6)(y_{h2} + y_{h3} + y_{h4} + y_{h6} + y_{h7} + y_{h8} - (y_{h-1,1} + y_{h-1,2} + y_{h-1,3} + y_{h-1,5} + y_{h-1,6} + y_{h-1,7})).$$

When A = 0, the AK composite estimate y_h''' will reduce to the simple composite estimate y_h''. When A = 0, K = 0.5, the AK composite estimate is the current composite estimate y_h'' with K = 0.5. When A = 0, K = 0, the AK composite estimate is the simple estimate y_h.

The variance of the AK composite estimator for level defined in (2.2) with the assumptions given above is given in (6).

When terms involving the ninth or higher power of K can be ignored, $V(y_h''')$ becomes

$$V(y_h''') \doteq \sigma^2\{a A^2 + bA + c\}, \quad (2.3)$$

where

$$a = \{6 - \rho_1 K - 2\rho_2 K^2 - 3\rho_3 K^3\}/144(1-K^2)$$

$$b = \{3K(-2 + \rho_1) + K^2(-2 + \rho_1 + 4\rho_2) + K^3(-4\rho_1 + 2\rho_2 + 5\rho_3) + K^4(-6\rho_2 + 3\rho_3)\}/72(1-K^2)$$

$$c = \{1/8 - \rho_1 K/16 - (1 + \rho_1 + \rho_2)K^2/24 + (4 + 6\rho_1 - 8\rho_2 + 5\rho_3)K^3/144 + (4\rho_1 + \rho_2 - 5\rho_3)K^4/72 + (4\rho_2 - \rho_3)K^5/48\}/(1-K^2).$$

For a fixed K, the variance of the AK composite estimator defined in (2.3) is a parabolic function of A.

It can be shown that for a fixed K, $0 < K < 1$, the optimum A is $-b/2a$, the optimum variance of the AK composite estimator is $(-b^2/4a + c)\sigma^2$, and $b < 0$, $a > 0$, while the variance of a simple composite estimator is $c\sigma^2$. (See (6).) Hence for estimating level, for a given K, $0 < K < 1$, the optimum variance of the AK composite estimator is always less than the variance of a simple composite estimator.

The variance of $y'''_h - y'''_{h-1}$ under the 4-8-4 rotation pattern as an estimator of month-to-month change with the assumptions given above is given in (6).

For the 3-9-3 rotation pattern, assumptions (1)-(3) defined in II.A. remain the same except that there are 6 instead of 8 rotation groups.

The variances of the AK composite estimator for level and month-to-month change under a 3-9-3 rotation pattern using the assumptions above are given in (6).

II.B. The Variance of the AK Composite Estimator Relative to the Simple Estimator

The variances of the AK composite estimator relative to the simple estimator for estimating monthly level, month-to-month change, and annual average are defined to be the ratios of the two variances; i.e., $V(y'''_h)/V(y_h)$, $V(y'''_h - y'''_{h-1})/V(y_h - y_{h-1})$, and $V(\sum_{h=1}^{12} y'''_h/12)/V(\sum_{h=1}^{12} y_h/12)$ respectively. The optimum A,K in the range of K = 0.1(0.1)0.9, A = 0(0.1)0.9 are the values of A,K which minimize the relative variance.

The variances of the AK composite estimator (A = 0(0.1)0.9, K = 0.1(0.1)0.9) relative to the simple estimator (K = 0, A = 0) for monthly level, month-to-month change and annual average under both rotation patterns 4-8-4 and 3-9-3 were calculated for selected characteristics. In the calculation of the variance of the AK composite estimator, estimates of correlations supplied by the CPS branch, Statistical Methods Division, Bureau of the Census are used. For K = 0.5, A = 0(0.1)0.4, the variances of the AK composite estimator (relative to the simple estimator) are tabulated in Table 1 for selected characteristics. There is no loss of generality to confine the tabulation to K = 0.5, A = 0(0.1)0.4 because the computer results show that for K = 0.5, the optimum A occures below 0.5 for monthly level and month-to-month change estimates (although the optimum A was greater than 0.5 for annual average estimate) for all the characteristics studied. To compare the variances of the AK composite estimator (K = 0.5, A = 0(0.1)0.9) with the current composite estimator (K = 0.5, A = 0), it is sufficient to examine Table 1.

As seen in Table 1 under both rotation patterns, for monthly level estimate, given K = 0.5, the variances (relative to the simple estimator) of AK composite estimators (K = 0.5, A = 0.1(0.1)0.4) are smaller than the variances (relative to the simple estimator) of the current composite estimator (K = 0.5, A = 0) for all the characteristics considered.

For the month-to-month change estimation, the reduction of variance in using the AK composite estimator with respect to the simple estimator is much higher than for the monthly level estimate. However, the variances of AK composite estimator (K = 0.5, A = 0.1(0.1)0.4) for month-to-month change are not always less than the variance of the current composite estimator (K = 0.5, A = 0).

For estimating annual averages, the current composite estimator is less efficient than the simple estimator (see Table 1 when A = 0). When we confine ourself to the range of values K = 0.5, A = 0(0.1)0.4 for annual average, we find that the AK composite estimator (K = 0.5, A = 0.4) is the best, and therefore it is better than the current composite estimator for both rotation patterns.

The optimum A,K for the AK composite estimator, the optimum K for the simple composite estimator and the corresponding variance (relative to the simple estimator) are tabulated for both rotation patterns in Table 2. As seen in Table 2, the optimum A,K vary by characteristic. Under a 4-8-4 rotation pattern, the optimum A,K for the monthly level estimator are K = 0.7, A = 0.4; and K = 0.5, A = 0.4 for civilian labor force, and unemployed respectively. The optimum A,K for the month-to-month change estimate are K = 0.8, A = 0.1 and K = 0.5, A = 0.2 for civilian labor force and unemployed respectively. Note that for estimating annual average, the optimum A,K occured when A > K, and the optimum AK composite estimator shows about 1-2% gain in efficiency over the simple estimator.

II.C. The Bias of the AK Composite Estimator

So far we have considered variance aspects of the AK composite estimator. It has been observed in the CPS that for many characteristics, estimates from the different rotation groups relating to the same time period do not appear to have the same expected value. Hence it is worthwhile to investigate the bias and mean square error of the AK composite estimator.

Let a_{hi} be the bias from month h associated with the rotation group in its i-th time in the sample, that is, $a_{hi} = E(y_{hi}) - \mu_h$, $i=1, \ldots, 8$.

Note that the simple or AK composite estimator defined in (2.1) and (2.2) is in a 'mean' form--average of estimates from all rotation groups, and the estimate from each rotation group assumed to be an estimate of the population parameter. In the CPS, each rotation group estimate y_{hi} is an estimate of one eighth of the monthly level. We shall define μ_h as the monthly level of certain characteristics divided by the total number of rotation groups in a given month. We assume that the biases for the rotation groups of a given month in sample are constant over months i.e., $a_{hi} = a_i$ for all h. (This may not be true as indicated in Bailar (1979).) Under these assumptions the expected values of the simple estimator, composite estimator, and AK composite estimator for level can be shown to be as follows:

For the 4-8-4 rotation pattern:

$$E(y_h) = E((1/8)\sum_{i=1}^{8} y_{hi}) = \mu_h + (1/8)\sum_{i=1}^{8} a_i, \quad (2.4)$$

$$E(y''_h) = \mu_h + (1/8)\sum_{i=1}^{8} a_i + (K/6(1-K))((a_4 + a_8) - (a_1 + a_5)), \quad (2.5)$$

$$E(y'''_h) = \mu_h + (1/8)\sum_{i=1}^{8} a_i + (K/6(1-K))((a_4 + a_8) - (a_1 + a_5)) + (A/8(1-K))((a_1 + a_5) - (1/3)(a_2 + a_3 + a_4 + a_6 + a_7 + a_8)). \quad (2.6)$$

For the 3-9-3 rotation pattern:

$$E(y_h) = E((1/6)\sum_{i=1}^{6} y_{hi}) = \mu_h + (1/6)\sum_{i=1}^{6} a_i, \quad (2.7)$$

$$E(y''_h) = \mu_h + (1/6)\sum_{i=1}^{6} a_i + (K/4(1-K))((a_3 + a_6) - (a_1 + a_4)), \quad (2.8)$$

$$E(y'''_h) = \mu_h + (1/6)\sum_{i=1}^{6} a_i + (K/4(1-K))((a_3 + a_6) - (a_1 + a_4)) + (A/6(1-K))((a_1 + a_4) - (1/2)(a_2 + a_3 + a_5 + a_6)). \quad (2.9)$$

The corresponding expected value for annual average can be shown to be the same as for monthly level, while all the estimators are unbiased for month-to-month change based on the assumption that $a_{hi} = a_i$ for all h.

Before we examine the effect of rotation group bias on the current composite (K = 0.5, A = 0) and the AK composite estimator in the Current Population Survey, we shall briefly describe the four steps of the estimation procedure in the Current Population Survey (5). The first step is the preparation of unbiased estimates; the second step is the adjustment for type A noninterviews; the third step is the formation of two stages ratio estimates; the fourth step is composite estimation. We assumed in this study that the ratio estimate from each group used in the CPS is an unbiased estimate of μ_h. We estimated the rotation group bias a_i using January 1975 to December 1977 CPS data as follows.

For the 4-8-4 rotation pattern:

$$a_i = (\sum_{j=1}^{8} \hat{y}_j/8)(I_i - 100)/100,$$

where $\hat{y}_j$'s are the average ratio estimate for its j-th time in the sample for the period January 1975 to December 1977. I_i's are the rotation group index for its i-th time in the sample. This index is the ratio of the estimate based on the sample units in a particular rotation group to the average estimate from all eight rotation groups combined, multiplied by 100. The indexes are averaged over 3 years (January 1975 to December 1977). (See Bailar (1).)

Notice 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 group is constant over months, and $\sum_{i=1}^{8} a_i = 0$, the simple estimator of level is unbiased.

The biases of the simple composite and AK composite estimators for estimating μ_h, the expected value of the estimate from each rotation group, were calculated and tabulated in Table 3 for selected characteristics. The bias for monthly total estimate is 8 times that shown in Table 3. The results showed that the simple composite estimator and AK composite estimator were both underestimates, but the AK composite estimator had much less bias than the simple composite estimator for the same K.

The standard error for the simple composite and AK composite estimators for estimating μ_h are tabulated in Table 3. The parameters in the variance of AK composite estimator were estimated by CPS branch, Statistical Methods Division based on actual data (September 1976 to December 1977). It appears that the assumption of constant variance for each rotation group estimate as well as the assumption of stationary covariance of simple estimates of the matched groups do hold approximately. The root mean square error is also tabulated. The standard error and root mean square error for estimating total are 8 times the figures given in Table 3. For the civilian labor force characteristic, the optimum variance of AK composite estimator for level is achieved (see Table 2) when K = 0.7, A = 0.4 among all values of K = 0(0.1)1 and A = 0(0.1)1. But when the mean square error is considered, the AK composite estimator for K = 0.5, A = 0.4 is better than K = 0.7 A = 0.4, and the optimum composite estimator (K = 0.6). For the unemployed characteristic, the optimum AK composite estimator (K = 0.5, A = 0.4) shows a smaller bias and root mean square error than the current composite estimator (K = 0.5) and the optimum simple composite estimator (K = 0.3). For estimating monthly level and annual average, the AK composite estimator for K = 0.5, and A = 0.4 shows a smaller variance, bias and mean square error than those of the current composite estimator (K = 0.5).

A similar study is done for an alternative rotation pattern 3-9-3 using 1975 to 1977 data, where we treat rotation groups (in the order of i-th month in the sample) 1, 2, 4, 5, 6, 8 from the 4-8-4 rotation pattern as rotation groups 1, 2, 3, 4, 5, 6 in the 3-9-3 rotation pattern. (See (6).)

The results indicate that the bias and root mean square error of the AK composite estimator (K = 0.5, A = 0.4) for all characteristics under both rotation patterns are less than those of the current composite estimator (K = 0.5) for estimating level and annual average. If total error is considered in a CPS sample redesign, then the mean square error instead of the variance of the estimate should be used as the criterion upon which the choice of estimator is based.

III. Empirical Comparison of Bias of AK Composite Estimator Versus Current Composite Estimator

The model studied above indicated that the AK composite estimator with K = 0.5 and A = 0.4 yielded a better efficiency, less bias and smaller mean square error than those of the current composite estimator for all the characteristics considered.

In the following, we used monthly CPS data for the period April 1978 to March 1980 to calculate the AK composite estimator (K = 0.5, A = 0.4) and the current composite estimator for each month. Our objective was to compare the magnitude of the bias of the AK composite and the current composite estimators for level without a model as was used in II. This raised the question of what was the "true value" of the characteristic being estimated. No definite knowledge of the "true value" exists. Hence we assumed three different "true values" for each characteristic. These three "values" were:

(1) Ratio estimate from the rotation group which is in its first time in sample;

(2) Ratio estimate from all 8 rotation groups;

(3) Ratio estimate in (2) adjusted by the bias estimated from CPS reinterview response.

Causey (1976) studied the relationship of rotation group bias and response inconsistency based on 252,812 matched 1st- and 2nd-month responses of CPS data. He presented evidence that of the first and second months in sample, the first is the more nearly correct.

Bailar (1975) gave some evidence from reinterview data that the ratio estimate might be an underestimate for many characteristics.

We computed the 3 assumed "true values", the current composite estimate, and the AK composite estimate (K = 0.5, A = 0.4) for level using April 1978 to March 1980 CPS data. The bias was calculated using the average estimate in the period with respect to the assumed "true value", and the bias rate (the ratio of the bias with respect to the assumed "true value" multiply by 100) was also calculated and tabulated in Table 4. The results showed that no matter which of three "true values" were assumed, the AK composite estimator always had less bias than the current composite estimator; the AK composite and the current composite estimator were both negatively biased for the employed and unemployed characteristics considered.

We also performed a similar bias study for the 3-9-3 rotation pattern using monthly CPS data for the period, April 1978 to March 1980 (see (6)). Although the bias pattern of 3-9-3 is unknown to us, we may simulate the 3-9-3 rotation pattern data from the 4-8-4 pattern in various ways. We treated rotation groups 1, 2, 4, 5, 6, 8 in the 4-8-4 rotation pattern as rotation group 1, 2, 3, 4, 5, 6 in the 3-9-3 rotation pattern. The results showed that the AK composite estimator (K = 0.5, A = 0.4) had less bias than the current composite estimator, and both estimators were biased downward.

IV. Conclusion

We have studied the variance and bias aspects of the AK composite estimator versus the current composite estimator for the current sample design 4-8-4 rotation pattern as well as an alternative 3-9-3 rotation pattern. We assumed a constant variance and covariance assumption for all observations at all time periods. We conclude that for each characteristic the optimum AK composite estimator has better efficiency than the current composite estimator for monthly level, month-to-month change, and annual average for both rotation patterns. For K = 0.5, A = 0.4, the AK composite estimator has better efficiency than the current composite estimator for level and annual average for all items considered under both rotation patterns. Under the current rotation pattern, if the rotation group bias can be assumed constant over months, and the average of 8 rotation group ratio estimates can be assumed to be unbiased, then the bias of the AK composite estimator is less than the bias of the current composite estimator for the same K. The AK composite estimator (K = 0.5, A = 0.4) had the smallest mean square error for monthly level among the AK composite and simple composite estimators for most of the characteristics considered under the current rotation pattern. The empirical study showed that the AK composite estimator (K = 0.5, A = 0.4) for monthly level had less bias than the current composite estimator under all three "true" level assumptions used.

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FOOTNOTE

1/ Excerpted from "Report on the Comparison of an Alternative Estimator to the Current Composite Estimator in CPS", internal document, Bureau of the Census (6).

Table 1. Comparison of Variances of AK Composite Estimator (K = 0.5, A = 0(0.1)0.4)relative to Simple Estimator

Characteristic \ A	Monthly Level 0	0.1	0.2	0.3	0.4	Month-to-Month Change 0	0.1	0.2	0.3	0.4	Annual Average 0	0.1	0.2	0.3	0.4
Rotation Pattern 4-8-4															
C.L.F.	0.812	0.797	0.790	0.790	0.797	0.674	0.677	0.691	0.719	0.758	1.038	1.022	1.008	0.996	0.987
Unemployed	0.996	0.967	0.946	0.933	0.928	0.923	0.914	0.913	0.919	0.933	1.197	1.149	1.109	1.075	1.048
Male C.L.F.	0.851	0.833	0.822	0.819	0.824	0.744	0.743	0.753	0.775	0.807	1.064	1.042	1.024	1.009	0.997
Male Unemployed	0.997	0.968	0.947	0.934	0.929	0.925	0.916	0.914	0.920	0.934	1.196	1.149	1.108	1.074	1.047
Female C.L.F.	0.802	0.788	0.781	0.782	0.790	0.653	0.656	0.672	0.702	0.743	1.031	1.016	1.004	0.993	0.985
Female Unemployed	1.034	1.002	0.978	0.962	0.955	0.952	0.942	0.939	0.942	0.953	1.252	1.194	1.144	1.103	1.070
Nonwhite C.L.F.	0.841	0.824	0.814	0.812	0.818	0.735	0.734	0.745	0.767	0.801	1.056	1.036	1.020	1.006	0.995
Nonwhite Unemployed	1.008	0.978	0.956	0.942	0.937	0.936	0.926	0.924	0.929	0.942	1.212	1.162	1.120	1.084	1.056
Rotation Pattern 3-9-3															
C.L.F.	0.779	0.762	0.754	0.756	0.768	0.625	0.626	0.643	0.676	0.727	1.094	1.067	1.043	1.024	1.008
Unemployed	1.035	0.993	0.962	0.942	0.934	0.910	0.897	0.894	0.903	0.922	1.385	1.302	1.230	1.169	1.120
Male C.L.F.	0.831	0.808	0.796	0.793	0.801	0.700	0.697	0.709	0.736	0.778	1.141	1.105	1.073	1.047	1.025
Male Unemployed	1.037	0.994	0.963	0.944	0.935	0.912	0.899	0.896	0.905	0.924	1.384	1.301	1.229	1.169	1.119
Female C.L.F.	0.766	0.749	0.743	0.746	0.759	0.603	0.605	0.623	0.659	0.711	1.082	1.057	1.036	1.018	1.004
Female Unemployed	1.085	1.038	1.003	0.979	0.967	0.947	0.932	0.927	0.933	0.948	1.466	1.368	1.283	1.211	1.152
Nonwhite C.L.F.	0.820	0.798	0.787	0.785	0.794	0.690	0.687	0.700	0.728	0.771	1.128	1.095	1.066	1.042	1.022
Nonwhite Unemployed	1.050	1.007	0.974	0.954	0.944	0.926	0.912	0.909	0.916	0.934	1.403	1.317	1.243	1.180	1.130

Table 2. The Optimum A,K and Variance (relative to Simple Estimator) for AK Composite Estimator and Simple Composite Estimator

	Monthly Level					Month-to-Month Change					Annual Average				
	Composite		AK Composite			Composite		AK Composite			Composite		AK Composite		
Characteristic	K	Variance	K	A	Variance	K	Variance	K	A	Variance	K	Variance	K	A	Variance
Rotation Pattern 4-8-4															
C.L.F.	0.6	0.789	0.7	0.4	0.731	0.8	0.607	0.8	0.1	0.599	0.2	0.998	0.5	0.7	0.975
Unemployed	0.3	0.958	0.5	0.4	0.928	0.4	0.921	0.5	0.2	0.913	0.1	1.000	0.3	0.5	0.986
Male C.L.F.	0.6	0.848	0.7	0.5	0.793	0.8	0.710	0.8	0.2	0.698	0.1	0.998	0.4	0.6	0.979
Male Unemployed	0.3	0.958	0.5	0.4	0.929	0.4	0.922	0.5	0.2	0.914	0.1	1.000	0.3	0.5	0.985
Female C.L.F.	0.7	0.772	0.7	0.4	0.713	0.8	0.575	0.9	0.1	0.567	0.2	0.997	0.5	0.7	0.974
Female Unemployed	0.2	0.971	0.3	0.2	0.952	0.3	0.944	0.4	0.1	0.938	0.1	1.001	0.3	0.5	0.986
Nonwhite C.L.F.	0.6	0.832	0.7	0.4	0.777	0.8	0.696	0.8	0.2	0.685	0.1	0.998	0.5	0.7	0.980
Nonwhite Unemployed	0.3	0.963	0.4	0.3	0.935	0.4	0.931	0.5	0.2	0.924	0.1	1.001	0.3	0.5	0.987
Rotation Pattern 3-9-3															
C.L.F.	0.6	0.774	0.6	0.3	0.726	0.8	0.563	0.8	0.2	0.553	0.1	0.998	0.4	0.6	0.982
Unemployed	0.3	0.952	0.4	0.3	0.922	0.4	0.904	0.5	0.2	0.894	0.1	1.002	0.2	0.4	0.990
Male C.L.F.	0.5	0.831	0.6	0.4	0.783	0.7	0.670	0.7	0.1	0.660	0.1	0.999	0.4	0.6	0.984
Male Unemployed	0.3	0.953	0.4	0.3	0.923	0.4	0.906	0.5	0.2	0.896	0.1	1.002	0.2	0.3	0.990
Female C.L.F.	0.6	0.753	0.7	0.4	0.708	0.8	0.529	0.8	0.1	0.521	0.1	0.998	0.4	0.6	0.981
Female Unemployed	0.2	0.965	0.3	0.2	0.944	0.3	0.932	0.4	0.1	0.924	0.1	1.003	0.2	0.4	0.991
Nonwhite C.L.F.	0.5	0.820	0.6	0.4	0.771	0.7	0.656	0.8	0.2	0.645	0.1	0.999	0.4	0.6	0.986
Nonwhite Unemployed	0.2	0.958	0.4	0.3	0.930	0.4	0.917	0.4	0.1	0.908	0.1	1.002	0.2	0.3	0.992

Table 3 The Effect of Rotation Group Bias on the Reliability of Sample Estimates Under 4-8-4 Rotation Pattern[1/]

Unit: 10^3

Characteristic & Estimator	Estimate	Monthly Level Standard error	Monthly Level Bias	Monthly Level RMSE	Change Standard error (RMSE)	Annual Average Standard error	Annual Average Bias	Annual Average RMSE
C.L.F.								
Simple	11,915	29.383	0	29.383	20.777	14.999	0	14.999
Simple composite								
K = 0.6		26.096	-53.25	59.301	16.643	15.729	-53.25	55.524
K = 0.5	11,880	26.484	-35.50	44.290	17.059	15.279	-35.50	38.648
AK Composite								
K = 0.7 A = 0.4		25.114	-30.167	39.253	16.937	15.633	-30.167	33.977
K = 0.5 A = 0.4	11,910	26.229	-3.900	26.517	18.094	14.904	-3.900	15.406
Unemployed								
Simple	928	14.243	0	14.243	10.072	6.108	0	6.108
Simple composite								
K = 0.3		13.940	-6.857	15.535	9.688	6.206	-6.857	9.248
K = 0.5	913	14.218	-16.000	21.404	9.678	6.682	-16.000	17.161
AK Composite								
K = 0.5, A = 0.4	925	13.724	-3.067	14.063	9.727	6.254	-3.067	6.966
Male C.L.F.								
Simple	7,075	15.811	0	15.811	11.179	8.138	0	8.138
Simple composite								
K = 0.6		14.556	-14.	20.196	9.507	8.749	-14.	16.509
K = 0.5	7,065	14.581	-9.3	17.294	9.665	8.394	-9.3	12.528
AK Composite								
K = 0.7 A = 0.5		14.082	-2.334	14.274	9.805	8.584	-2.334	8.896
K = 0.5 A = 0.4	7,075	14.351	0	14.351	10.011	8.125	0	8.125
Male Unemployed								
Simple	499	9.870	0	9.870	6.979	4.226	0	4.226
Simple composite								
K = 0.3		9.663	-1.786	10.054	6.718	4.293	-1.786	4.649
K = 0.5	495	9.857	-4.167	10.702	6.713	4.622	-4.167	6.223
AK Composite								
K = 0.5 A = 0.4	499	9.514	-0.433	9.524	6.744	4.325	-0.433	4.347
Female C.L.F.								
Simple	4,838	23.697	0	23.697	16.756	12.198	0	12.198
Simple composite								
K = 0.7		20.826	-56.389	60.112	12.870	13.485	-56.389	57.979
K = 0.5	4,814	21.222	-24.167	32.162	13.539	12.198	-24.167	27.071
AK Composite								
K = 0.7 A = 0.4		20.009	-22.167	29.862	13.424	12.612	-22.167	25.503
K = 0.5 A = 0.4	4,835	21.056	-3.634	21.367	14.448	12.107	-3.634	12.640
Female Unemployed								
Simple	429	9.451	0	9.451	6.683	3.886	0	3.885
Simple composite								
K = 0.2		9.316	-2.875	9.750	6.520	3.909	-2.875	4.852
K = 0.5	417	9.610	-11.500	14.987	6.522	4.347	-11.500	12.294
AK Composite								
K = 0.2 A = 0.2		9.277	-0.042	9.277	6.531	3.870	-0.042	3.871
K = 0.5 A = 0.4	426	9.236	-2.433	9.551	6.524	4.018	-2.433	4.697

[1/] The bias, standard error, and RMSE for monthly total are 8 times the figures given in this table.

Table 4. Comparison of Bias Rate for Ratio, Composite and AK Composite Estimators for 1978-1980 for Selected Characteristics (Under 4-8-4 Rotation Pattern)

Characteristic	(I) Assuming MIS 1 is Correct: MIS1 Estimate	(I) Bias rate of Ratio	(I) Bias rate of Composite	(I) Bias rate of AK Comp.	(II) Ratio Estimate is Correct: Ratio	(II) Bias rate of Composite	(II) Bias rate of AK Comp.	(III) Assuming Reinterview Data are Correct: Estimate	(III) Bias rate of Ratio	(III) Bias rate of Composite	(III) Bias rate of AK Comp.
	10^3	%	%	%	10^3	%	%	10^3	%	%	%
Agri. employed	3,364	-0.68	-0.86	-0.80	3,341	-0.17	-0.09	3,449	-3.13	-3.31	-3.22
Nonagri. employed	94,426	-1.23	-1.40	-1.25	93,267	-0.18	-0.03	93,931	-0.70	-0.88	-0.73
Unemployed	6,729	-8.65	-9.90	-8.68	6,149	-1.39	-0.08	6,600	-6.83	-8.13	-6.89
Male											
Agri. employed	2,697	-0.67	-0.85	-0.78	2,679	-0.19	-0.15	2,725	-1.69	-1.91	-1.87
Nonagri. employed	54,105	-0.81	-0.89	-0.79	53,669	-0.09	0.01	53,888	-0.41	-0.49	-0.39
Unemployed	3,278	-5.92	-6.44	-5.70	3,084	-0.56	0.23	3,309	-6.80	-7.34	-6.59
Female											
Agri. employed	668	-1.05	-1.20	-1.05	661	-0.14	0.09	718	-7.94	-8.08	-7.80
Nonagri. employed	40,322	-1.79	-2.09	-1.87	39,599	-0.30	0.08	40,036	-1.09	-1.39	-1.17
Unemployed	3,450	-11.16	-13.16	-11.51	3,065	-2.23	-0.37	3,283	-6.64	-8.74	-7.01