# A Comparison of Population Estimation Methods: Housing Unit Versus Component II, Ratio Correlation, and Administrative Records

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The housing unit (HU) method is often characterized as inferior to other methods for estimating the population of states and local areas. We believe this characterization must be challenged. In this article we evaluate population estimates produced by the housing unit method and by three other commonly used methods: component II, ratio correlation, and administrative records. Basing our analysis on 1980 census data from 67 counties in Florida and testing for precision, bias, and the distribution of errors, we find our application of the HU method performs at least as well as the more highly acclaimed methods of local population estimation.

KEY WORDS: Population estimation techniques; Housing unit method; Local population estimates; Demographic methodology.

## 1. INTRODUCTION

The housing unit (HU) method is the most commonly used method for estimating the population of local areas. A recent survey conducted by the U.S. Bureau of the Census showed that more than three-fourths of all agencies making substate population estimates use some form of the housing unit method (U.S. Bureau of the Census 1978, p. 7). Yet many professional demographers believe the housing unit method is an inferior estimation method. It is widely perceived to be inaccurate, to have an upward bias, and to be subject to severe data limitations (see e.g., Starsinic and Zitter 1968; Morrison 1971; U.S. Bureau of the Census (undated); Brockway and Wurdock 1981).

There is some justification for this characterization. Some applications of the housing unit method have produced poor population estimates. These poor estimates, however, are the results of the specific data and techniques used in applying the method, not of the method itself. As emphasized in several earlier papers (Smith and Lewis 1980,1983), there are many types of data and techniques that can be used to apply the housing unit method. Some are better than others. We believe that if sound data and techniques are used to estimate each of its components, the housing unit method can produce local population estimates at least as accurate as those produced by more highly acclaimed methods.

In this article we evaluate the population estimates produced by four different methods: the component II, the ratio-correlation, and the administrative records methods used by the U.S. Bureau of the Census, and our application of the housing unit method. Using 1980 census data for 67 counties in Florida, we compare population estimates with respect to their precision, bias, and distribution of errors. On the basis of these comparisons we conclude that the HU method can produce population estimates at least as accurate as those produced by the other methods.

## 2. METHODS OF ESTIMATION

The U.S. Bureau of the Census uses three methods to make population estimates for states and counties: component II, ratio-correlation, and administrative records. For estimates of states, all three of these methods are used only to estimate the population younger than age 65. The population aged 65 and older is estimated by adding the net change in Medicare enrollees since the previous census to the population aged 65 and older enumerated in that census. For estimates of counties, the component II and administrative records methods use Medicare data to estimate the population aged 65 and older, while the ratio-correlation method does not. In all three methods the population residing in large group quarters is estimated separately. In this section we briefly describe these three methods and the HU method. More detailed descriptions of the Census Bureau methods can be found elsewhere (U.S. Bureau of the Census 1976, pp. 8–12; National Research Council 1980, pp. 131–187).

The component II method (COMP-II) uses vital statistics data to measure natural increase and elementary school enrollment data to estimate net migration. Birth and death data are provided by the vital statistics offices of each state. Net migration for children ages 6–14 is estimated from changes in school enrollment for grades 1–8. This is converted into a net migration rate for all persons less than age 65 by relating it to migration data derived from the most recent decennial census. Current

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population is estimated as the population counted in the most recent census plus the natural increase of the population less than age 65, net migration of persons less than age 65, changes in Medicare enrollment, and changes in the group-quarters population.

Ratio-correlation (R-CORR) is a regression method in which changes in population are related to changes in such symptomatic indicators of population change as school enrollment, the number of federal income tax returns, the number of passenger car registrations, and the number of persons in the work force. In Florida the variables used are births, school enrollment, and occupied housing units. For estimates of states the dependent variable in the regression equation is the percentage change between the two most recent censuses in the state's share of national population less than age 65. The independent variables are the percentage changes between the two most recent censuses in the state's share of national numbers for the symptomatic indicators. The coefficients derived from the regression analysis are applied to percentage changes in the shares for symptomatic indicators since the most recent census to estimate percentage changes in a state's share of national population. Population estimates are then calculated by applying these percentage changes in population shares to independent estimates of the United States population. County estimates are made in an identical manner, using county shares of state totals instead of state shares of national totals. For counties, however, R-CORR uses the entire population rather than the population less than age 65.

Administrative records (AD-REC) is a component method identical to COMP-II, except that net internal migration of persons less than age 65 is based on changes in addresses on federal income tax returns. Addresses are matched for different years, and address changes are noted. The total number of persons represented by each income tax return is estimated from the number of persons claimed as exemptions. Estimates of net internal migration of persons less than age 65 are derived from the address changes indicated by the income tax returns. Immigration from abroad is estimated separately from records of the Immigration and Naturalization Service. Changes in Medicare enrollment and the group-quarters population are added to provide estimates of total population.

Under the HU method, population is estimated as the number of households times the average number of persons per household, plus the population living in group quarters:

$$P_t = (H_t \cdot PPH_t) + GQ_t,$$

where $P_t$ = total population at time $t$, $H_t$ = occupied housing units at time $t$, $PPH_t$ = average number of persons per household at time $t$, and $GQ_t$ = group-quarters population at time $t$. This is an identity, not an estimate. If these three components were known exactly, the exact total population would also be known. The failure to obtain exact population estimates from the HU method is due to inaccurate data or imperfect application techniques, not to any inherent characteristic of the method itself.

These three components are never known exactly, of course. Many techniques and data sources can be used to estimate each component, which gives rise to the great diversity that exists among population estimates produced by the housing unit method. In this article the number of households is estimated from the number of active residential electric customers. *PPH* is estimated from the *PPH* calculated at the most recent census, the national decline in *PPH* since the most recent census, and the change since the most recent census in the local mix of housing unit types (single family, multifamily, mobile home). The number of people living in group quarters is assumed to remain a constant proportion of total population, except where data from large group-quarters (e.g., college dormitories, military barracks) indicate otherwise. A detailed description of these estimating techniques can be found in Smith and Lewis (1980).

## 3. COMPARISON OF ESTIMATES

Population estimates for Florida's 67 counties were produced by each of the four methods for 1 April 1980. The estimates for COMP-II, R-CORR, and AD-REC are the revised estimates produced by the U.S. Bureau of the Census. The HU estimates were produced by the Bureau of Economic and Business Research at the University of Florida. Two other sets of estimates were also produced, one based on the average of the first three methods (CENSUS) and one based on the average of all four methods (AVERAGE). The three-method average (CENSUS) is the method used by the Bureau of the Census for its official state and county population estimates.

The Census Bureau controls county estimates to state estimates for all three of its methods. (For R-CORR, of course, county estimates cannot be produced that are *not* controlled to a state estimate.) The HU county estimates, however, have not been controlled to a state total. When county estimates are controlled, errors may be caused either by the uncontrolled county estimates themselves or by the state control total. In order to distinguish between these two sources of error, we evaluate two different sets of estimates. In one set we control all county estimates to a common state total and call them *controlled* estimates. In the other set we use uncontrolled HU estimates and COMP-II, R-CORR, and AD-REC estimates in which county numbers have been controlled to the respective state population estimates produced by these methods. That is, the COMP-II county estimates were controlled to the COMP-II state estimate, the R-CORR county estimates were controlled to the R-CORR state estimate, and the AD-REC county estimates were controlled to the AD-REC state estimate. This is an attempt to evaluate "pure" estimates, or to conduct evaluations in which the estimates produced by each method are unaffected by the estimates produced by any other method. We call these *independent* estimates.

Ideally we would use COMP-II and AD-REC county estimates for which no state-level controls have been employed. Unfortunately, such estimates are not available from the Census Bureau. Controlling county estimates to their respective state estimates is as close as we can come to uncontrolled county numbers for these methods. Our understanding is that this adjustment procedure produces county estimates that are quite close to the original uncontrolled numbers.

## Independent Estimates

We first evaluate the independent estimates, or the set that includes the uncontrolled HU estimates and the COMP-II, R-CORR, and AD-REC estimates in which county numbers have been controlled to their respective state population estimates. The estimates produced by each method were compared to the population enumerated in the 1980 census of population and housing. At the state level the HU method clearly performed better than the other methods. The 1980 census count for Florida was 9,746,324. Estimates were 9,486,455 for HU method, 9,128,321 for COMP-II, 9,295,848 for R-CORR, 9,181,890 for AD-REC, and 9,202,344 for CENSUS. The absolute error for the HU estimate was 259,869 (2.7%), compared with 618,003 (6.3%) for COMP-II, 450,476 (4.6%) for R-CORR, 564,434 (5.8%) for AD-REC, and 543,980 (5.6%) for CENSUS. At the state level, then, the error for the HU estimate was only about half as large as the errors for the other methods. (In this article we refer to the differences between population estimates and census counts as errors of the estimates, although they may have been caused by enumeration error as well as by estimation error.)

The magnitude and direction of the errors for counties are summarized in Tables 1 and 2. The top part of Table 1 shows the mean absolute percentage error, or the average when the sign of the error is excluded. This provides a measure of the precision of each method. The bottom part of Table 1 shows the mean algebraic percentage error, or the average when the sign of the error is included. This provides a measure of the bias of each method. A mean algebraic percentage error of zero indicates a lack of bias, while a positive or negative error indicates a tendency to over- or underestimate.

Overall, the degrees of precision for all methods except COMP-II were about the same. The average error for all counties was 7.7% for COMP-II, compared with 5.2% to 5.7% for the other methods. COMP-II also displayed considerably more variation around the mean than the other methods, as shown by the relatively high standard deviation of 5.4. The smallest overall error was for AVERAGE. It is notable that the error for AVERAGE was smaller than for CENSUS in all four size-of-place categories, indicating that the inclusion of the HU estimates in the average with the other three methods consistently reduced the size of errors.

For estimates of large counties the HU method had considerably smaller errors than any other method. For

*Table 1. Mean Absolute and Algebraic Percentage Errors of Independent Population Estimates for Florida Counties*

| *Size—1970* | *N* | *HU* | *COMP-II* | *R-CORR* | *AD-REC* | *CENSUS* | *AVERAGE* |
|---|---|---|---|---|---|---|---|
| | | | | *Mean Absolute Percentage Error* | | | |
| <15,000 | 25 | 5.6 | 6.5 | 5.0 | 6.0 | 4.8 | 4.4 |
| | | (4.0) | (4.4) | (4.2) | (3.7) | (3.4) | (3.6) |
| 15,000–49,999 | 18 | 7.2 | 9.5 | 7.1 | 4.8 | 6.8 | 6.5 |
| | | (4.2) | (5.4) | (4.5) | (3.2) | (3.1) | (3.4) |
| 50,000–99,999 | 9 | 4.7 | 9.6 | 5.8 | 5.5 | 6.9 | 6.1 |
| | | (3.3) | (9.1) | (5.2) | (5.5) | (6.0) | (5.2) |
| 100,000+ | 15 | 3.1 | 6.4 | 4.0 | 6.0 | 5.4 | 4.5 |
| | | (2.3) | (3.5) | (2.8) | (3.3) | (2.5) | (2.5) |
| Total | 67 | 5.4 | 7.7 | 5.4 | 5.6 | 5.7 | 5.2 |
| | | (3.9) | (5.4) | (4.2) | (3.7) | (3.6) | (3.6) |
| Weighted Average* | | 3.9 | 6.4 | 4.8 | 6.0 | 5.6 | 4.9 |
| | | | | *Mean Algebraic Percentage Error* | | | |
| <15,000 | 25 | −1.1 | −5.1 | −1.2 | −2.9 | −3.1 | −2.6 |
| | | (6.9) | (6.1) | (6.5) | (6.5) | (5.0) | (5.1) |
| 15,000–49,999 | 18 | −5.7 | −9.3 | −6.7 | −4.3 | −6.8 | −6.5 |
| | | (6.1) | (5.6) | (5.2) | (3.8) | (3.1) | (3.4) |
| 50,000–99,999 | 9 | −4.0 | −9.6 | −5.8 | −5.2 | −6.9 | −6.1 |
| | | (4.2) | (9.1) | (5.2) | (5.8) | (6.0) | (5.2) |
| 100,000+ | 15 | −1.8 | −6.4 | −4.0 | −6.0 | −5.4 | −4.5 |
| | | (3.5) | (3.6) | (2.8) | (3.3) | (2.5) | (2.5) |
| Total | 67 | −2.9 | −7.1 | −3.9 | −4.3 | −5.1 | −4.6 |
| | | (6.0) | (6.2) | (5.7) | (5.2) | (4.5) | (4.5) |
| Weighted Average* | | −2.7 | −6.3 | −4.6 | −5.8 | −5.6 | −4.9 |

* Weighted by population size in 1970.
NOTE: Values within parentheses are standard deviations.

counties with a population of 50,000–99,999 in 1970, the average absolute error was 4.7% for the HU method, compared with 5.5% to 9.6% for the other methods. For counties with 100,000 or greater population, the average absolute error was 3.1% for the HU method, compared with 4.0% to 6.4% for the other methods. The comparative superiority of the HU method for estimating large counties can also be seen in the weighted average, where errors are weighted by each county's population size. The weighted average error was 3.9% for the HU method, compared with 6.4% for COMP-II, 4.8% for R-CORR, 6.0% for AD-REC, 5.6% for CENSUS, and 4.9% for AVERAGE.

The distribution of errors is shown in Table 2. The HU method produced more small errors than any other method: 36 of the HU errors were less than 5%, compared with 26 for COMP-II, 33 for R-CORR, 31 for AD-REC, 29 for CENSUS, and 33 for AVERAGE. For counties with 100,000 or more residents, 12 of the 15 HU estimates were within 5% of the census count, compared with 6 for COMP-II, 9 for R-CORR, 6 for AD-REC, 5 for CENSUS, and 8 for AVERAGE. The HU method produced only 7 errors greater than 10%, compared with 23 for COMP-II, 9 for R-CORR and AD-REC, 8 for CENSUS, and 6 for AVERAGE. The HU method, then, produced more small errors than any other method and fewer large errors than any method except AVERAGE.

Evidence regarding bias is found in both Tables 1 and 2. While all methods showed a marked downward bias, the tendency to underestimate was much less severe for the HU method than for the other methods. Forty-four of the 67 HU estimates were low, compared with 62 for COMP-II, 53 for R-CORR, 56 for AD-REC, 62 for CENSUS, and 60 for AVERAGE. The average algebraic error was −2.9% for HU, compared with −7.1% for COMP-II, −3.9% for R-CORR, −4.3% for AD-REC, −5.1% for CENSUS, and −4.6% for AVERAGE. The inclusion of the HU estimates in the average lessened the tendency of the CENSUS method to underestimate in every size-of-place category.

The comparative superiority of the HU method with respect to bias was greatest for the large counties. The average algebraic percentage error for counties of 100,000 or more was less than half as large for the HU method than for any other method. The average algebraic percentage error weighted by population size was roughly only half as large for the HU method as for the other methods, again reflecting the much smaller downward bias for large counties.

The bias observed for the HU method is noteworthy. It is often assumed that the HU method tends to overestimate population (see, e.g., Starsinic and Zitter 1968, p. 80). These results show a tendency to underestimate. It is likely that part of this apparent tendency was caused by a smaller undercount in the 1980 census than in the 1970 census. To completely overcome the downward bias, however, would require a 1980 undercount only half as large as the 5% to 6% estimated for Florida in 1970

*Table 2. Distribution of Mean Absolute Percentage Errors of Independent Population Estimates for Florida Counties*

| | | Mean Absolute Percentage Error | | | | | |
|---|---|---|---|---|---|---|---|
| *Size—1970* | *N* | *High* | *Low* | *<5* | *5–10* | *10–15* | *15+* |
| *HU* | | | | | | | |
| <15,000 | 25 | 12 | 13 | 13 | 8 | 4 | 0 |
| 15,000–99,999 | 27 | 5 | 22 | 11 | 13 | 2 | 1 |
| 100,000+ | 15 | 6 | 9 | 12 | 3 | 0 | 0 |
| Total | 67 | 23 | 44 | 36 | 24 | 6 | 1 |
| *COMP-II* | | | | | | | |
| <15,000 | 25 | 4 | 21 | 12 | 6 | 6 | 1 |
| 15,000–99,999 | 27 | 1 | 26 | 8 | 6 | 8 | 5 |
| 100,000+ | 15 | 0 | 15 | 6 | 6 | 3 | 0 |
| Total | 67 | 5 | 62 | 26 | 18 | 17 | 6 |
| *R-CORR* | | | | | | | |
| <15,000 | 25 | 13 | 12 | 15 | 6 | 4 | 0 |
| 15,000–99,999 | 27 | 1 | 26 | 9 | 13 | 3 | 2 |
| 100,000+ | 15 | 0 | 15 | 9 | 6 | 0 | 0 |
| Total | 67 | 14 | 53 | 33 | 25 | 7 | 2 |
| *AD-REC* | | | | | | | |
| <15,000 | 25 | 8 | 17 | 9 | 11 | 5 | 0 |
| 15,000–99,999 | 27 | 3 | 24 | 16 | 8 | 2 | 1 |
| 100,000+ | 15 | 0 | 15 | 6 | 8 | 1 | 0 |
| Total | 67 | 11 | 56 | 31 | 27 | 8 | 1 |
| *CENSUS* | | | | | | | |
| <15,000 | 25 | 5 | 20 | 14 | 9 | 2 | 0 |
| 15,000–99,999 | 27 | 0 | 27 | 10 | 12 | 4 | 1 |
| 100,000+ | 15 | 0 | 15 | 5 | 9 | 1 | 0 |
| Total | 67 | 5 | 62 | 29 | 30 | 7 | 1 |
| *AVERAGE* | | | | | | | |
| <15,000 | 25 | 7 | 18 | 14 | 9 | 2 | 0 |
| 15,000–99,999 | 27 | 0 | 27 | 11 | 12 | 3 | 1 |
| 100,000+ | 15 | 0 | 15 | 8 | 7 | 0 | 0 |
| Total | 67 | 7 | 60 | 33 | 28 | 5 | 1 |

(U.S. Bureau of the Census 1977, p. 99). If such a large decline in undercount has occurred, the HU estimates should display virtually no bias. Even if the 1980 undercount were zero, the upward bias would be quite small. These results, then, do not support the contention that the HU method tends to overestimate population.

Census undercount, and particularly the change in undercount between 1970 and 1980, could affect the results shown in this article. Adjustments that try to deal with this problem have been suggested (see, e.g., National Research Council 1980, pp. 232–236). We question the usefulness of such adjustments for counties because estimates of undercount by county are not available. Since the degree of undercount varies a great deal from one place to another, the application of a constant (or artificially varying) undercount adjustment factor to all counties is not likely to provide any useful information. In addition, even state and national estimates of the 1980 undercount are currently subject to considerable disagreement among demographers. Because of this uncertainty no adjustments for undercount were made in the present analysis.

The results summarized in Tables 1 and 2 show that the HU method performed better than the other methods according to three criteria. The HU estimates were more precise, especially for large counties where the average absolute errors were much smaller than those produced by any other method. The HU estimates displayed less downward bias, having a more nearly equal distribution of over- and underestimates and a smaller average algebraic percentage error than any other method. The HU method produced more small errors and fewer large errors than any other method. Furthermore, including the HU estimates in the average with the other three methods improved the performance of the average on every test and in every size-of-place category.

The HU method thus performed better—sometimes by a large amount—than COMP-II, R-CORR, AD-REC, and CENSUS on all tests of estimation accuracy. It is particularly interesting to compare the HU estimates with CENSUS, the average of the other three methods. This is the method used by the Bureau of the Census for its official population estimates of states and counties. The HU method performed better than the CENSUS method on every test. In this sample, then, the HU method produced better estimates than the method widely accepted as the state of the art.

## Controlled Estimates

A second set of estimates was produced in which county numbers for each method were adjusted to add to a common state total of 9,202,344, the Census Bureau's revised 1980 estimate for Florida. Controlling to a common total permits one of focus on the distribution of population among counties, independent of differences in state totals. Controlling county estimates to independent state estimates is frequently believed to improve the accuracy of county estimates (Shryock and Siegel 1973, p. 728; U.S. Bureau of the Census 1973, p. 3).

The results for county estimates controlled to a common state total are summarized in Tables 3 and 4. For the entire sample of counties the HU method had a smaller average absolute error than COMP-II and a larger error than R-CORR and AD-REC. The two averages (CENSUS and AVERAGE) had smaller overall average absolute errors than any individual method except AD-REC. The HU method performed particularly well for counties of 100,000 or more, having the smallest (along with R-CORR) average absolute percentage error of any method. As would be expected, the weighted average percentage error was virtually the same for all six methods.

As shown in Table 4, R-CORR and AD-REC had more small errors and fewer large errors than HU and COMP-II, but the AVERAGE method had the best overall performance. Thirty-three errors for AVERAGE were less than 5%, and 8 were greater than 10%. For counties of more than 100,000 population in 1970, the HU method had 8 errors of less than 5% and none greater than 10%, again showing the HU method to perform as well as or better than any other method in producing population estimates for large counties.

*Table 3. Mean Absolute and Algebraic Percentage Errors of Controlled Population Estimates for Florida Counties[a]*

| *Size—1970* | *N* | *HU* | *COMP-II* | *R-CORR* | *AD-REC* | *CENSUS* | *AVERAGE* |
|---|---|---|---|---|---|---|---|
| | | *Mean Absolute Percentage Error* | | | | | |
| <15,000 | 25 | 6.0 | 6.1 | 5.0 | 5.9 | 4.8 | 4.8 |
| | | (4.9) | (4.3) | (4.5) | (3.7) | (3.4) | (3.7) |
| 15,000–49,999 | 18 | 8.9 | 8.8 | 7.9 | 4.6 | 6.8 | 7.2 |
| | | (5.4) | (5.3) | (4.6) | (3.1) | (3.1) | (3.3) |
| 50,000–99,999 | 9 | 6.9 | 8.8 | 6.8 | 5.4 | 6.9 | 6.9 |
| | | (4.0) | (9.1) | (5.1) | (5.5) | (6.0) | (5.2) |
| 100,000+ | 15 | 4.9 | 5.7 | 4.9 | 5.8 | 5.4 | 5.3 |
| | | (3.2) | (3.5) | (2.8) | (3.3) | (2.5) | (2.5) |
| Total | 67 | 6.6 | 7.1 | 6.0 | 5.5 | 5.7 | 5.8 |
| | | (4.8) | (5.3) | (4.4) | (3.7) | (3.6) | (3.7) |
| Weighted Average[b] | | 5.7 | 5.7 | 5.7 | 5.8 | 5.6 | 5.6 |
| | | *Mean Algebraic Percentage Error* | | | | | |
| <15,000 | 25 | −4.1 | −4.3 | −2.3 | −2.7 | −3.1 | −3.3 |
| | | (6.7) | (6.1) | (6.4) | (6.5) | (5.0) | (5.1) |
| 15,000–49,999 | 18 | −8.6 | −8.6 | −7.6 | −4.1 | −6.8 | −7.2 |
| | | (5.9) | (5.7) | (3.8) | (5.4) | (3.1) | (3.3) |
| 50,000–99,999 | 9 | −6.9 | −8.8 | −6.8 | −5.0 | −6.9 | −6.9 |
| | | (4.1) | (9.1) | (5.1) | (5.9) | (6.0) | (5.2) |
| 100,000+ | 15 | −4.8 | −5.6 | −4.9 | −5.8 | −5.4 | −5.3 |
| | | (3.4) | (3.6) | (2.8) | (3.3) | (2.5) | (2.4) |
| Total | 67 | −5.8 | −6.4 | −4.9 | −4.1 | −5.1 | −5.3 |
| | | (5.9) | (6.2) | (5.6) | (5.2) | (4.5) | (4.4) |
| Weighted Average[b] | | −5.6 | −5.6 | −5.6 | −5.6 | −5.6 | −5.6 |

[a] Controlled to 9,202,344.
[b] Weighted by population size in 1970.
NOTE: Values within parentheses are standard deviations.

*Table 4. Distribution of Mean Absolute Percentage Errors of Controlled Population Estimates for Florida Counties**

| | | Mean Absolute Percentage Error | | | | | |
|---|---|---|---|---|---|---|---|
| *Size—1970* | *N* | *High* | *Low* | *<5* | *5–10* | *10–15* | *15+* |
| *HU* | | | | | | | |
| <15,000 | 25 | 8 | 17 | 13 | 6 | 5 | 1 |
| 15,000–99,999 | 27 | 3 | 24 | 8 | 7 | 11 | 1 |
| 100,000+ | 15 | 1 | 14 | 8 | 7 | 0 | 0 |
| Total | 67 | 12 | 55 | 29 | 20 | 16 | 2 |
| *COMP-II* | | | | | | | |
| <15,000 | 25 | 5 | 20 | 13 | 7 | 4 | 1 |
| 15,000–99,999 | 27 | 1 | 26 | 10 | 7 | 7 | 3 |
| 100,000+ | 15 | 1 | 14 | 8 | 4 | 3 | 0 |
| Total | 67 | 7 | 60 | 31 | 18 | 14 | 4 |
| *R-CORR* | | | | | | | |
| <15,000 | 25 | 10 | 15 | 17 | 4 | 3 | 1 |
| 15,000–99,999 | 27 | 1 | 26 | 9 | 11 | 5 | 2 |
| 100,000+ | 15 | 0 | 15 | 8 | 7 | 0 | 0 |
| Total | 67 | 11 | 56 | 34 | 22 | 8 | 3 |
| *AD-REC* | | | | | | | |
| <15,000 | 25 | 8 | 17 | 9 | 11 | 5 | 0 |
| 15,000–99,999 | 27 | 3 | 24 | 17 | 7 | 2 | 1 |
| 100,000+ | 15 | 1 | 14 | 6 | 8 | 1 | 0 |
| Total | 67 | 12 | 55 | 32 | 26 | 8 | 1 |
| *CENSUS* | | | | | | | |
| <15,000 | 25 | 5 | 20 | 14 | 9 | 2 | 0 |
| 15,000–99,999 | 27 | 0 | 27 | 10 | 12 | 4 | 1 |
| 100,000+ | 15 | 0 | 15 | 5 | 9 | 1 | 0 |
| Total | 67 | 5 | 62 | 29 | 30 | 7 | 1 |
| *AVERAGE* | | | | | | | |
| <15,000 | 25 | 4 | 21 | 16 | 7 | 2 | 0 |
| 15,000–99,999 | 27 | 0 | 27 | 9 | 13 | 4 | 1 |
| 100,000+ | 15 | 0 | 15 | 8 | 6 | 1 | 0 |
| Total | 67 | 4 | 63 | 33 | 26 | 7 | 1 |

* Controlled to 9,202,344.

When controlled to a common state total, all six methods show a strong tendency to underestimate population. Fifty-five of the 67 HU estimates were below the census count, compared with 60 or COMP-II, 56 for R-CORR, 55 for AD-REC, 62 for CENSUS, and 63 for AVERAGE. The average algebraic error for the entire sample of counties fell between −4.1% and −6.4% for each of the six methods. When weighted by population size, the average algebraic errors were identical for all six methods. The strong downward bias for all methods, of course, was caused by the state control total, which was considerably lower than the census count.

The results for the controlled county estimates thus show some differences among the six methods, but the differences are not as large as they were for the independent county estimates. COMP-II had the largest overall average absolute and algebraic percentage errors for the controlled estimates, and AD-REC had the smallest. The performance of the HU method usually fell between that of COMP-II and AD-REC, although for counties of 100,000 or more the HU method performed as well as or better than any other method. Including the HU estimates in an average with the other three methods had very little effect, sometimes raising errors slightly and sometimes lowering them. It is impossible to conclude from these results that the HU method performs persistently better or worse than the other methods.

The calculations shown in Tables 3 and 4 were replicated using the 1980 census count of 9,746,324 as the state control total. The results (not shown here) were somewhat different than those reported in Tables 3 and 4. The average absolute percentage errors were smaller, ranging from $3\frac{1}{2}$% to 5% instead of $5\frac{1}{2}$% to 7%. The bias disappeared almost completely, as roughly half the errors were too high and half too low for every method. Such results are to be expected, given that the control total was the actual census count. The performance of the different methods compared with one another, however, was basically the same as that reported above.

## 4. DISCUSSION

The primary focus of this article is the question, Is the HU method inherently inferior to other methods of estimating state and local populations? Demographers often answer this question affirmatively, which we believe is wrong. We have compared a set of HU population estimates for the 67 counties in Florida with estimates produced by more highly acclaimed methods, once using independent county numbers and once using county numbers controlled to a common state total. For the independent numbers we found the HU estimates to have smaller average absolute percentage errors (especially for large counties), to display much less downward bias, and to have more small errors and fewer large errors than the estimates produced by any other method. These differences were sometimes small but at other times quite large. For the numbers that were controlled to a common state total we found the HU method to perform somewhat better than COMP-II and somewhat worse than R-CORR and AD-REC. For large counties, however, the HU method performed as well as or better than any other method even for the controlled estimates.

On the basis of this evidence we have concluded that the HU method is not inherently inferior to other common methods of population estimation. By this we mean there is nothing inherent in the method itself that causes it to produce poor population estimates. The HU method is more nearly an *approach* to population estimation than a set of explicit, cut-and-dried techniques. If high-quality data and sound assumptions are used, HU estimates can be produced that are at least as good as those produced by other methods. If poor data and assumptions are used, HU estimates may well be worse than those produced by other methods. The performance of the HU method in producing population estimates is determined entirely by the specific techniques used in its application, not by the nature of the method itself.

We have shown in this article that the HU method used in Florida produced population estimates at least as accurate as those produced by other common methods. We believe this performance can be repeated elsewhere. Indeed, some evidence of this is already available. Evaluations of HU estimates in several states besides Florida have found them to stand up very well in testing against other methods (see, e.g., Gates 1981, U.S. Bureau of the Census 1982). Research into new sources of data and application techniques will further improve the accuracy of the HU method and make it more accessible to potential users. The limits of the HU method have not yet been reached.

One distinct advantage of the HU method is that it can be used to estimate the population of cities, census tracts, zip codes, and other subcounty areas. The data required by the R-CORR and COMP-II methods, such as school enrollment, auto registrations, and births, are seldom available for small subcounty areas; consequently, it is very difficult to use these methods for subcounty estimates. The Census Bureau uses the AD-REC method for making city estimates. This method is quite cumbersome, however, and estimates are generally not available until two years after the estimation date. Furthermore, the confidential nature of federal income tax data means the public has no direct access to the data, so AD-REC estimates cannot be made by private citizens or state and local agencies. The HU method is not subject to such limitations. Many types of symptomatic data (e.g., electric customers, telephone customers, and building permits) are available to the public, often down to small subcounty areas. Data from past censuses are also available to serve as benchmarks. While care must be taken to ensure that data are of acceptable quality, the HU method lends itself quite readily to subcounty population estimates.

We have also evaluated a set of subcounty estimates produced by the HU and AD-REC methods. The HU method was again found to perform very well. For the 388 incorporated places in Florida, the HU method produced estimates with more small errors, fewer large errors, less bias, and a smaller average absolute percentage error than the AD-REC method. The differences were greatest in large places. For places with populations of 50,000 and over in 1970, the average absolute percentage error for the HU method was only half as large as the error for the AD-REC method. Unpublished evaluations performed by the Bureau of the Census show subcounty HU estimates to perform as well or better than AD-REC estimates in California, New Jersey, and Washington as well as in Florida (U.S. Bureau of the Census 1982). The strongest advantage of the HU method compared with other methods may well lie in the area of subcounty population estimates.

In this article we analyzed two sets of county estimates, one that was controlled to a common state number and one that was not. Controlling county estimates to an independent state estimate is a common practice, but what does it mean for the evaluation of alternative methods? While it may be important to evaluate the distribution among counties of a given state total, it is also important to evaluate the raw, unadjusted estimates produced by each method. If county numbers are controlled to independent state totals when a method is used for postcensus estimates, then it is legitimate to follow the same procedure in evaluating that method. If a method is used for postcensus estimates with no controls, however, it is not clear that controls should be used in evaluating that method.

The conventional wisdom is that controlling to an independent state estimate will improve county estimates. We believe this assumption must be questioned. A comparison of Tables 1 and 3 shows that controlling county estimates to a common state total lowered average absolute and algebraic percentage errors slightly for COMP-II and AD-REC but raised them considerably for R-CORR and HU. In particular, controlling the HU county estimates to the CENSUS state estimate greatly weakened the performance of the HU estimates, making them less precise and more biased and causing them to have many more large errors. Further testing is needed to determine whether the conventional wisdom holds as a general rule or only under special circumstances.

Another piece of conventional wisdom that deserves closer scrutiny is the assumption that state populations can be estimated more accurately through a top–down than a bottom–up procedure. It is certainly true that large places can be estimated more accurately than small places. This does not imply, however, that the *sum* of the estimates for small places will be less accurate than an independent estimate of the large place. If estimates for counties have no strong upward or downward biases, then positive and negative errors will tend to cancel each other out, and the sum of the county estimates will provide a good state estimate. That was the case in Florida, where the sum of the HU county estimates provided a much more accurate estimate of the state population than did the COMP-II, R-CORR, AD-REC, or CENSUS state-level estimates.

## 5. CONCLUSION

We do not claim to have shown in this article that the HU method is superior to the COMP-II, R-CORR, AD-REC, and CENSUS methods of local population estimation. The HU method performed better than the other four methods on many of the tests in this sample, but not on all. In other samples or other time periods the results might have been different. There is not yet enough evidence to determine whether the HU method is superior to the other methods.

However, we do believe we have shown that the blanket condemnation of the HU method as an inferior method of local population estimation must be rejected. The results reported in this article show that the HU method can perform at least as well as more highly acclaimed methods if good data and techniques are applied. We hope that this study will lead to a greater acceptance and wider application of the HU method among professional demographers, and that it will promote additional research into the development of new data sources and techniques that might further improve the application of the method.

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