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The purpose of this presentation is to examine the degree of reliability of postcensal population estimates constructed for the 1960-1970 intercensal period for the State of Arkansas and its respective counties.

To measure the reliability or accuracy of the estimative techniques, a comparison was made between estimates prepared for April 1, 1970, and United States Bureau of the Census counts as of this date. Three estimative techniques, standardized methods recommended by the Bureau of the Census for participants in its Federal-State Cooperative Program for Local Population Estimates, were used in the analyses.

The techniques were Component Method II, Composite Method and Ratio-Correlation Method [1, p. 66].

The remainder of the report contains: 1) a brief description of each of the methods used and the procedure followed in making the estimates; 2) background information concerning Arkansas' population; 3) the comparison of estimate results with 1970 census counts; and 4) presentation of findings and recommendations.

1. ESTIMATIVE PROCEDURE

Only a summary description of each of the three methods used in preparing the estimates is provided, since detailed published explanations of these techniques are readily available.

In applying Component Method II, the latest Bureau of the Census civilian population count for the area is used as the estimate base. Adjustments are made to this count to account for changes, resulting from natural increase and net migration, occurring to the area's population over the estimate time interval. The specific population components accounting for change are births, deaths, net civilian migration, net movement of civilians into the Armed Forces, and military personnel stationed in the area as of the estimate date. A symptomatic data series, school enrollment, is utilized as the base for measuring net civilian migration.¹

By contrast the Composite Method consists of estimates prepared by age, sex, and color, utilizing various symptomatic data to estimate the population of the several age groups. A frequently used age classification is: under 5; 5-17; 18-44; 45-64; and 65 years of age and over. Birth registrations, census counts and school enrollment data are used to estimate the size of the populations under five years of age and 5-17 years of age; births for females ages 18-44, and estimated sex ratios applied to the expected female population to determine the number of males estimated to be in this age group; and death registrations for those groups 45 years of age and over. Estimates for each of these age groups are then summed to provide a total expected population. The Census Bureau's Composite estimate technique is a variation of the Bogue-Duncan Composite Method.²

The third estimating technique utilized was the Ratio-Correlation Method. A multiple regression equation based on data for the 1950-1960 intercensal period was derived for use in preparing post-1960 census annual county population estimates. The equation states the relationship between five independent variables, which are expressed as ratios reflecting the change over the intercensal period, in a county's share of the State total for each of the symptomatic data series and the dependent variable, which is a ratio reflecting the change in the county's share of the State population over the intercensal period.³ The symptomatic data series included in the equation were births, deaths, school enrollment, employment, and motor vehicle registrations.⁴

County estimates, as of July 1, 1969, were prepared utilizing each of the three methods. The resulting three estimates for each county were then averaged to derive a single county number. These county estimates were adjusted to agree with the Census Bureau's estimate of the State's total population. As a final step, the county estimates were then extrapolated to April 1, 1970, on the basis of the annual rate of population change estimated to have occurred within each county between April 1, 1960, and July 1, 1969.

2. BACKGROUND INFORMATION ABOUT ARKANSAS' POPULATION

Arkansas' 1970 census count of 1,923,295 ranks thirtysecond in size among the 50 states, reflecting a population growth of 137,023 (7.7 percent) during the 1960's. Although this rate of increase (7.7 percent) is not as great as that of the Nation (13.3 percent), it does represent a significant reversal of a pattern experienced during the previous twenty years in which Arkansas' population fell from a 1940 count of 1,949,387 to 1,786,272 in 1960, reflecting a population loss of 163,115 (8.4 percent). Prior to this period the State's population had increased in each decennial census from an 1890 count of 1,128,211 to 1,949,387 in 1940.

Percent of total state births in county i, 1960

¹For a detailed discussion of this method see [2].

²The Bogue-Duncan Method is described in [3] and the Census Bureau's Composite Method in [4].

³For example, the value of an independent variable X, births, would be expressed as follows:

Percent of total state births in county i, 1950

⁴A description of this method is contained in [5, pp. 279-281] and [6, pp. 36-39].

Only 12 of Arkansas' 75 counties had larger populations in 1960 than in 1940. However, 46 (61.3 percent) of the State's counties experienced growth between 1960 and 1970.

Of Arkansas' 75 counties the 1970 census showed: one having a population larger than 100,000; 21 with populations ranging from 25,000 to 100,000; 20 with populations ranging from 15,000 to 25,000; and 33 counties with populations of less than 15,000.

There are four SMSA's whose central cities are located entirely (three) or partially (one) within the State. The SMSA's are Little Rock-North Little Rock; Pine Bluff; Fort Smith, Arkansas-Oklahoma; and Texarkana, Texas-Arkansas.

3. COMPARISON OF ESTIMATES TO CENSUS

As previously stated, this presentation involves a comparison of county population estimates prepared as of April 1, 1970, with Bureau of the Census counts as of the same date. The basic summary measure used in examining the relative reliability of the estimates is the average percent error. This measure is the average of the total of percentage deviations of each county estimate from its census count, signs disregarded.

Two sets of county estimates, each utilizing the three estimate techniques were prepared. One set of estimates was adjusted to agree with the State estimate total prepared by the Bureau of the Census and the other set was not adjusted.⁵

Tables 1 and 1-A show the average percent error and other summary measures of percentage error pertaining to the 1970 Arkansas county population estimates.

The average error for the adjusted county estimates (Table 1), considering each technique separately, was 7.0 percent for Ratio-Correlation Method, 7.8 percent for the Composite Method, and 9.1 percent for Component Method II. However, averaging the results of either the Composite and Ratio-Correlation or the results derived from applying all three techniques provides an even smaller average error, 6.8 percent.

Significantly smaller average errors were obtained when the estimates were not adjusted (Table 1-A). The average error for the Ratio-Correlation Method was 5.5 percent; Component Method II, 6.5 percent; and the Composite Method, 7.1 percent. An even smaller average error, 5.0 percent, is realized by averaging the results of either the application of all three techniques or the average of Component Method II and the Ratio-Correlation Method.

⁵The adjusted 1970 State estimate, based on the Component Method II and Ratio-Correlation Techniques, differed from the Bureau of the Census Count by 5.4 percent whereas, the unadjusted State estimate, based on the Component Method II and Composite Techniques differed by only 2.1 percent.

An upward adjustment in reported school enrollment to derive the population 7.5 through 14.5 years of age and the resulting effect on estimated net migration accounted for a substantial part of the difference between the adjusted and unadjusted estimates. Distributions of the State's 75 counties by size of error, utilizing an average of the three techniques (Table 1-A), indicated that five of the counties had errors in excess of ten percent, 34 in excess of five percent, and 48 in excess of three percent.

Tables 2 and 2-A seem to indicate that the average percentage error is less for metropolitan (SMSA) county estimates than for other urban and for rural counties, although population size may be a factor in this observation. For the adjusted estimates the smallest average error observed was 4.1 percent for the metropolitan (SMSA) counties; 6.5 percent for those counties whose population is 50 percent or more urban; and 6.8 percent for the rural counties. Smallest average errors for the nonadjusted estimates were 1.9 percent, 4.2 percent, and 5.2 percent respectively.

Average percentage errors by county population size are also shown in Tables 2 and 2-A. The adjusted estimates indicate that the smallest average error was 0.1 percent for the State's only county with a population of over 100,000; 6.1 percent for the 21 counties with populations between 25,000 and 100,000; 7.6 percent for the 20 counties with populations between 15,000 and 25,000; and 6.6 percent for the 33 counties with populations of 15,000 or less. For the unadjusted estimates the percents were 0.3; 4.1; 5.2; and 5.4 respectively. These average errors seem to indicate that no improvement is secured in estimates of counties with populations of 15,000 to 25,000 when compared to estimates for counties with populations of 15,000 or less.

Counties with increasing populations experienced smaller average percentage errors than counties that were losing population. Tables 3 and 3-A show that for Arkansas' 29 counties that lost population, between 1960 and 1970, the smallest average percentage error was 8.2 for the adjusted estimates and 5.3 percent for the unadjusted estimates. These percents compare to average percentage errors of 5.7 and 3.5 respectively for the 13 counties growing at an intercensal rate of less than 7.7 percent and to average percentage errors of 5.5 and 4.7 respectively for the 33 counties growing at a rate greater than 7.7 percent.

4. FINDINGS AND RECOMMENDATIONS

1. The preceding analysis shows that the adjustment of the county estimates to agree with the Bureau of the Census' State control total resulted in estimate errors (the smallest of which was an average deviation of 6.8 percent for the counties and a percentage deviation of 5.4 for the State) that were greater than desired.

2. However, the estimate errors computed on the basis of the unadjusted estimates (the smallest of which was an average error of 5.0 percent for the counties and a percentage deviation of 2.1 for the State) would have been acceptable.

3. It is recommended that the desirability of the school enrollment adjustment procedure be reevaluated prior to its continued use. This adjustment contributed substantially to the upward bias in the Arkansas population estimate. 4. Births occurring in Arkansas were corrected for underregistration on the basis of a 1950 Birth Completeness Test. This correction procedure should be modified by the Bureau of the Census to reflect improvements occurring in birth registrations, since it also contributed to the upward bias in the State estimate.

5. To summarize, results of the evaluation appear to indicate that the method utilized in constructing the estimates was appropriate (an average of Component Method II, Composite and Ratio-Correlation techniques); that the input data were sufficiently reliable; and that had the assumptions concerning the adjustments for school enrollment and births been more realistic, then the Arkansas estimates would have been within an acceptable range of error.

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TABLE 1

SUMMARY MEASURES OF PERCENTAGE ERRORS FROM 1970 CENSUS OF 1970 COUNTY POPULATION ESTIMATES, ARKANSAS

(walaster)	(▲	djusted	ι)
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$\frac{\begin{array}{c} \text{Component} \\ \text{Method II} \\ \text{Summary Measures} \end{array} \begin{pmatrix} \text{Component} \\ \text{Method II} \\ (X_1) \\ (X_2) \\ (X_3) \\ (X_3) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_3) \\ (X_1, X_2) \\ (X_1, X_2) \\ (X_2) \\ (X_1, X_2) \\ ($						
Summary Measures (x_1) (x_2) (x_3) (x_1, x_2) (x_2)	Averages					
(,x ₃)	(x ₁ ,x ₃)	(x ₁ ,x ₂ ,x ₃)			
Average error (percent) 7.1 /.0 /.0 /.0	.8	7•3	6.8			
Root mean square error 11.1 9.9 8.4 9.1 8	•3	8.7	8.2			
Number of errors in excess of 3.0 percent 61 55 56 58	56	57	55			
Number of errors in excess of 5.0 percent 50 42 44 43	41	48	46			
Number of errors in excess of 10.0 percent 31 25 18 22	16	23	21			
Number of positive errors 63 56 60 61	58	66	62			

TABLE 1-A

(Not Adjusted¹)

Average error (percent)	6.5	7.1	5•5	5•5	5.6	5.0	5.0
Root mean square error	8.0	9.0	6.9	6.9	6.9	6.0	6.1
Number of errors in exce of 3.0 percent	5 3	54	47	52	50	46	48
Number of errors in exce of 5.0 percent	55 41	38	39	35	37	33	باو
Number of errors in excent of 10.0 percent	55 19	23	9	12	10	8	5
Number of positive errors	s 49	46	43	49	49	48	52

l The State totals resulting from these county estimates were not adjusted to agree with State population estimate totals prepared by the U.S. Bureau of the Census.

Source: Industrial Research and Extension Center, University of Arkansas.

TABLE 2

AVERAGE PERCENTAGE ERRORS FROM 1970 CENSUS OF 1970 COUNTY POPULATION ESTIMATES, ARKANSAS, BY COUNTY SIZE CLASS (Adjusted¹)

	Number	Component Method II	Composite Method (X ₂)	Ratio Correlation (X ₃)		Averages				
County Size Class	Counties	(X ₁)			(X ₁ ,X ₂)	(X ₂ ,X ₃)	(x ₁ ,x ₃)	(x ₁ ,x ₂ ,x ₃)		
Group I										
Metropolitan counties, SMSA's	7	6.4	5•5	4.1	5.2	4.1	5.2	4.7		
Other urban counties (50 percent or more of population urban)	10	6.7	10.2	6.7	7.8	8.2	6.5	7.4		
Rural counties	58	9.8	7.7	7•4	7.5	6.8	7.7	7.0		
All counties	75	9 .1	7.8	7.0	7.4	6.8	7•3	6.8		
Group II										
Population 100,000 or more	1	0.1	5.0	3•7	2.5	4.3	1.9	2.9		
Population between 25,000 and 100,000	21	7.1	6.2	6.8	6.2	6.1	7.0	6.4		
Population between 15,000 and 25,000	20	9.4	8.5	7•7	8.0	7.8	7.6	7.6		
Population less than 15,000	33	10.4	8.6	6.7	7•9	6.6	7.6	6.8		
All counties	75	9.1	7.8	7.0	7.4	6.8	7•3	6.8		

1 The State totals resulting from these county estimates were adjusted to agree with State population estimate totals prepared by the U.S. Bureau of the Census.

Source: Industrial Research and Extension Center, University of Arkansas.

AVERAGE PERCENTAGE ERRORS FROM 1970 CENSUS OF 1970 COUNTY POPULATION ESTIMATES, ARKANSAS, BY COUNTY SIZE CLASS

(Not Adjusted¹)

Number Component Com	Composite Method	ite Ratio	Averages				
Counties	(X1)	(X ₂)	(X3)	(X1,X2)	(X ₂ ,X ₃)	(X1,X3)	(X1,X2,X3)
7	5.5	4.1	1.9	3.8	2.7	3.4	3.1
10	4.3	8.8	5.2	5•7	6.6	4.2	5•3
58	7.0	7.1	6.0	5•7	5.8	5.3	5.2
75	6.5	7.1	5•5	5-5	5.6	5.0	5.0
1	4.4	3.1	0.4	0.7	1.7	2.0	0.3
21	4.4	5.0	4.7	4.1	4.4	4.2	4.1
20	6.3	7.5	5.5	5•9	6.4	5.2	5.6
33	8.0	8.2	6.2	6.3	6.0	5.4	5.4
75	6.5	7.1	5.5	5•5	5.6	5.0	5.0
	7 10 58 75 1 21 20 33 75	7 5.5 10 4.3 58 7.0 75 6.5 1 4.4 21 4.4 20 6.3 33 8.0 75 6.5	7 5.5 4.1 10 4.3 8.8 58 7.0 7.1 75 6.5 7.1 1 4.4 3.1 21 4.4 5.0 20 6.3 7.5 33 8.0 8.2 75 6.5 7.1	7 5.5 4.1 1.9 10 4.3 8.8 5.2 58 7.0 7.1 6.0 75 6.5 7.1 5.5 1 4.4 3.1 0.4 21 4.4 5.0 4.7 20 6.3 7.5 5.5 33 8.0 8.2 6.2 75 6.5 7.1 5.5	Journities (\mathbf{x}_1) (\mathbf{x}_2) (\mathbf{x}_3) $(\mathbf{x}_1, \mathbf{x}_2)$ 7 5.5 4.1 1.9 3.8 10 4.3 8.8 5.2 5.7 58 7.0 7.1 6.0 5.7 75 6.5 7.1 5.5 5.5 1 4.4 3.1 0.4 0.7 21 4.4 5.0 4.7 4.1 20 6.3 7.5 5.5 5.9 33 8.0 8.2 6.2 6.3 75 6.5 7.1 5.5 5.5	Journities (X_1) (X_2) (X_3) (X_1, X_2) (X_2, X_3) 7 5.5 4.1 1.9 3.8 2.7 10 4.3 8.8 5.2 5.7 6.6 58 7.0 7.1 6.0 5.7 5.8 75 6.5 7.1 5.5 5.5 5.6 1 4.4 3.1 0.4 0.7 1.7 21 4.4 5.0 4.7 4.1 4.4 20 6.3 7.5 5.5 5.9 6.4 33 8.0 8.2 6.2 6.3 6.0 75 6.5 7.1 5.5 5.5 5.6	Jourities (X_1) (X_2) (X_3) (X_1, X_2) (X_2, X_3) (X_1, X_3) 7 5.5 4.1 1.9 3.8 2.7 3.4 10 4.3 8.8 5.2 5.7 6.6 4.2 58 7.0 7.1 6.0 5.7 5.8 5.3 75 6.5 7.1 5.5 5.5 5.6 5.0 1 4.4 3.1 0.4 0.7 1.7 2.0 21 4.4 5.0 4.7 4.1 4.4 4.2 20 6.3 7.5 5.5 5.9 6.4 5.2 33 8.0 8.2 6.2 6.3 6.0 5.4 75 6.5 7.1 5.5 5.5 5.6 5.0

1 The State totals resulting from these county estimates were not adjusted to agree with State population estimate totals prepared by the U.S. Bureau of the Census.

Source: Industrial Research and Extension Center, University of Arkansas.

TABLE 3

AVERAGE PERCENTAGE ERRORS FROM 1970 CENSUS OF OF 1970 COUNTY POPULATION ESTIMATES, ARKANSAS, BY RATE OF GROWTH

(Adjusted)

County Growth Rate Class, 1960 to 1970	Number of Counties	Component Method II (X1)	Composite Method (X ₂)	Ratio Correlation (X ₃)	Averages				
					(X1,X2)	(X2,X3)	(X1,X3)	(X1,X2,X3)	
Fast growing counties (more than 7.7 percent)	33	9.1	6.9	6.0	6.4	5•5	7.0	5.8	
Slow growing counties (less than 7.7 percent)	13	8.3	7•7	5•7	7.2	5.8	6.3	6.2	
Counties losing population	29	9.4	9.0	8.6	8.5	8.7	8.2	8.3	
All counties	75	9.1	7.8	7.0	7.4	6.8	7•3	6.8	
			TABLE	3-4					
			(Not Adju	usted ¹)					

Fast growing counties (more than 7.7 percent)	33	7.5	6.4	5.1	5•3	4.7	5•3	4.7
Slow growing counties (less than 7.7 percent)	13	5.2	6.7	4.1	4.9	4.7	3•5	4.2
Counties losing population	29	5.9	8.0	6.6	6.1	7.0	5.3	5.8
All counties	75	6.5	7.1	5•5	5-5	5.6	5.0	5.0

l The State totals resulting from these estimates were not adjusted to agree with State population estimate totals prepared by the U.S. Bureau of the Census.

Source: Industrial Research and Extension Center, University of Arkansas.