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An appraisal of the utility of current measures in estimating the population subregions of Virginia

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AN APPRAISAL OF THE UTILITY
OF CURRENT MEASURES
IN ESTIMATING THE POPULATION
OF SUBREGIONS OF VIRGINIA

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CHAPTER I

INTRODUCTION

The need for estimating population below the state level during intercensal periods has been recognized for a number of years. Many varied methods have been suggested as possible measures; this thesis will examine and test some of these current measures with respect to the situation in Virginia and will also experiment with a new technique.

The measurement of current population trends is important to the efficient operation of many segments of the economy. In order to make intercensal studies of fertility, morbidity, mortality, employment, unemployment, and relief rates, intercensal estimates of population are necessary. They are also basic to the estimation of per capita incomes and sales of various items. The worth of any studies supposedly related to population in particular areas of necessity demands reliable, up-to-date population estimates.[1]

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[1] P. K. Whelpton, Needed Population Research (Lancaster, Pennsylvania: The Science Press Printing Company, 1938), p. 11.

As Mr. Calvin F. Schmid stated in the Foreword to a study of population trends in the State of Washington:

> Future long-term plans for virtually every type of governmental program or activity, as well as for business, industry, agriculture, and even the professions, can be developed more effectively and intelligently if reliable data on population trends and forecasts are available.[1]

It is the purpose of this thesis then to test the procedures for estimating local populations by using data for Virginia.

In trying to estimate population below the state level, the twenty-three subregions of Virginia as outlined by the Bureau of Population and Economic Research at the University of Virginia were used. The counties and cities of Virginia were grouped into these subregions by the Bureau some years ago on the basis of geographical proximity and some degree of similarity in economic activity.

Many reasons may be suggested for using the regions instead of trying to work with the individual counties and cities of Virginia. Among the most important is the cumbersomeness of the task involved with the counties and cities since they number ninety-eight and thirty-two, respectively, at the present time. The census population count in 1950 showed the extreme variations in size among them; the largest political entity, Richmond City, with 230,310 inhabitants, was about sixty-seven times larger in population than Craig County, the smallest entity, with a

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[1]Calvin F. Schmid and others, Population and Enrollment Trends and Forecasts—State of Washington (Seattle: Washington State Census Board, 1953), p. i.

population numbering only 3,452 in 1950. Of the subregions which were used in this study, the largest had a population of 446,200 in 1950 while the smallest had 33,473 inhabitants, the larger being only thirteen times as great as the smallest. In particular, it has been demonstrated that the degree of distortion resulting from estimation is more likely to be greater when smaller entities are used. Therefore, in order to reduce distortion to a minimum and to make the task less cumbersome, the twenty-three subregions have been used in preference to the individual counties and cities of Virginia.

The nature of the data used in the preparation of population estimates makes it desirable to use the larger areas. Reporting of births and deaths may not always be made on the basis of residence of the individual but rather where the birth or death occurred. In most cases, use of the subregion reduces the error of residence versus place of occurrence. Again, when covered employment is one of the factors used in estimating population, the inherent situs problem caused by reporting by location of employment instead of residence of worker is virtually eliminated through use of the subregions of Virginia.

Another problem connected with estimates for individual counties and cities arises from the annexation procedures in which county territory is acquired by a city. This creates many minor problems which are troublesome in preparing estimates for small areas. Statistics available from the reporting agencies are very often one, two, and sometimes five years behind the reclassifications of areas due to annexations and the incorporations of new independent cities. These difficulties are all circumvented when larger areas, such as the twenty-three subregions of Virginia, are used.

The subregions of Virginia as outlined by the Bureau of Population and Economic Research are as follows:

Region 1.A	Arlington Area	Arlington and Fairfax counties; Alexandria and Falls Church cities
1.B	Richmond Area	Chesterfield, Dinwiddie, Henrico, Prince George counties; Colonial Heights, Hopewell, Petersburg, Richmond cities
1.C-N	Northside Hampton Roads	Hampton, Newport News, and Warwick cities
1.C-S	Southside Hampton Roads	Norfolk, Princess Anne counties; Norfolk, Portsmouth, South Norfolk, Virginia Beach cities
1.1	Eastern Shore	Accomack and Northampton counties
1.2	Southern Tidewater	Greensville, Isle of Wight, Nansemond, Southampton, Surry, Sussex counties; Suffolk city
1.3	York Peninsula	Charles City, James City, New Kent, York counties; Williamsburg city
1.4	Middle Peninsula	Essex, Gloucester, King and Queen, King William, Mathews, Middlesex counties
1.5	Northern Neck	King George, Lancaster, Northumberland, Richmond, Westmoreland counties
1.6	Fall Line	Caroline, Hanover, Spotsylvania, Stafford counties; Fredericksburg city

Region 1.7	Central Piedmont	Amelia, Appomattox, Buckingham, Cumberland, Fluvanna, Goochland, Louisa, Powhatan counties
1.8	Northwest Piedmont	Albemarle, Culpeper, Greene, Madison, Nelson, Orange, Rappahannock counties; Charlottesville city
1.9	Northern Piedmont	Clarke, Fauquier, Loudoun, Prince William counties
2.1	Central Southside	Brunswick, Charlotte, Halifax, Lunenburg, Mecklenburg, Nottoway, Prince Edward counties
2.2	Western Southside	Henry, Pittsylvania counties; Danville, Martinsville cities
3.1	Lower Shenandoah	Frederick, Page, Shenandoah, Warren counties; Winchester city
3.2	Upper Shenandoah	Augusta, Rockingham counties; Harrisonburg, Staunton, Waynesboro cities
4.1	Midwest Piedmont	Amherst, Bedford, Campbell counties; Lynchburg city
4.2	James-New River-Highlands	Alleghany, Bath, Botetourt, Craig, Highland, Rockbridge counties; Buena Vista, Clifton Forge, Covington cities
4.3	Roanoke-Radford	Giles, Montgomery, Pulaski, Roanoke counties; Radford, Roanoke cities
5.1	Blue Ridge-Piedmont	Floyd, Franklin, Patrick counties
5.2	Central Southwest	Bland, Carroll, Grayson, Scott, Smyth, Washington, Wythe counties; Bristol, Galax cities
5.3	Cumberland	Buchanan, Dickenson, Lee, Russell, Tazewell, Wise counties; Norton city

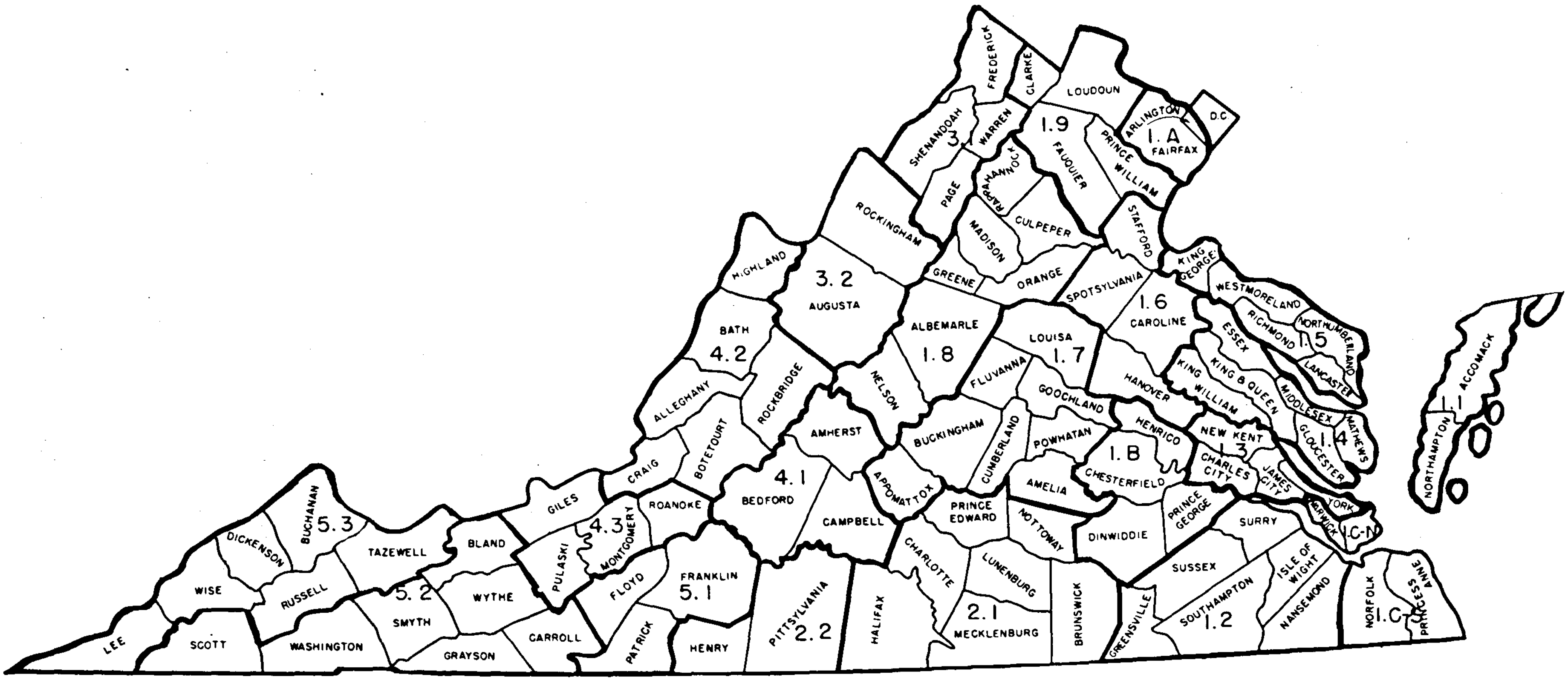
The map on page 7 shows the geographical proximity of the counties and cities in each region.

Thus far in the first chapter, the need for intercensal estimates of population below the state level has been demonstrated. The possible meaning and worth of up-to-date and reliable estimates of area population trends to the economist, to the demographer, to the businessman, to the manufacturer, and to the government official have been pointed out. Also, use of the twenty-three subregions of Virginia as the entities for population estimates has been explained as being less cumbersome than use of the counties and cities, as probably cutting down on the degree of distortion, and as eliminating many problems involved with the data which were used as factors in some of the estimating methods. Lastly, this first section will be concluded with a brief explanation of what is to follow in the next four chapters.

Chapter II deals with recent attempts to estimate population during intercensal periods, with primary emphasis on the techniques most widely used at the present time. The oldest of the methods described in this section makes use of mathematical techniques, arithmetic projection and apportionment, in which reliance is placed on developments of the recent past decade. Although relatively little success has been experienced with these mathematical techniques during the past two decades, they are still used by many states. Another scheme, and perhaps the most time-consuming, is that currently used by the Bureau of the Census for estimating the population of states. This method utilizes statistics

FIGURE I

THE SUBREGIONS OF VIRGINIA



on school enrollment to provide the migration factor plus the actual natural increase figures which are the net of births over deaths. Actually, there are two versions of this scheme: Method I referred to by the Bureau of the Census as being the short-cut version; and Method II, a longer involved technique in current use by the Bureau. A satisfactory degree of success has been experienced with Method II.

The latest attempts to arrive at reliable intercensal population estimates concern themselves with simple symptomatic data, such as births, deaths, school membership, car registrations, registered voters, and county welfare recipients. Two methods utilizing these symptomatic data are the proration and the censal ratio techniques. Another method designated as "vital rates" involves computing two estimates of population by applying the estimated birth and death rates to the number of births and deaths, respectively, and averaging the two results.

Chapter III presents a description of a new method of population estimation developed by the Bureau of Population and Economic Research. This technique, termed a multiple factor method, also employs symptomatic data. Four factors are used as measures of change in births, in deaths, in school enrollment as expressed by average daily attendance in public, primary, elementary, and high schools, and in employment as measured by employment covered under the Unemployment Compensation Act of Virginia.

The third chapter will also include the actual measurement of these dynamic forces in operation in the economies of small areas of Virginia and the relationship of these forces to population trends.

Each factor—births, deaths, school enrollment, and covered employment—will be considered separately and in combination with others as possible indicators of the trend of population growth or diminution in the twenty-three subregions of Virginia. The years 1940 and 1950 will be used as benchmark years for the obvious reasons that census counts are complete for those years and they encompass the most recent past decade. Relationships of the four factors to population trends in the forty-eight states and the District of Columbia will also be pointed out.

Chapter IV presents the results obtained when the factors are combined into a single estimator of population, an index of change, and applied to the 1940-50 data for the Virginia subregions and the states. The results are tested for accuracy and compared with results obtained from several other recent methods.

Presented in the concluding chapter are estimates of population for the subregions of Virginia for 1954 based on the multiple factor technique. Estimates based on several other methods are also included. The conclusions that may be drawn from an appraisal of current measures of estimating intercensal population are discussed, while further use of the multiple factor technique is suggested.

CHAPTER II

RECENT ATTEMPTS TO ESTIMATE POPULATION BELOW THE STATE LEVEL

In this chapter a number of techniques in present-day use will be discussed and tested on the subregions of Virginia. The extent of usage of the various methods was studied by the Bureau of the Census just last year. The results of their survey of current methods of making population estimates by agencies in state governments throughout the country were published in a pamphlet dated June 6, 1955, under the title "Current Status of Population Estimates Prepared by State Agencies."

The Bureau of the Census found that in all but seven states there was at least one agency preparing the estimates for local areas. Nine states had two or more agencies making estimates for localities. The most popular technique used was some form of the migration and natural increase method in which those components of population change were estimated separately. Of the fifty-one state agencies surveyed, sixteen used one or another form of this technique. The variation of this method as set up by the Bureau of the Census for making its annual state estimates was followed by eight of the sixteen state agencies using migration and natural increase.

Six states used natural increase alone. This method involved adding postcensal natural increase (the excess of births over deaths) to the census count. No allowance is made for net in- or out-migration in this method. Other methods included arithmetic projection, utilized by nine agencies, which involved applying the average yearly increase in the most recent intercensal period to the postcensal year to find yearly absolute growth.

The censal ratio method was the technique applied by six more state agencies. In this technique symptomatic data, such as school data, births and deaths, are used and related to the last census counts as ratios. These ratios are then applied to postcensal symptomatic data on the premise that the ratios remained constant. Still another method utilized to some extent was the technique developed by Donald J. Bogue designated as "vital rates." Birth and death rates were found for the census year and applied to numbers of births and deaths in a subsequent year to obtain two separate estimates of population which were then averaged.[1]

These varied methods surveyed by the Bureau of the Census are discussed in the next sections. Certain ones are tested on the twenty-three subregions of Virginia.

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[1] U. S. Bureau of the Census, Current Population Reports, Series P-25, No. 116, "Current Status of Population Estimates Prepared by State Agencies," June 6, 1955, pp. 1-2.

Arithmetic Techniques: Projection and Apportionment

The arithmetic projection technique used the average yearly increase in the most recent intercensal period for the area in question as being equal to the yearly absolute growth in the postcensal period.[1] Thus, if the decade 1930-40 were studied as the basis for projection into the 1940's, the estimates contained in Table 1 would result. (The projection is actually made for 1950 since the census of that year may be used for comparison. No averaging was needed in this instance because ten times the average yearly growth in the 1930-40 decade would be equal to the actual increase in the census count.)

The average percentage deviation (signs disregarded) of the estimates for 1950 using the arithmetic projection method was 10.1. The quadratic mean deviation, that is, the square root of the arithmetic mean of the squares of the deviations, yielded 14.6.

The second mathematical technique tested was the apportionment formula which was used by the Bureau of the Census from 1926 to 1934 for its estimates of state and city population.[2] The underlying assumption in this method is that the estimated postcensal increase or decrease in the state population was divided among the areas of the state according

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[1] Ibid., p. 2.

[2] Robert C. Schmitt, "Short-Cut Methods of Estimating County Population," Journal of the American Statistical Association, 47 (258), June 1952, 232, citing Henry S. Shryock, Jr., "Methods of Estimating Postcensal Populations," American Journal of Public Health, Vol. 28, 1938, p. 1042.

TABLE 1

SUBREGIONS OF VIRGINIA—ESTIMATION OF 1950 POPULATION
BY ARITHMETIC PROJECTION AND BY APPORTIONMENT

Region	Arithmetic projection				Apportionment			
	Absolute increase 1930-40	Estimated 1950 population	1950 census count	% devi-ation	% devi-ation	Shares of 1930-40 change	1940-50 estimated change	Estimated 1950 population
1-A	55,464	186,956	303,328	-38.4	-10.9	20.9	138,683	270,175
1-B	27,905	363,792	417,918	-13.0	- 3.0	10.5	69,674	405,561
1-C-N	15,033	99,529	143,227	-30.5	-14.6	5.7	37,823	122,319
1-C-S	29,292	288,219	446,200	-35.4	-25.6	11.0	72,992	331,919
1.1	- 3,792	46,835	51,132	- 8.4	-19.6	-41.9	- 9,493	41,134
1.2	1,817	109,298	114,329	- 4.4	- 1.9	0.7	4,645	112,126
1.3	1,620	27,693	33,473	-17.3	-10.2	0.6	3,981	30,054
1.4	- 3,514	41,671	44,624	- 6.6	-18.5	-38.9	- 8,812	36,373
1.5	177	41,003	41,699	- 1.7	- 0.5	0.1	664	41,490
1.6	4,767	66,731	70,436	- 5.3	4.9	1.8	11,944	73,908
1.7	- 806	72,490	70,649	2.6	0.9	- 8.9	- 2,016	71,280
1.8	602	107,800	111,800	- 3.6	- 2.9	0.2	1,327	108,525
1.9	4,186	70,413	72,061	- 2.3	6.6	1.6	10,617	76,844
2.1	- 934	152,028	154,125	- 1.4	- 2.3	-10.3	- 2,333	150,629
2.2	19,543	150,550	149,632	0.6	20.4	7.4	49,104	180,111
3.1	5,347	78,563	82,500	- 4.8	4.8	2.0	13,271	86,487
3.2	9,072	105,238	112,327	- 6.3	5.9	3.4	22,760	118,926
4.1	8,892	129,441	126,563	2.3	12.9	3.4	22,362	142,911
4.2	4,538	92,688	87,090	6.4	14.2	1.7	11,281	99,431
4.3	14,085	191,867	218,927	-12.4	- 2.7	5.3	35,169	212,951
5.1	2,622	57,066	51,553	10.7	18.5	1.0	6,636	61,080
5.2	20,198	201,285	189,154	6.4	22.4	7.6	50,431	231,518
5.3	39,808	252,539	225,913	11.8	38.5	15.1	100,197	312,928

to their shares in the state change of the previous intercensal decade. This method, when applied to the twenty-three subregions of Virginia on the 1930-40 base, produced estimates for 1950 which were slightly more in error than those obtained from the projection method. These estimates are included in Table 1. The average percentage deviation was 11.4 and the quadratic mean deviation was 14.9

Migration and Natural Increase Methods

The migration and natural increase methods were formulated by the Bureau of the Census and are used in their current yearly estimates of the populations of states. The techniques are based on the reasoning that the population of an area at the close of a period is equal to its population at the beginning of the period plus natural increase (the excess of births over deaths), plus or minus the net in-migration or out-migration.[1]

The migration factor is estimated in two ways by the Census Bureau, thus differentiating Method I from Method II. Both are based on changes in school enrollment figures, the procedure designated Method I being simpler in operation than Method II.

In Method I the percentage change in enrollment in the elementary grades (one through eight) of the public schools (and private and parochial,

[1] U. S. Bureau of the Census, Current Population Reports, Series P-25, No. 20, "Illustrative Examples of Two Methods of Estimating the Current Population of Small Areas," May 6, 1949, p. 1.

if available) of an area from the base date to the date for which the estimate is wanted is first determined. Next, the percentage change in the number of children six to thirteen years of age in the United States for those dates is subtracted. This correction factor is based on the premise that school enrollment for an area may be expected to increase or decrease, even without migration, somewhat as the total number of children of school age for the United States increases or decreases.

The resulting percentage change in school enrollment is used as the change in the migration pattern of the total population of an area, and when applied to the base date population gives the amount of in- or out-migration that has occurred over the period. Thus, the base date population plus migration plus the excess of births over deaths during the period provides an estimate of population for an area for the intercensal year.[1]

A few other corrections are sometimes made, one of which is necessary when there is a large military population present. In that event, the number in the armed forces is removed and estimated separately.

Method II involves a more complicated procedure for determining migration, but there is evidence of more accurate results obtainable from this technique. The migration factor is based on the difference between the population of elementary school age as estimated from school

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[1]Hope Tisdale Eldridge, U. S. Bureau of the Census, Population—Special Reports, Series P-47, No. 4, "Suggested Procedures for Estimating the Current Population of Counties," April 30, 1947, pp. 1-5.

enrollment data and the expected population of elementary school age, had there been no migration since the base date.

In order to determine the expected population six through thirteen years of age on the estimate date, survival rates are applied to a single-year-of-age distribution of the desired cohort in the last census population count. Thus, the proper cohort on the base date is "aged" to the estimate date desired. The population of school age on the base date is related to school enrollment on that date and expressed as a ratio. When this ratio is applied to school enrollment on the estimate date, an estimated population of school age including the effect of migration is obtained.

The difference between the estimated population and the expected population which was obtained through application of survival rates is the net change due to migration in this age group. Dividing the migration figure by the base date population of the proper age group yields a percentage change which is applied to total population as the rate of migration. This application is based on the assumption that the migration rate of children is the same as that of all ages combined.[1]

The above description is brief and does not include mention of any of the special adjustments made. However, it does offer a general idea of the functioning of this technique of population estimation. Neither Method I nor Method II employing migration and natural increase

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[1] _Ibid._, pp. 5-6.

was tested on the 1940-50 data for the subregions of Virginia. Grade-age distributions are not published for the localities of Virginia. They are available only on the state level. Also, differential migration rates during the war years were such that these methods could hardly be expected to yield results significantly more accurate than some of the short-cut methods tested. For these reasons the migration and natural increase methods were not tested on the subregions.

These methods have been tested by the Bureau of the Census as techniques for population estimation of states. Their conclusion was:

> . . . that Method II on the average may be expected to yield more accurate estimates than Method I, and that on the average either may be depended upon to yield more accurate estimates than would arithmetic projection based on figures from the last two censuses, or the apportionment method formerly used by the Bureau of the Census.[1]

Methods Utilizing Symptomatic Data

A technique of population estimation based on the changes in one or more series of statistical data believed to be symptomatic of the direction of population change is a short-cut method as compared with the migration and natural increase methods previously discussed. A considerable amount of current work is being done in testing various indicators for their reliability.

Symptomatic data may be either indirect, that is, in units other than persons, or direct, expressed in terms of numbers of people.

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[1]U. S. Bureau of the Census, Current Population Reports, Series P-25, No. 20, op. cit., p. 1.

Utility outlets, housing units, rural route boxes, registered passenger automobiles, and postal receipts are among those indicators which would classify as indirect symptomatic data. Direct and expressed in numbers of persons, whether limited to certain elements of the population or all elements, are such data as births, deaths, school enrollment, city directories, election registers, county welfare recipients, and employment.[1]

In the individual instance of testing in a particular state or area, the first decision to be made is the choice of currently available data. The bases for choosing suitable data would include the following:

1) Accurate official records are maintained and are made available to the public at reasonable intervals of time, at least biennially.

2) Data for both the most recent census and the postcensal period must be comparable and available.

3) Each kind of data should comprise a large number of cases or at least represent a relatively large percentage of the population of which it is symptomatic.

4) The ratio of symptomatic data to total population is relatively constant from area to area and year to year.[2]

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[1]Carl M. Frisen, "Symptomatic Data in Population Estimates: Problems and Limitations," Research Studies of the State College of Washington, 19(2), June 1951 (Pullman, Washington: State College of Washington), p. 107.

[2]Schmitt, op. cit., p. 232.

There also remains the question of the degree to which the data take into account the effect of relevant factors other than population change.[1]

With these principles in mind the choice of which series of symptomatic data to be used is made. The technique of applying the data to the individual situation is another problem, and various techniques would be tried and the results tested for accuracy. Three techniques utilizing symptomatic data have been applied to the subregions of Virginia; they are described and the results shown in the next sections.

The series of data used in Virginia were number of yearly births; number of yearly deaths; school enrollment as expressed by average daily attendance (adjusted) in the public primary, elementary, and high schools; and employment, that is, the average yearly covered employment under the Unemployment Compensation Act. Reasons for these choices are explained in the next chapter. Table 2 gives the ratios of population to these series of symptomatic data in Virginia, the coefficients of variation among the twenty-three subregions, and the correlation coefficients between 1940 and 1950 by subregion.

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[1] Frisen, op. cit., p. 107.

TABLE 2

RATIOS OF POPULATION TO SYMPTOMATIC DATA IN VIRGINIA

Type of data	Ratio (for entire state)		Coefficient of variation (23 subregions)		Correlation coefficient between 1940 and 1950 by subregion
	1940	1950	1940	1950	
Births	46.8404	39.5840	12.5	8.4	plus .61
Deaths	93.8614	112.6504	13.9	16.8	plus .78
School enrollment	5.4529	6.2158	12.1	18.6	plus .94
Covered employment	8.4409	6.6963	73.0	49.5	plus .96

Proration Method

The proration method consisted of a simple allocation of postcensal state population on the basis of each type of symptomatic data under consideration. It was simple and independent of decennial census data but dependent upon a reliable postcensal estimate of state population. The Bureau of the Census' annual state estimates might prove most trustworthy in the majority of cases.

The accuracy of the proration method depends upon the degree of equality in the population-to-symptomatic data ratios for all subregions.[1] Table 2 gives the coefficients of variation for the indicators selected.

[1]Schmitt, op. cit., p. 234.

Singly, births would appear to be the most reliable estimator for 1950 and covered employment the least, since the intersubregional differences were lowest among births and highest among numbers of covered employees.

Table 3 presents a utilization of the proration method for the subregions of Virginia in 1950. Estimates from the single indicators may be averaged and weighted in many different ways so as to provide the most accurate estimates. Schmitt, in his analysis using the thirty-nine counties of the State of Washington, suggested weighting by the reciprocals of the ratios of symptomatic data to state population. Also used by Schmitt, and providing the most accurate results in his study, was a weighting system using the reciprocals of the coefficients of variation. Schmitt worked with six series of symptomatic data in Washington and so chose the three series in each case which suggested the highest degree of validity.[1] These weighting methods were tested on the subregions of Virginia and are included in Table 14 in Chapter IV.

Censal Ratio Method

The censal ratio technique involved a number of steps, first of which was the computation of censal ratios of population to symptomatic data for each subregion. These ratios for 1940 and 1950 for the areas of Virginia using the four series of symptomatic data chosen are shown in Table 4.

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[1] *Ibid.*, pp. 236-237.

TABLE 3

PRORATION METHOD OF POPULATION ESTIMATION: VIRGINIA, 1950

Region	Share of births	Population estimate	Share of deaths	Population estimate	Share of school enrollment	Population estimate	Share of covered employment	Population estimate	Population estimates: equal weighting
1-A	10.68	354,435	5.90	195,802	6.27	208,081	5.94	197,130	238,862
1-B	11.59	384,635	14.02	465,279	9.86	327,222	22.37	742,389	479,881
1-C-N	4.58	151,996	3.83	127,105	3.78	125,446	4.51	149,672	138,555
1-C-S	13.77	456,982	12.12	402,224	10.37	344,147	12.02	398,905	400,564
1.1	1.46	48,453	2.17	72,015	1.40	46,462	.88	29,204	49,034
1.2	3.70	122,791	4.22	140,048	3.90	129,428	2.61	86,618	119,721
1.3	.94	31,196	1.00	33,187	1.01	33,519	.64	21,240	29,786
1.4	1.17	38,829	1.91	63,387	1.51	50,112	.76	25,222	44,388
1.5	1.11	36,837	1.61	53,431	1.53	50,776	.61	20,244	40,322
1.6	2.02	67,037	2.43	80,644	2.24	74,338	1.70	56,418	69,609
1.7	1.94	64,382	2.84	94,251	2.61	86,618	.73	24,226	67,369
1.8	3.01	99,892	3.86	128,101	3.61	119,804	2.49	82,635	107,608
1.9	2.03	67,369	2.35	77,989	2.32	76,993	.70	23,231	61,396
2.1	4.74	157,305	5.38	178,545	5.86	194,475	2.96	98,233	157,140
2.2	4.80	159,297	4.18	138,721	5.18	171,908	7.22	239,609	177,384
3.1	2.32	76,993	2.88	95,578	2.79	92,591	2.72	90,268	76,358
3.2	3.19	105,866	3.37	111,840	3.34	110,844	4.19	139,053	116,901
4.1	3.63	120,468	4.08	135,402	4.02	133,411	5.23	173,567	140,712
4.2	2.44	80,976	2.83	93,919	3.04	100,888	2.53	83,963	89,936
4.3	6.05	200,780	6.37	211,400	6.61	219,365	9.37	310,960	235,626
5.1	1.46	48,453	1.56	51,771	1.99	66,042	.51	16,925	45,798
5.2	5.25	174,231	5.21	172,903	7.13	236,622	4.41	146,354	182,528
5.3	8.12	269,477	5.88	195,138	9.63	319,588	4.90	162,614	236,704

TABLE 4

RATIOS OF POPULATION TO SYMPTOMATIC DATA—SUBREGIONS OF VIRGINIA, 1940 AND 1950

Region	Births		Deaths		School enrollment		Covered employment	
	1940	1950	1940	1950	1940	1950	1940	1950
1-A	46.6038	33.8309	116.47	178.11	7.02	9.05	12.37	10.29
1-B	60.3788	43.1644	88.62	97.35	6.40	7.94	4.28	3.77
1-C-N	50.1758	36.3890	92.45	127.31	6.09	7.11	5.60	6.41
1-C-S	51.2828	38.1563	83.66	121.55	6.50	8.06	6.83	7.49
1.1	60.3421	43.2589	68.67	79.40	6.01	6.86	22.42	11.79
1.2	42.9409	37.0717	77.32	91.83	5.49	5.48	10.58	8.82
1.3	49.6628	41.4270	89.60	109.39	5.60	6.20	19.69	10.56
1.4	55.5781	47.5736	76.07	80.69	4.99	5.56	22.10	11.76
1.5	50.4025	44.6935	77.91	91.04	4.58	5.10	31.31	13.90
1.6	48.2962	43.0801	81.42	102.83	4.94	5.89	11.13	8.37
1.7	47.3794	42.6110	85.63	87.54	5.04	5.08	32.22	19.41
1.8	47.8136	42.4933	89.86	97.47	5.44	5.80	14.88	9.05
1.9	50.9047	42.4006	86.12	100.53	5.34	5.82	43.31	20.86
2.1	42.3835	38.6472	94.01	99.37	4.85	4.93	21.81	10.51
2.2	40.8631	37.0835	101.16	121.85	5.16	5.40	5.00	4.18
3.1	50.8092	42.7240	86.44	98.21	5.49	5.55	9.81	6.12
3.2	49.9045	42.3556	96.55	111.21	5.66	6.28	7.99	5.41
4.1	50.2916	42.6569	99.30	106.00	5.45	5.88	6.68	4.88
4.2	49.0540	44.1409	100.63	106.47	5.07	5.36	10.63	6.94
4.3	49.6182	42.6094	104.52	115.90	5.26	6.20	6.45	4.72
5.1	41.9769	41.9813	109.77	116.11	4.15	4.86	49.14	20.29
5.2	42.3298	43.0287	111.03	127.03	5.01	4.96	14.19	8.66
5.3	32.5975	33.7435	117.47	128.72	4.58	4.40	10.45	9.31

The second step involved the application of the censal ratios to postcensal symptomatic data to obtain tentative postcensal population estimates.[1] The assumption underlying this step was that the ratios of population to symptomatic data were relatively stable over time. The estimates were then adjusted to make them total an independent state-wide estimate. As illustrated in Table 5, the 1940 censal ratios of population to school enrollment were applied to the 1950 school enrollment figures for a preliminary estimate for 1950. The actual state census count for 1950 was then used as the control, and the tentative regional estimates were adjusted to it. The last column shows the percentage differences between the estimates and the actual 1950 Census count.

The average percentage deviation was 6.85, while the standard error of estimate reached 8.25. Results obtained when estimates based on the other series were used and weighted by various techniques are shown in Table 14 in Chapter IV.

"Vital Rates" Method

The "vital rates" method developed by Donald J. Bogue was a modified version of a procedure suggested by P. K. Whelpton in the late thirties. Since the number of births and deaths which occur each year among a population is roughly proportional to the size of the population, it was felt that through the use of a few statistical refinements this

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[1] Ibid., p. 235.

TABLE 5

ESTIMATION OF POPULATION BY CENSAL RATIO METHOD USING SCHOOL ENROLLMENT DATA

Region	1940 ratios of population to school enrollment	1950 school enrollment	Preliminary population estimate for 1950	Shares in state total	Estimates adjusted to state census count	Per cent difference—estimates and census counts
1-A	7.02	33,524	235,338	7.96	264,167	-12.9
1-B	6.40	52,642	336,909	11.40	378,330	- 9.5
1-C-N	6.09	20,152	122,726	4.16	138,057	- 3.6
1-C-S	6.50	55,370	359,905	12.18	404,215	- 9.4
1.1	6.01	7,458	44,822	1.52	50,444	- 1.4
1.2	5.49	20,862	114,532	3.87	128,433	+12.3
1.3	5.60	5,399	30,234	1.03	34,182	+ 2.1
1.4	4.99	8,032	40,080	1.35	44,802	+ 0.4
1.5	4.58	8,180	37,464	1.27	42,147	+ 1.1
1.6	4.94	11,960	59,082	2.00	66,374	- 5.8
1.7	5.04	13,905	70,081	2.37	78,653	+11.3
1.8	5.44	19,274	104,851	3.55	117,813	+ 5.4
1.9	5.34	12,388	66,152	2.24	74,338	+ 3.1
2.1	4.85	31,285	151,732	5.13	170,248	+10.5
2.2	5.16	27,697	142,916	4.84	160,624	+ 7.3
3.1	5.49	14,858	81,570	2.76	91,596	+11.0
3.2	5.66	17,881	101,206	3.43	113,831	+ 1.3
4.1	5.45	21,425	116,766	3.95	131,088	+ 3.6
4.2	5.07	16,248	82,377	2.79	92,591	+ 6.3
4.3	5.26	35,290	185,625	6.28	208,413	- 4.8
5.1	4.15	10,612	44,040	1.49	49,448	- 4.1
5.2	5.01	38,097	190,866	6.46	214,387	+13.3
5.3	4.58	51,369	235,270	7.97	264,499	+17.1

principle could be converted into a technique for making postcensal population estimates. The method itself involved relating the crude birth and death rates of a sub-area for which a postcensal population estimate was desired to the known or accurately estimated rates for the larger area—as in the case of Virginia, relating the subregions to the state.[1]

Estimates based on the birth rate and the death rate are obtained and averaged. Because of the inverse relation between annual changes in the two, a combination of the two series should tend to make the estimates of a sub-area agree more closely with the trend of the larger area than either series alone.[2] Admittedly, there are differences between birth and death rate trends among areas, but the differences do not become large during an intercensal period.[3]

Table 6 contains an application of the "vital rates" method to the twenty-three subregions of Virginia, using 1940 as the base year for estimates of 1950. One step which Bogue outlined has not been included; that is, investigating how the crude birth and death rates of the various subregions have behaved in the recent past in relation to the trend of

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[1]Donald J. Bogue, "A Technique for Making Extensive Population Estimates," Journal of the American Statistical Association, 45 (250), June 1950, p. 150.

[2]P. K. Whelpton, Needed Population Research (Lancaster, Pennsylvania: The Science Press Printing Company, 1938), p. 15, citing Harold Hotelling and Floy Hotelling, "Causes of Birth Rate Fluctuations," Journal of the American Statistical Association, 26 (174), June 1931, pp. 135-149.

[3]Whelpton, op. cit., p. 15.

vital rates in the state. If a definite change of ratio over time has been discerned for any subregion, a correction factor should be devised and applied to the ratio of the base year in order to obtain a "corrected" ratio for the year of the estimate.[1] The average percentage deviation was 3.79, while the standard error of estimate was 4.58.

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[1]Bogue, *op. cit.*, pp. 150-156.

TABLE 6

ILLUSTRATION OF "VITAL RATES" METHOD OF POPULATION ESTIMATION

Step 1: Computation of Crude Birth and Death Rates for Virginia and the Subregions, 1940

Region	Number of births, 1939-40 average	1940 census population	Crude birth rate	Ratio of subregional rate to state	Number of deaths, 1939-40 average	Crude death rate	Ratio of subregional rate to state
1-A	2,585	131,492	19.6	94.7	1,106	8.4	80.0
1-B	5,375	335,887	16.0	77.3	3,761	11.2	106.7
1-C-N	1,467	84,496	17.4	84.1	848	10.0	95.2
1-C-S	4,584	258,927	17.7	85.5	2,868	11.1	105.7
1.1	843	50,627	16.6	80.2	732	14.4	137.1
1.2	2,478	107,481	23.1	111.6	1,381	12.8	121.9
1.3	515	26,073	19.8	95.6	292	11.2	106.7
1.4	795	45,185	17.6	85.0	588	13.0	123.8
1.5	784	40,826	19.2	92.8	518	12.7	121.0
1.6	1,246	61,964	20.1	97.1	736	11.9	113.3
1.7	1,541	73,296	21.0	101.4	849	11.6	110.5
1.8	2,223	107,198	20.7	100.0	1,200	11.2	106.7
1.9	1,317	66,227	19.9	96.1	779	11.8	112.4
2.1	3,631	152,962	23.7	114.5	1,632	10.7	101.9
2.2	3,143	131,007	24.0	115.9	1,274	9.7	92.4
3.1	1,422	73,216	19.4	93.7	862	11.8	112.4
3.2	1,842	96,166	19.2	92.8	989	10.3	98.1
4.1	2,404	120,549	19.9	96.1	1,236	10.2	97.1
4.2	1,781	88,150	20.2	97.6	884	10.0	95.2
4.3	3,401	177,782	19.1	92.3	1,677	9.4	89.5
5.1	1,315	54,444	24.2	116.9	488	9.0	85.7
5.2	4,172	181,087	23.0	111.1	1,608	8.9	84.8
5.3	6,498	212,731	30.5	147.3	1,726	8.1	77.1
State	55,358	2,677,773	20.7	100.0	28,034	10.5	100.0

TABLE 6 (continued)

Step 2: Estimation of Crude Birth and Death Rates and Estimated Population, 1950 (Unadjusted)

Region	Estimated crude birth rate, 1950	Number of births 1950	Estimated population	Estimated crude death rate, 1950	Number of deaths 1950	Estimated population	Average estimated population	Shares of estimate
1-A	23.4	8,761	374,402	7.1	1,754	247,042	310,722	9.10
1-B	19.1	9,503	497,539	9.5	4,159	437,789	467,664	13.70
1-C-N	20.8	3,755	180,529	8.5	1,138	133,882	157,206	4.61
1-C-S	21.1	11,289	535,024	9.4	3,597	382,660	458,842	13.45
1.1	19.8	1,192	60,202	12.2	645	52,869	56,536	1.65
1.2	27.6	3,034	109,928	10.8	1,250	115,741	112,834	3.31
1.3	23.6	775	32,839	9.5	299	31,474	32,156	.94
1.4	21.0	960	45,714	11.0	565	51,364	48,539	1.42
1.5	22.9	906	39,563	10.8	480	44,444	42,004	1.23
1.6	24.0	1,655	68,958	10.1	719	71,188	70,073	2.06
1.7	25.0	1,593	63,720	9.8	845	86,224	74,972	2.19
1.8	24.7	2,471	100,040	9.5	1,146	120,632	110,336	3.24
1.9	23.7	1,658	69,958	10.0	697	69,700	69,829	2.04
2.1	28.3	3,893	137,562	9.1	1,595	175,275	156,418	4.59
2.2	28.6	3,932	137,482	8.2	1,240	151,220	144,351	4.23
3.1	23.1	1,900	82,251	10.0	857	85,700	83,976	2.46
3.2	22.9	2,619	114,367	8.7	1,000	114,942	114,654	3.36
4.1	23.7	2,978	125,654	8.6	1,209	140,581	133,118	3.90
4.2	24.1	1,999	82,946	8.5	841	98,941	90,944	2.66
4.3	22.8	4,958	217,456	8.0	1,891	236,375	226,916	6.65
5.1	28.9	1,199	41,488	7.6	463	60,921	51,204	1.50
5.2	27.4	4,303	157,044	7.5	1,545	206,000	181,522	5.32
5.3	36.4	6,653	182,775	6.9	1,745	252,898	217,836	6.39
State	24.7	81,986		8.9	29,680		3,412,652	

TABLE 6 (continued)

Step 3: Adjustment of Estimated Population to Census Total "Vital Rates" Method

Region	Estimated population (adjusted)	Per cent deviation from census
1-A	302,000	-0.4
1-B	454,659	+8.8
1-C-N	152,991	+6.8
1-C-S	446,362	0.0
1.1	54,758	+7.1
1.2	109,848	-3.9
1.3	31,196	-6.8
1.4	47,125	+5.6
1.5	40,820	-2.1
1.6	68,365	-3.0
1.7	72,679	+2.9
1.8	107,525	-3.8
1.9	67,701	-6.1
2.1	152,327	-1.2
2.2	140,380	-6.2
3.1	81,640	-1.0
3.2	111,508	-0.7
4.1	129,428	+2.3
4.2	88,277	+1.4
4.3	220,692	+0.8
5.1	49,780	-3.4
5.2	176,554	-6.7
5.3	212,064	-6.1

CHAPTER III

A MULTIPLE-FACTOR TECHNIQUE

A method of population estimation developed by the Bureau of Population and Economic Research at the University of Virginia involves the weighting and combination of four series of symptomatic data, each expressed as an index of change over the base period. The reasons for the choice of data and the technique of combination were based on current availability of the statistical series and ease with which they are transposed into indicators of the trend of population change. The purpose was to obtain a short-cut method of estimation with considerable reliability.

With respect to the symptomatic data chosen and its availability, the number of births and the number of deaths by locality may be obtained within six or eight months of their occurrence. School enrollment figures (in this case, the average daily attendance, adjusted for tuition pupils, of the public primary, elementary, and high schools) are available less than one year after the completion of the school year. Covered employment numbers by locality are published quarterly by the Unemployment

Compensation Commission anywhere from two to three quarters after completion of the period in question. Also, these series of data are available for the most recent census year and are comparable to the data for the post-censal period.

The rationale for using data on births and deaths is fairly obvious since these are direct measured changes in the population. If births are increasing or if the number of deaths is rising in an area, the assumption would be that the population is increasing because the number of women in the child-bearing age group would be increasing or the number of persons exposed to death had risen. However, when an index of change in births is applied to total population, an overestimate would result in times when the birth rate itself is rising (as in most areas during the 1940-1950 decade), and there would be a tendency to underestimation where there is a declining birth rate. The same is true of the death rate, only the reverse occurred during the 1940-1950 decade when the death rate declined in all but a few states and subregions and the population estimates based on the change in the number of deaths were low. Because of these opposite changes in direction of the crude birth and death rates in most areas during the 1940-1950 decade, a combination and averaging of the two tended to cancel some of the error which resulted from use of one measure alone.

The use of births and deaths, however, does not give effect currently to happenings which may induce in- or out-migration of sizeable proportions. Births and deaths are not sensitive indicators in that they do not generally immediately reflect migration, and, in fact, may not show migration at all but simply a change in the birth or death rate itself.

The other two measures selected, school enrollment and covered employment, are considered to be more sensitive indicators of migration trends. School enrollment may not reflect migration quite as quickly as employment since there is a deterrent for the family with children of school age to pull up stakes and move to a new area before the school year is completed. The head of the household may move on to accept a good job offer (and the move would be reflected in employment statistics), then send for the family at the end of the school term or year. Even more important, migration is an easier task for unmarried males and females; if the employment measure is not considered in estimating migration, the impact of their moves into or out of an area would not be demonstrated for several years, until they married and bore children, sent their children to school, or died.

Some measure of school enrollment has long been considered a good indicator of the direction of migration. Indeed, the migration and natural increase method of the Bureau of the Census discussed in the last chapter is based on the assumption that the migration rate of the total population is the same as that of children in the school age group. The measure of school enrollment used by the Census and the measure of preference according to many demographers is the number of school children aged 6 through 13 years. Since the requirements of law pertain to this group almost without exception, it is presumed that this group will be least affected by any influence other than simply an increase in population of that age.

However, in the multiple-factor technique herein described, school enrollment is composed of average daily attendance (adjusted for tuition pupils) in the public primary, elementary, and high schools. This is used as the measure for several reasons. In the first place, data on age-grade distributions are not published for the localities of Virginia, being available only on the state level so that the preferred measure cannot be obtained. Secondly, although average daily attendance figures for the primary, elementary, and high schools may be gotten separately so that the first two might be summed to provide the age group most closely approximating the census group, the figures are not adjusted for tuition pupils from outside the area. And because of the inclusion of the eighth grade at varying times throughout the state, adjustments and refinements in many areas would be necessary to make the data comparable. Another reason for using the total attendance adjusted was that this figure is published and no further computation is necessary. Finally, and most important, there has not been sufficient evidence that all the refinements and adjustments aimed at securing a "clean" figure have produced results which are significantly better than the cruder shorter methods provide.

It has already been pointed out that the utilization of an employment measure may pick up migration more quickly than any other measure. Also, the migration of young unmarried population, particularly, most often occurs for the purpose of procuring better employment. A factor which demonstrates the changes in employment will receive the force of this migration, whereas none of the other three factors already discussed will.

However, it is not intended that employment alone be used as the guide to estimating population trends in an area. Granted that it is a sensitive indicator, employment would be sensitive to other forces besides migration, especially economic conditions. For this reason an employment indicator alone would tend to overestimate heavily in good times and underestimate as business and employment turned downward, since welfare payments and other factors tend to deter immediate out-migration following loss of jobs. Some demographers have objected to its use as data symptomatic of population change because of this fact. But it does not seem clear why this should make limited use of the measure impractical. An attempt to divorce economic conditions from migration is not completely justifiable for an expanding employment picture and higher relative per capita income in an area many times afford the attraction to bring new residents there. Lorin Thompson found in a study of the relationships between population, migration, and income level that "policy decisions either by industry or government influence the migration of substantial numbers of people to particular areas."[1]

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[1]Lorin A. Thompson, "Patterns of Population Change, Migration, and Income Level," Unpublished paper read before the Annual Meeting of

These policy decisions concerning the opening or closing of plants, offices, etc., have a direct bearing on the economic outlook of the community. One of the conclusions of the study was that closer analyses of changing patterns of employment and income of areas should be made in preparing short- and long-range forecasts of population.[1]

The changes in employment from 1940 to 1950 by states, using the total employed in the civilian labor force 14 years of age and over according to the census, were expressed as indexes and correlated with the indexes of change in the population. The correlation coefficient using the product moment method was $+$ .8824, which suggests a noticeable degree of relationship. In the majority of cases the change in employment was greater than that in population, reflecting the more advantageous general economic picture of 1950 as compared with 1940. However, the divergencies were neither too great nor too numerous to conclude that the biggest factor in the relationship was chance. Table 7 shows a distribution of errors in the indexes of employment compared with the indexes of population in the forty-eight states and the District of Columbia. The average deviation, signs disregarded, was .098 per cent.

For the subregions of Virginia the average deviation between the index of total wage and salary employment and the index of population

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the Population Association of America, Princeton, New Jersey, April 19-20, 1952.

[1]*Ibid.*

was much higher, .2303. However, a correlation coefficient between the indexes of $\neq$ .9078 suggests a relationship worth noting.

TABLE 7

FREQUENCY DISTRIBUTION OF PERCENTAGE DIFFERENCES BETWEEN CHANGES IN EMPLOYMENT AND POPULATION BY STATES, 1940-1950

Class Interval	Frequency
-.0300 to -.0001	3
.0001 to .0299	6
.0300 to .0599	6
.0600 to .0899	9
.0900 to .1199	7
.1200 to .1499	3
.1500 to .1799	10
.1800 to .2099	4
.2700 to .2999	1

Having explained why an employment measure was included in the multiple-factor technique, an explanation remains to be given concerning the particular measure used. Complete employment figures like the census counts just used in the correlations are, of course, only available every ten years. Covered employment as reported by the Unemployment Compensation Commission remains the most complete current local employment measure available in Virginia. For this reason it was used in the estimates for the subregions; and although covered employment statistics are not the most complete on the state level, they were used in the test run on the states for purposes of comparability.

To demonstrate the extent of coverage of workers in the subregions of Virginia Table 8 is included. It may suggest heavier weighting of this factor in those areas where it represents such a large percentage of total employment and correspondingly decreased weight where covered employment is not a significant share.

TABLE 8

RELATIONSHIP OF COVERED TO TOTAL WAGE AND SALARY EMPLOYMENT BY SUBREGIONS OF VIRGINIA, 1950

Region	Per cent	Region	Per cent
1-A	23.3	1.9	14.8
1-B	68.4	2.1	50.7
1-C-N	42.4	2.2	79.5
1-C-S	31.9	3.1	56.1
1.1	29.7	3.2	62.3
1.2	46.2	4.1	65.9
1.3	33.6	4.2	51.6
1.4	36.2	4.3	65.0
1.5	28.4	5.1	27.8
1.6	40.7	5.2	54.0
1.7	24.6	5.3	53.7
1.8	39.0	State	47.1

The four series of symptomatic data just discussed are used as is. That is, they are not changed into ratios of population to the series, but the percentage change in the number of births, for example, is used as the index. This cuts out a series of computations necessary in another short-cut method described in Chapter II, the censal ratio technique.

The actual set-up of the multiple-factor technique may be seen more clearly in the pages that follow, which show examples of the make-up of each factor in the subregions of Virginia and in the forty-eight states and the District of Columbia.

Births

For the subregions the numbers of births as reported by the Virginia State Department of Health, Bureau of Vital Statistics, for 1939, 1940, and 1941 were averaged and used as the base, 1940, for purposes of estimating the 1950 population. For the states the number of births in 1940 was used as the base. The source for the birth data was the Statistical Abstract of the United States, 1953. Some of the indexes of change representing the number of births in 1950 over the 1940 base are shown in Table 9, along with the change in census population counts. The indexes were correlated using the product-moment correlation method.

The correlation coefficient for the subregions of Virginia between the indexes of population change and the indexes of change in the number of births was + .973, while the correlation coefficient for the States and the District of Columbia was + .868. As an individual indicator of population trend the change in the number of births would, of course, heavily overestimate for nearly all areas. The average deviation of the indexes of births and population for the states was .3545; and for the regions of Virginia, .2084; the quadratic mean deviation for the states was .3751, while for the regions it rose to .2728.

TABLE 9

CHANGES IN NUMBER OF BIRTHS IN SELECTED STATES AND SUBREGIONS OF VIRGINIA AND IN POPULATION, 1940 AND 1950

State or subregion	Number of births		Index of change in:	
	1940	1950	Births	Population
Alabama	62,938	82,616	1.3127	1.0808
Arizona	11,503	20,823	1.8102	1.5014
Arkansas	38,473	45,592	1.1850	.9795
California	112,287	244,871	2.1808	1.5326
Colorado	21,034	33,885	1.6110	1.1796
Connecticut	25,548	40,620	1.5900	1.1744
1-A	2,948	8,761	2.9718	2.3068
1-B	5,563	9,503	1.7082	1.2442
1-C-N	1,684	3,755	2.2298	1.6951
1-C-S	5,049	11,289	2.2359	1.7233
1.1	839	1,192	1.4207	1.0100
1.2	2,503	3,034	1.2121	1.0637

Deaths

The data on numbers of deaths corresponded to the birth data; that is, for the subregions, the numbers in 1939, 1940, and 1941 were averaged for use as the 1940 base. In the case of the states the actual numbers of deaths in 1940 were used. Since the death rate itself was declining in most areas during the 1940-1950 decade, it is fairly obvious that the indexes of change in numbers of deaths would be noticeably lower than the indexes of population change. This is demonstrated in Table 10, which includes the experience of selected states and subregions.

The correlation coefficient between the indexes of change in deaths and in population among the states was + .774, while among the subregions of Virginia the coefficient obtained from the product-moment method was + .949. The average deviation of the indexes in the states was .1354, and the square root of the average of the sum of the squared deviations was .1617. For the subregions the average deviation reached .1730, while the quadratic mean deviation increased to .2422.

TABLE 10

CHANGES IN NUMBERS OF DEATHS IN SELECTED STATES AND SUBREGIONS OF VIRGINIA AND IN POPULATION, 1940 AND 1950

State or subregion	Number of deaths		Index of change in:	
	1940	1950	Deaths	Population
Alabama	29,554	26,836	.9080	1.0808
Arizona	5,556	6,422	1.1559	1.5014
Arkansas	17,247	15,411	.8935	.9795
California	79,742	98,760	1.2385	1.5326
Colorado	12,291	12,280	.9991	1.1796
Connecticut	18,070	19,123	1.0583	1.1744
1-A	1,129	1,754	1.5536	2.3068
1-B	3,790	4,159	1.0974	1.2442
1-C-N	914	1,138	1.2451	1.6951
1-C-S	3,095	3,597	1.1622	1.7233
1.1	729	645	.8848	1.0100
1.2	1,390	1,250	.8993	1.0637

School Enrollment

The statistics on school enrollment for the states were taken from the Statistical Abstract of the United States, 1953 and 1943. The data include public elementary and secondary school enrollment and also data for kindergartens. The school enrollment data for the subregions of Virginia include the average daily attendance adjusted for the public primary, elementary, and secondary schools from the Annual Reports of the Superintendent of Public Instruction of the Commonwealth.

The correlation coefficient between the indexes of change in school enrollment from 1940 to 1950 and in population for the states was + .928, while for the subregions it was + .958. The average deviation of the indexes for the states was .1469, whereas the quadratic mean deviation increased to .1560. For subregions the average deviation was .1234, while the quadratic mean deviation rose to .1712. Below are several examples of the make-up of the school enrollment index and illustrations of its lag behind the population index.

TABLE 11

CHANGES IN SCHOOL ENROLLMENT IN SELECTED STATES AND SUBREGIONS OF VIRGINIA AND IN POPULATION, 1940 AND 1950

State or subregion	School enrollment		Index of change in:	
	1940	1950	School enrollment	Population
Alabama	686,767	680,066	.9902	1.0808
Arizona	110,205	139,244	1.2635	1.5014
Arkansas	465,339	407,084	.8748	.9795
California	1,189,106	1,757,424	1.4779	1.5326
Colorado	221,409	229,196	1.0352	1.1796
Connecticut	281,032	273,015	.9715	1.1744
1-A	18,728	33,524	1.7900	2.3068
1-B	52,484	52,642	1.0030	1.2442
1-C-N	13,875	20,152	1.4524	1.6951
1-C-S	39,825	55,370	1.3903	1.7233
1.1	8,428	7,458	.8849	1.0100
1.2	19,572	20,862	1.0659	1.0637

Covered Employment

The source of covered employment data for the states was the "Handbook of Unemployment Insurance Financial Data, 1938-1948," published by the Department of Labor, Bureau of Employment Security, in December 1949, and the 1950 supplement published in August 1951. The yearly employment figures are averages of monthly numbers. The data for the subregions of Virginia are also averages of monthly covered employment numbers, reported by the Unemployment Compensation Commission, Division of Research, Statistics, and Information, in quarterly reports. For the base year 1940 the employment statistics were not readily available, so the data for 1939 were used instead in the case of the subregions.

TABLE 12

CHANGES IN COVERED EMPLOYMENT IN SELECTED STATES AND SUBREGIONS OF VIRGINIA AND IN POPULATION, 1940 AND 1950

State or subregion	Covered employment		Index of change in:	
	1940	1950	Covered employment	Population
Alabama	288,869	409,910	1.4190	1.0808
Arizona	60,308	106,235	1.7615	1.5014
Arkansas	146,179	223,162	1.5266	.9795
California	1,380,688	2,525,443	1.8291	1:5326
Colorado	133,464	205,323	1.5384	1.1796
Connecticut	494,890	616,345	1.2454	1.1744
1-A	10,632	29,486	2.7733	2.3068
1-B	78,502	110,823	1.4117	1.2442
1-C-N	15,083	22,361	1.4825	1.6951
1-C-S	37,911	59,581	1.5716	1.7233
1.1	2,258	4,337	1.9207	1.0100
1.2	10,160	12,954	1.2750	1.0637

The average deviation of the indexes for the states was .3327, while for the subregions it was .6177. The standard errors were .3782 and .7219, respectively. The correlation coefficient obtained using the product-moment method was + .403 for the states and + .308 for the subregions. Among the indexes of change in covered employment in the states all were found to be substantially higher than the changes in population (there were only five that were less than 10 percentage points higher), primarily reflecting the growth of employment eligible under unemployment compensation plans during the 1940-1950 decade, and the increase in the percentage of covered to total employment itself. There was an average increase of 6.87 per cent in the ratio of covered to total wage and salary employment among the states from 1940 to 1950, the average proportion covered increasing from 44.87 to 51.74 per cent. Among the subregions of Virginia the average proportion of workers covered under Unemployment Compensation rose from 37.3 per cent in 1940 to 44.6 per cent in 1950, or an average of 7.3 per cent.

It may be felt that the covered employment factor differs too greatly from the change in population in most cases to be of any practical significance. Particularly among the subregions of Virginia during the 1940-1950 decade the divergencies were extreme. However, allusion to Table 4 in Chapter II, showing the ratios of population to covered employment, suggests that since the ratio decreased substantially between 1940 and 1950, this factor may continue to grow to be more representative of population trends. And the greater the proportion covered employment becomes to total employment, the smaller will be the positive errors between the covered employment index and the population index. Therefore, it is reasonable to assume that covered employment will prove to be a more reliable estimator in the present decade. Since, however, it was not shown to be such in the 1940-1950 decade, the weight given this factor was much reduced as is illustrated in the next chapter.

CHAPTER IV

COMPARISON OF RESULTS OBTAINED FROM TECHNIQUES OF ESTIMATING INTERCENSAL POPULATION

The four series of symptomatic data used in the multiple-factor technique and explained in the last chapter were related and expressed in a multiple correlation coefficient for the states and for the subregions of Virginia. The coefficient for the states was $+.953$, while that for the subregions was $+.994$. The estimating equation used X_1 = index of births; X_2 = index of deaths; X_3 = index of school enrollment; X_4 = index of covered employment; X_5 = index of population; the multiple regression equations in score form were as follows:

$$\frac{\text{States}}{X_5} = +.12871246\ X_1 + .27228572\ X_2 + .64892230\ X_3 - .00515387\ X_4 + .0363$$

$$\frac{\text{Subregions}}{X_5} = +.30974375\ X_1 + .35430566\ X_2 + .54950802\ X_3 + .03646257\ X_4 - .2545$$

The estimates obtained from the equation for the states for 1950 were compared for reliability with those obtained from the Census Bureau's methods of migration and natural increase, with Donald Bogue's "vital rates" technique, and with the arithmetic methods also discussed in the second chapter. The results of the tests for accuracy of these latter methods were published in the American Sociological Review, August 1954, in an article by Messrs. Siegel, Shryock, and Greenberg of the U. S. Bureau of the Census.[1]

The criteria which were used to measure the accuracy of the estimates are those outlined in the cited article. One criterion used, the average deviation, is simply the arithmetic mean of the per cent deviations disregarding sign. Another was the quadratic mean deviation which is the square root of the arithmetic mean of the squares of the deviations. This latter test points out the methods which yield relatively large errors. The two tests have been alluded to previously and were used in the examination of various other methods contained in Chapter II.

Another way of emphasizing the relatively large errors produced by any of the methods is to examine how many errors exceed a certain value. A final check made was the aggregate number of positive deviations, enabling the identification of methods which tend to overestimate more often than underestimate.[2]

Table 13 contains data from Table I in the American Sociological Review article cited, plus the results of testing estimates derived from

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[1] J. S. Siegel, H. S. Shryock, Jr., and B. Greenberg, "Accuracy of Postcensal Estimates of Population for States and Cities," American Sociological Review, 19 (4), August 1954, p. 442.

[2] Ibid., pp. 441-442.

the equation based on "four factors," estimates based on a simpler weighting procedure of the four factors, and estimates based on an equal weighting of only three of the factors. The estimates obtained from the multiple regression equation using four factors were not adjusted to the national total since the sum of these was less than 150,000, or only .08 of 1 per cent in deviation from the census national total of 1950. To rework the estimates and adjust them to the census count would not have produced changes in results significant enough to warrant the task.

The measures of deviation from the population standard as examined in Table 13 show that the multiple-factor regression analysis produced estimates of considerably greater reliability than the other methods tested. However, in the strict sense, it is not justifiable to compare these results with the others since the weighting of the factors was based on a backward look. That is, the census counts for 1950 were used in the regression analysis itself; the reliability of estimates from the particular regression equation would not be demonstrated until the current decade. The degree of similarity between current estimates from the equation and actual population counts (if there were any available) would depend upon the degree to which the four factors continued to account for the variation in population changes.

The four factors expressed as indexes of change were also weighted and averaged into a single estimator by a simpler procedure, the results of which are also shown in Table 13. First, the indexes of births and covered employment were weighted equally and averaged into a

TABLE 13

SUMMARY OF PERCENTAGE DEVIATIONS FROM POPULATION STANDARD OF POPULATION ESTIMATES BY VARIOUS METHODS FOR STATES, 1950

Measure	Migration and natural increase I	Migration and natural increase II	Bogue's "vital rates"	Arithmetic	Geometric	Four factor regression equation	Four factor simple weighting procedure	Three factor equal weighting procedure
Adjusted to national total States: 1950								
Average deviation	5.84	3.47	4.38	6.39	6.35		3.55	3.66
Quadratic mean deviation	7.38	4.78	5.54	8.01	8.01		4.72	4.45
Deviations of 10% or more	10	2	4	11	11		2	0
Deviations of 5% or more	22	11	19	24	23		11	11
Not adjusted to national total States: 1950								
Average deviation	5.86	3.89	4.39	7.42	7.04	2.57	4.36	4.53
Quadratic mean deviation	7.41	4.94	5.53	9.57	9.03	3.34	5.67	5.44
Deviations of 10% or more	10	2	3	11	12	0	5	1
Deviations of 5% or more	22	13	18	28	29	8	15	24
Position deviations	29	21	24	8	3	28	35	36

single index. This index and the indexes of deaths and school enrollment were then weighted equally (by one) and averaged into a single estimator of change. The results of this arbitrary weighting procedure produced surprisingly good estimates, estimates which after adjustment to the national total ranked in reliability with those obtained from the involved and lengthy migration and natural increase Method II.

The other weighting procedure tested also produced very reliable estimates as compared with the estimates from other techniques. The indexes of births, deaths, and school enrollment (with covered employment excluded) were averaged into a single estimator of population change; when adjusted to the national total, there resulted no estimates which showed a deviation of as much as 10 percentage points.

It may safely be assumed from the results of the foregoing analysis that population estimation at the state level may be approached successfully through use of short-cut methods involving series of symptomatic data, as well as from the laborious and exact migration and natural increase methods. In other words, because a method is longer and more precise with manifold refinements and adjustments, there can be no assurance that the results produced will be significantly more reliable than short-cuts provide. Further investigation of series of symptomatic data and their historically demonstrated relationships with changes in population at the state level should be undertaken as an adjunct to the continuation of research in the field of population estimation already begun.

In an examination of the results obtained from techniques which estimated intercensal population below the state level, it should be kept in mind that the degree of reliability which may be reasonably approximated would be less than on the state level. Generally, the smaller the entities used as the bases for estimation, the larger the percentage errors which result may be expected to be.

Table 14 gives the results of the same tests or measures of deviation which were applied to the state estimates on the estimates for 1950 for the twenty-three subregions of Virginia. The results are commented upon in the paragraphs that follow.

A: Arithmetic projection technique. The estimates based on this method produced among the highest average and quadratic mean deviations from the population standard of all the methods tested. The estimates were not adjusted to the state total since this would defeat the working of the technique itself.

B: Apportionment method. The estimates obtained showed the lowest degree of reliability on the particular decade tested, slightly in excess of the arithmetic projection technique. The results of testing the estimates are shown only as adjusted to the state total since the method itself is based on a given control total.

C: Proration method with equal weighting of estimates based on four factors. This short-cut method produced results which were better than A and B but which were substantially less reliable than several other techniques tested.

TABLE 14

SUMMARY OF PERCENTAGE DEVIATIONS FROM POPULATION STANDARD OF POPULATION ESTIMATES BY VARIOUS METHODS FOR SUBREGIONS OF VIRGINIA, 1950

Measure	Method												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Adjusted to state total Subregions: 1950													
Average deviation		11.4	7.44	11.68	6.53	3.95	2.96	3.79			3.52		3.10
Quadratic mean deviation		14.9	9.30	13.98	8.46	4.74	3.70	4.58			4.31		3.86
Deviations of 10% or more		12	8	12	6	1	0	0			0		0
Deviations of 5% or more		14	10	19	12	7	3	9			6		3
Not adjusted to state total Subregions: 1950													
Average deviation	10.1					3.75	3.44	4.08	2.36	8.32	3.71	2.69	3.60
Quadratic mean deviation	14.6					4.52	3.95	5.18	2.99	9.99	4.56	3.25	4.15
Deviations of 10% or more	8					1	0	2	0	10	1	0	0
Deviations of 5% or more	14					7	4	6	3	16	6	3	5
Positive deviations	7					15	9	14	12	15	15	11	8

D: Proration method with each estimate weighted by the reciprocal of the ratio of state population to the particular series of symptomatic data. This weighting procedure was suggested by Schmitt and used in his tests on the counties of the State of Washington. For example, the estimate for a subregion based on its share of births in 1950 would be weighted by 1 divided by 46.8404 or .021349, the ratio of state population to number of births in 1940 being 46.8404. Weights based on the other three factors would be obtained in the same manner and applied to each preliminary estimate, respectively. Finally, the sum of the weighted estimates would be divided by the sum of the weights with the quotient representing the final population estimate.

The estimates obtained from this weighting technique did not prove very reliable, the deviations being large enough to discourage any extensive use of the procedure in Virginia. The estimates in D ranked in reliability at the bottom of the techniques tested along with the arithmetic methods.

E. Proration method with each estimate weighted by the reciprocal of its coefficient of variation. This weighting scheme was also used by Schmitt in Washington and proved the most successful of those tested there. The procedure followed is essentially the same as the weighting in D; however, the reciprocal of the coefficient of variation among the ratios of population to symptomatic data in the subregions is used instead of the reciprocal of the actual ratio of population to symptomatic data in the state. For example, the preliminary estimate for a subregion in 1950 based on the share of total deaths in the state which that subregion accounted for in 1950 would be weighted by 1 divided by 13.9 or .071942. The coefficient of variation among the ratios of population to deaths in the subregions in 1940 was 13.9.

The average deviation among these estimates was 6.53 per cent while the quadratic mean deviation rose to 8.46. There were twelve deviations of more than 5 per cent, of which six reached more than 10 per cent. Among the weighting systems applied to the estimates from the proration method, the use of the reciprocal of the coefficient of variation proved most successful.

F. Censal ratio method using four factors weighted by the reciprocals of the coefficients of variation. The estimates obtained from the censal ratio method for the subregions proved quite reliable. When each of the four estimates was weighted by the reciprocal of the coefficient of variation of the respective factor, and the four averaged into a single estimate, the final estimates showed an average deviation of 3.75 per cent and a quadratic mean deviation of 4.52 per cent. After adjustment to the state total, the estimates produced slightly greater deviations. There was produced only one deviation in excess of 10 per cent, while seven estimates showed deviations of 5 per cent or more.

G. Censal ratio technique using three factors weighted by the reciprocals of the coefficients of variation. The estimates based on the ratios of population to covered employment were excluded; those resulting from the combination and weighting of the other three factors produced estimates which deviated even less from the population standard than F. These estimates were the most reliable aside from those based on the multiple regression equation; only three subregional estimates were as much as 5 per cent in error and there were none as much as 10 per cent in deviation.

H. Bogue's "vital rates" technique. The estimates obtained from this simple short-cut method exhibited a considerable degree of reliability. When adjusted to the state total for 1950, they showed an average deviation of 3.79 per cent and a quadratic mean deviation of 4.58 per cent. While nine estimates were in deviation 5 per cent or more, there were none as much as 10 per cent in error.

I. Four-factor multiple regression equation. These estimates proved the most reliable of all tested. The average deviation was only 2.36 per cent and the quadratic mean deviation only 2.99 per cent. The estimates were not adjusted to the state total for 1950 since the sum was only .20 of 1 per cent less than the census count.

J. Four-factor simpler weighting procedure. When the indexes of births and covered employment were averaged into a single index, and this index in turn averaged with those of deaths and school enrollment for the subregions, the resulting estimates exhibited rather high deviations. An average deviation of 8.32 per cent and a quadratic mean deviation of 9.99 per cent would tend to discourage much further use of this arbitrary weighting procedure.

K: Four-factor equal weighting procedure substituting census total employment for U. C. C. covered employment. This was included only to illustrate that with a complete employment count (or as inclusive as may be obtained) the simplest weighting procedure produced quite reliable estimates for the subregions. After adjustment to the state total, the estimates showed a 3.52 per cent average deviation and a quadratic mean deviation of 4.31 per cent.

L: Three-factor multiple regression equation. When covered employment was removed from the analysis, the multiple regression equation in score form became:

$$X_5 = + .31570688\ X_1 + .40463240\ X_2 + .52128356\ X_3 - .2191$$

Removal of the fourth factor produced estimates which were only slightly more in deviation from the population standard than the four-factor regression equation provided. An average deviation of 2.69 per cent and a quadratic mean deviation of 3.25 per cent resulted. The estimates were not adjusted to the state total since the sum was but .18 of 1 per cent in excess of the census count for 1950.

M: Three-factor equal weighting technique. A simple averaging of the indexes of births, deaths, and school enrollment produced surprisingly good estimates for the subregions for 1950. After adjustment to the state total they deviated on the average only 3.10 per cent from the census figures. The quadratic mean deviation was 3.86 per cent; only three estimates were 5 or more percentage points in error and none were as much as 10 per cent.

CHAPTER V

THE PREPARATION OF CURRENT ESTIMATES FOR THE SUBREGIONS OF VIRGINIA AND CONCLUSIONS

Estimates for the twenty-three subregions of Virginia for 1954 were prepared using several techniques. The methods chosen were those that produced estimates for 1950 which exhibited the lowest percentage deviations from the population standard. Included are three sets of estimates prepared from the multiple regression equation based on the changes between 1940 and 1950, Bogue's "vital rates" technique, and the censal ratio method weighted by the reciprocals of the coefficients of variation in 1950.

The percentage changes which each set of estimates for 1954 reflected over the 1950 Census were compared for similarity of trend and degree of increase or decrease. Another set of estimates prepared at the Bureau of Population and Economic Research by Mr. J. L. Lancaster was also compared with those obtained by the short-cut methods. Mr. Lancaster's estimates for the counties and cities were made using the migration and natural increase Method II of the Bureau of the Census with a few adjustments. Instead of age-grade distributions which are not available on the local level in Virginia, the average daily membership figures were used. The comparison of the four sets of estimates is found in Table 17.

None of the estimates were adjusted to the census estimate for the State of Virginia for July 1954 of 3,560,000.[1] The state total for 1954 used as the control for the three sets of estimates prepared herein was 3,678,000, or an estimated 2.7 per cent higher than the census figure. It was a conservative estimate arrived at after obtaining numerous state figures from different methods of estimation. Also, the estimate obtained by Mr. Lancaster was very close at 3,670,000.

Table 15 presents the indexes of change in the four factors symptomatic of the direction of population change for 1950 and 1954 (over the 1940 base) for the subregions of Virginia.

The population estimates for the subregions in 1954 using the indexes in Table 15 in the multiple regression equation were adjusted to the state control total of 3,678,000 and are presented in Table 16, along with the census 1950 count. The estimates prepared for 1950 from the regression equation are also given with the percentage deviations from the population standard pointed out. Any sizeable positive or negative deviation in 1950 may be perpetuated through use of the same equation; the errors in 1950 are noted to enable the recognition of possible like errors in the 1954 estimates.

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[1]U. S. Bureau of the Census, Current Population Reports, Series P-25, No. 124, October 24, 1955.

TABLE 15

INDEXES OF CHANGE IN BIRTHS, DEATHS, SCHOOL ENROLLMENT, AND COVERED EMPLOYMENT IN THE SUBREGIONS OF VIRGINIA, 1950 AND 1954 OVER 1940

Region	Births		Deaths		School enrollment		Covered employment	
	1950	1954	1950	1954	1950	1954	1950	1954
1-A	2.9718	3.9261	1.5536	1.7511	1.7900	2.8108	2.7733	3.8720
1-B	1.7082	2.0252	1.0974	1.0773	1.0030	1.2143	1.4117	1.5254
1-C-N	2.2298	3.2625	1.2451	1.3457	1.4524	1.9401	1.4825	2.1650
1-C-S	2.2359	3.2482	1.1622	1.2452	1.3903	1.8529	1.5716	1.8883
1.1	1.4207	1.6317	.8848	.8875	.8849	.9370	1.9207	1.8139
1.2	1.2121	1.3268	.8993	.8403	1.0659	1.1803	1.2750	1.4346
1.3	1.4762	2.1905	1.0275	1.1409	1.1596	1.3567	2.3935	2.6480
1.4	1.1808	1.2435	.9512	.9276	.8868	.9660	1.8557	1.7545
1.5	1.1185	1.3259	.9160	.8721	.9174	.9109	2.3014	2.5798
1.6	1.2899	1.4349	.9448	.9212	.9545	1.0972	1.5108	1.6492
1.7	1.0297	1.0840	.9872	.8797	.9554	.9896	1.6000	1.4716
1.8	1.1021	1.1918	.9606	.9438	.9783	1.0264	1.7146	1.9720
1.9	1.2744	1.5165	.9064	.9441	.9980	1.1146	2.2596	3.0608
2.1	1.0787	1.1277	.9803	.9053	.9915	1.0305	2.0904	2.1481
2.2	1.2264	1.2767	.9575	.9351	1.0912	1.1934	1.3654	1.4054
3.1	1.3185	1.3130	1.0118	.9894	1.1149	1.2271	1.8068	1.9105
3.2	1.3591	1.3851	1.0040	.9910	1.0519	1.1298	1.7261	1.7483
4.1	1.2424	1.2403	.9959	.9086	.9727	1.0321	1.4358	1.4800
4.2	1.1124	1.0478	.9600	.8973	.9349	.9586	1.5120	1.3685
4.3	1.3838	1.5060	1.1117	.9210	1.0438	1.1943	1.6833	1.8431
5.1	.9244	.8766	.9335	.8327	.8088	.8591	2.2933	2.7148
5.2	1.0058	1.0339	.9473	.9276	1.0540	1.0934	1.6388	1.6599
5.3	1.0195	.8881	.9636	.8470	1.1049	1.0875	1.1914	.8590
State	1.4341	1.6645	1.0403	1.0274	1.0872	1.2484	1.5622	1.7161

TABLE 16

POPULATION OF THE SUBREGIONS OF VIRGINIA: CENSUS COUNT AND ESTIMATES FOR 1950; ESTIMATES FOR 1954

Region	Census 1950 population	Estimated 1950 population	Percentage deviation	Estimated 1954 population
1-A	303,328	302,589	-0.24	417,453
1-B	417,918	425,266	+1.76	482,185
1-C-N	143,227	146,136	+2.03	195,302
1-C-S	446,200	432,693	-3.03	573,768
1.1	51,132	53,427	+4.49	56,273
1.2	114,329	115,198	+0.76	120,638
1.3	33,473	33,668	+0.58	42,297
1.4	44,624	45,330	+1.58	46,343
1.5	41,699	41,010	-1.65	42,297
1.6	70,436	65,645	-6.80	70,985
1.7	70,649	73,120	+3.50	70,618
1.8	111,800	110,124	-1.50	112,915
1.9	72,081	72,333	+0.35	82,019
2.1	154,125	160,304	+4.01	157,418
2.2	149,632	145,942	-2.47	150,430
3.1	82,500	87,193	+5.69	88,640
3.2	112,327	111,860	-0.42	112,915
4.1	126,563	128,987	+1.92	125,788
4.2	87,090	88,071	+1.13	82,755
4.3	218,927	213,872	-2.31	217,738
5.1	51,553	48,488	-5.95	46,711
5.2	189,154	186,809	-1.24	186,107
5.3	225,913	224,070	-0.82	196,405
State	3,318,680	3,312,135	-0.20	3,678,000

Table 17 contains the percentage changes from 1950 that four sets of estimates for 1954 reflect. There is a close correspondence in trend shown by the first three sets of estimates which were made using short-cut methods. Estimates I and II were, of course, based on the same four factors: changes in yearly births, deaths, school enrollment as expressed by average daily attendance adjusted, and covered employment. Estimates IV, containing the sums for the subregions of estimates made for the individual counties and cities by the migration and natural increase Method II, show divergent trends for a number of the subregions.

Simply because some of these last estimates may differ from a degree of unanimity among the other three, it is not to be implied that some of Estimates IV are in error. There is actually no basis upon which anyone inspecting the estimates might categorically claim exactness of one set of estimates over another. However, where a region would be in question due to divergent trends manifested by the several sets of estimates, an investigation of the social and economic forces in operation in the subregions should be made. Examination of the individual factors used in the regression equation would be of help along with any other knowledge of the area which might be obtained. The limitations inherent in any statistical series should always be acknowledged, while it would also be remembered that some areas are simply difficult to analyse and do not come close to fitting any pattern that may have been displayed by the so-called average area.

TABLE 17

PERCENTAGE CHANGES 1950 TO 1954 IN POPULATION OF SUBREGIONS OF VIRGINIA: FOUR SETS OF ESTIMATES FOR 1954

Sub-region	Regression equation I	Censal ratio method II	Vital rates III	Migration and natural increase II IV
1-A	+37.62	+32.90	+32.53	+28.49
1-B	+15.38	+11.86	+ 9.04	+11.79
1-C-N	+36.36	+31.99	+28.40	+18.89
1-C-S	+28.59	+29.08	+29.17	+22.47
1.1	+10.05	+ 8.62	+12.21	- 0.23
1.2	+ 5.52	+ 5.52	+ 4.88	+ 4.97
1.3	+26.36	+26.36	+32.95	+ 9.64
1.4	+ 3.85	+ 4.68	+ 4.68	+ 2.80
1.5	+ 1.43	+ 8.49	+11.14	+ 1.21
1.6	+ 0.78	+10.18	+12.27	+11.50
1.7	- 0.04	- 1.09	- 0.56	+ 1.82
1.8	+ 1.00	+ 2.31	+ 3.96	+ 2.42
1.9	+13.79	+13.28	+11.75	+ 9.98
2.1	+ 2.14	+ 0.94	+ 1.42	+ 3.34
2.2	+ 0.53	+ 2.25	+ 3.73	+ 7.67
3.1	+ 7.44	+ 1.65	+ 2.09	+ 5.43
3.2	+ 0.52	+ 1.18	+ 3.14	+ 3.57
4.1	- 0.61	- 0.32	- 0.32	+ 5.84
4.2	- 4.98	- 3.29	- 2.87	+ 3.24
4.3	- 0.54	+ 5.67	+ 5.84	+ 7.79
5.1	- 9.39	- 2.97	- 5.83	+ 3.22
5.2	- 1.61	+ 1.31	+ 2.86	+ 2.83
5.3	-13.06	-11.92	-10.62	- 0.42
State	+10.83	+10.83	+10.83	+10.59

Conclusions

The purpose of the thesis was to attempt to appraise several techniques in current usage for making intercensal population estimates and to experiment with a new method. The particular need stressed was reliable, up-to-date population estimates in areas below the state level. The twenty-three subregions of Virginia were used as the subjects of the tests on suggested procedures.

The many sets of estimates for 1950 made from current methods were tested by various measures of deviation from the population standard. It may be concluded that in the State of Virginia during the last decade the "vital rates" and censal ratio techniques offered reliable estimates through short-cut means.

The multiple-factor technique making use of four series of symptomatic data expressed as indexes of change in multiple regression equation also afforded reliable population estimates. The estimating equation may continue to account in a satisfactory degree for the population changes that take place in the current decade. That remains to be seen; however, the method should offer worthwhile indications of trends in the subregions during the intercensal years. The preparation of several sets of estimates using short-cut methods which have proved reliable in the past decade would be of practical use and significance to any state and the parties therein desirous of the information that current population estimates provide.

The exact numbers of people are not of prime importance to the user of regional population statistics. Indeed, it would be impossible to attain such certainty, particularly on the level of smaller areas than states. Mr. Harold Dorn in an indictment of forecasting at the national level thought it would become "increasingly difficult" to estimate the population "for periods as short as even five years . . . unless economic conditions remain stabilized."[1] The trend and extent of growth or decline within reasonable limits is the question whose answer provides the key to the formulation of plans for governmental and business activity in the social and economic spheres. The multiple-factor technique herein suggested may not only offer reliable indicators of population trends, but in the examination of the four dynamic forces in operation in regions below the state level will afford a broader view of the socio-economic make-up of the areas involved.

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[1]Harold F. Dorn, "Pitfalls in Population Forecasts and Projections," Journal of the American Statistical Association, 45 (251), September 1950, p. 332.

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V I T A

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