THE ACCURACY OF THE HAMILTON-PERRY METHOD FOR FORECASTING STATE POPULATIONS BY AGE

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Abstract

The Hamilton-Perry Method is a variant of the Cohort-Component population projection method that has minimal data input requirements. It only requires the age distributions for a population at two points in time, which generally are two successive census enumerations. Cohort Change ratios are calculated between the two census counts and a forecast is launched from the most recent census year by applying these cohort ratios to the age distribution of the most recent census. Typically, the forecast horizon is ten years. Ideally, the interval between the census enumerations (e.g., 10 years) is either equal to the width of the age groups (e.g., the age groups are given in ten year increments, 0-9, 10-19,…70-79, 80+) or a whole number multiple thereof (e.g., the age groups are given in five year increments, 0-4, 5-9,…,70-74,…), through the final open-ended age group (e.g., 75+). Although the method has gained acceptance, it has not been comprehensively tested for accuracy. In this paper we evaluate the accuracy of this method both in terms of age forecasts and forecasts of total population (obtained by summing up the forecasted age groups) using a sample of four states (one from each of the four Census Regions) and decennial census data from 1900 to 2010, which yield 10 census test points (1920, 1930, 1940,…, 2010). The four states and the ten test points provide a wide range of characteristics in regard to population size, growth, and age-composition, factors that affect forecast accuracy. The tests reveal that……..We discuss the results and make some observations regarding the implications and limitations of our study. We conclude that the results are encouraging and suggest that the Hamilton-Perry Method be considered when either a 10-year forecast of a state population by age or a total population are desired

Introduction

In a seminal paper, Hamilton and Perry (1962) proposed cohort-change ratios as a variant of the cohort-component method for purposes of short-term population projections. The major advantage of this variant of the full cohort-component method is that it has much smaller data requirements than its more data-intensive cousin while still providing a forecast of population by age (as well as sex, race, ethnicity, if so desired), which is the hallmark of the full cohort-component method (George et al. 2004, Smith Tayman and Swanson 2001, Swanson Schlottmann and Schmidt 2010). Instead of mortality, fertility, migration, and total population data by age and sex, the Hamilton-Perry method simply requires age (and sex, race, ethnicity, if these characteristics are desired in a forecast) data from the two most recent censuses. Consequently, it is much quicker, easier, and cheaper to implement than a full cohort-component model. Not surprisingly, it has mainly been used for small geographic areas in which mortality, fertility, and migration data are non-existent, unreliable, or very difficult to obtain (Baker et al. 2011, Smith Tayman and Swanson 2001, Swanson Schlottmann, and Schmidt 2010).

Although the Hamilton-Perry Method has primarily been used for small geographic areas, its minimal data input requirements combined with its capability for producing age and other characteristics in a forecast make it attractive for use at high levels of geography such as states and counties. Smith and Tayman (2003) evaluated the accuracy of Hamilton-Perry projections for all states and for counties in Florida using 1990 and 2000 as test points and a ten year forecast horizon. They found that its accuracy was equivalent to that of cohort-component method forecasts. This paper is intended to supplement the findings by Smith and Tayman by using a sample of states in conjunction with tests covering a long period of time. Unlike Smith and Tayman (2003, we do not evaluate all states, only a sample of four (one from each Census Region); but we also unlike them we use not just two recent test points, but ten test points, from 1920 to 2010.

In the paper that follows, we begin by describing the Hamilton-Perry Method and then move on to discuss three major dimensions of forecast accuracy and how they are measured. We then describe the data used in our empirical examination and our results. We conclude the paper with a discussion of our findings, their implications and limitations, which, in turn, lead to suggestions for future research in this area.

The Hamilton-Perry Method

Before describing the Hamilton-Perry method, it is useful to recall that any quantitative approach to forecasting is constrained to satisfy various mathematical identities (Land 1986). In regard to population forecasting, an approach should ideally satisfy demographic accounting identities, which is summarized in the identity known as the fundamental demographic equation:

$$P_t = P_0 + \text{Births} - \text{Deaths} + \text{Inmigrants} – \text{Outmigrants} \qquad [1]$$

That is, the population at some time in the future, P_t, must be equal to the population at an earlier time, P_0, plus the births and in-migrants and less the deaths and out-migrants that occur between time =0 and time=t. The most commonly used approach to population forecasting, cohort-component method, satisfies the fundamental equation, but it is data-intensive (George et al. 2004, Smith Tayman and Swanson 2001, Murdock and Ellis 1991, Pittenger 1976)

As we show at the end of this section, the Hamilton-Perry Method also satisfies the fundamental demographic equation. However, it has far less intensive input data requirements than does the cohort-component method (Hamilton and Perry 1962, Swanson Schlottmann and Schmidt, 2010, Swanson and Tedrow, 2012). Instead of mortality, fertility, migration, and population data by age and sex, which are required by the full-blown cohort-component method, the Hamilton-Perry method requires age data only from the two most recent censuses (Smith Tayman and Swanson 2001: 153-158, Swanson Schlottmann and Schmidt 2010, Swanson and Tedrow 2012).

The Hamilton-Perry method moves a population by age from time t to time t+k using cohort-change ratios (CCR) computed from data in the two most recent censuses. It consists of two steps. The first uses existing data to develop CCRs and the second applies the CCRs to the cohorts of the launch year population to move them into the future. As shown by Swanson, Schlottmann, and Schmidt (2010), the formula for the first step, the development of a CCR is:

$$_{n}CCR_{x,i,t} = ({}_{n}P_{x,i,t}) / ({}_{n}P_{x-k,i,t-k}) \quad [2]$$

where

$({}_{n}P_{x,i,t})$ is the population aged x to x+n in area i at the most recent census (t),

$({}_{n}P_{x-k,i,t-k})$ is the population aged x-k to x-k+n in area i at the 2nd most recent census (t-k),

and k is the number of years between the most recent census at time t for area i and the one preceding it for area i at time t-k.

The basic formula for the second step, moving the cohorts of a population into the future is:

$$_{n}P_{x+k,i,t+k} = ({}_{n}CCR_{x,i,t})*({}_{n}P_{x,i,t}) \quad [3]$$

where

${}_{n}P_{x+k,i,t+k}$ is the population aged x+k to x+k+n in area i at time t+k and both ($_nCCR_{x,i,t}$) and ($_nP_{x,i,t}$) are as defined in equation [2]

Given the nature of the CCRs, 10-14 is the youngest five-year age group for which projections can be made if there are 10 years between censuses. To project the population aged 0-4 and 5-9 one can use the Child Woman Ratio (CWR) or more generally a "Child Adult Ratio" (CAR). It does not require any data beyond what is available in the decennial census. For projecting the population aged 0-4, the CAR is defined as the population aged 0-4 divided by the population aged 20-34. For projecting the population aged 5-9, the CAR is defined as the population aged 5-9 divided by the population aged 25-39. Here are the CAR equations for projecting the population aged 0-4 and 5-9, respectively.

$$\text{Population 0-4: } {}_5P_{0,t+k} = ({}_5P_{0,t} / {}_{15}P_{20,t}) * ({}_{15}P_{20,t+k}) \quad [4a]$$

$$\text{Population 5-9: } {}_5P_{5,t+k} = ({}_5P_{5,t} / {}_{15}P_{25,t}) * ({}_{15}P_{25,t+k}) \quad [4b]$$

where

P is the population,

t is the year of the most recent census

and t+k is the projection year

Another way to project the youngest age groups is to take ratios of them at two points in time and apply that ratio to the launch year age group (t). In the first step, the ratios are as follows;

$$\text{Population 0-4: } {}_5R_{0,t} = ({}_5P_{0,t} / {}_5P_{0,t-k}) \quad [5a]$$

$$\text{Population 5-9: } {}_5R_{5,t} = ({}_5P_{5,t} / {}_5P_{5,t-k}) \quad [5b]$$

In the second step, the projected population at t+k is found as follows.

$$\text{Population 0-4: } {}_5P_{0,t+k} = ({}_5P_{0,t}) * {}_5R_{0,t} \quad [6a]$$

$$\text{Population 5-9: } {}_5P_{5,t+k} = ({}_5P_{5,t}) * {}_5R_{5,t} \quad [6b]$$

In this paper, we use the “CAR” approach in order to forecast children.

Projections of the oldest open-ended age group also differ slightly from the CCR projections for the age groups beyond age 10 up to the oldest open-ended age group. If, for example, the final closed age group is 70-74, with 75+ as the terminal open-ended age group, then calculations for the $CCR_{i,x+}$ require the summation of the three oldest age groups to get the population age 65+ at time t-k:

$$_{\infty}CCR_{75,i,t} = {}_{\infty}P_{75,i,t} \;/\; {}_{\infty}P_{65,i,t-k} \qquad [7a]$$

The formula for estimating the population 85+ of area i for the year t+k is:

$$_{\infty}P_{75+,i,t+k} = ({}_{\infty}CCR_{75,i,t})*({}_{\infty}P_{65,i,t}) \qquad [7b]$$

In terms of the Hamilton-Perry Method satisfying the fundamental demographic equation, we show that the former (equation [2]) can be re-stated using the latter (equation [1]) as follows.

Since $P_{i,t+k} = P_{i,t} + B_i – D_i + I_i - O_i$

where

$P_{i,t}$ = Population of area i at time t (the launch date)

$P_{i,t+k}$ = Population of area i at time t+k (the estimate date)

B_i = Births in area i between time t and t+k

D_i = Deaths in area i between time t and t+k

I_i = In-migrants in area i between time t and t+k

O_i = Out-migrants in area i between time t and t+k

Then

$$_{n}CCR_{x,i,t} = ({}_{n}P_{x-k,i,t-k} + B_i – D_i + I_i - O_i)/({}_{n}P_{x-k,i,t-k}) \qquad [8]$$

And we since can express equation [3] also in terms of equation [1]

$$ {}_{n}P_{x+k,i,t+k} = ({}_{n}P_{x-k,i,t-k} + B_i - D_i + I_i - O_i)/({}_{n}P_{x-k,i,t-k}))*({}_{n}P_{x,i,t}) \qquad [9] $$

and where x+k >= 10 then

$$ {}_{n}CCR_{x,i,t} = ({}_{n}P_{x-k,i,t-k} - D_i + I_i - O_i)/({}_{n}P_{x-k,i,t-k}) $$

and since $N_i = I_i - O_i$, we have, where $x+k \geq 10$,

$$ {}_{n}CCR_{x,i,t} = ({}_{n}P_{x-k,i,t-k} - D_i + N_i)/({}_{n}P_{x-k,i,t-k}) \qquad [10] $$

Equations [8], [9] and [10] show that the Hamilton-Perry Method is not only consistent with the fundamental demographic equation, but also closely related to the cohort-component method. The Hamilton-Perry Method simply expresses the individual components of change - births, deaths, and migration - in terms of Cohort Change Ratios. As such, it satisfies the fundamental demographic equation. As we will see in the following section, this way of expressing the components of population change can be exploited. An important reason for a demographic forecasting method to be consistent with the fundamental demographic equation is to minimize the potential errors associated with hidden heterogeneity (Vaupel and Yaushin 1985).

The Measurement of Error

There are three major dimensions to forecast (and estimation) accuracy: (1) bias; (2) precision; and (3) allocation. There are three measures that correspond to each of these three dimensions, respectively: (1) Mean Algebraic Percent Error (MALPE); (2) Mean Absolute Percent Error (MAPE); and (3) The Index of Allocation Error (IOAE). Although not perfect predictors of one another, all of these three direct measures of accuracy are correlated. We also note that “MEDAPE” (Median Absolute Percent Error) and “MAPE-R” can be used along with MAPE (Swanson Tayman and Bryan 2011, Swanson Tayman McKibben and Cropper 2012).

Forecast error (E) can be defined as the difference between a given forecast (F) for a particular population and the 2010 census (CEN): $E = F – CEN$. The error will be positive when the forecast is larger than the census count and it will be negative when it "under-forecasts" the census. Errors are often expressed as percent differences rather than absolute differences. The use of percent errors is particularly helpful when making comparison across geographic areas. A forecast error of 2,000 has a very different meaning for a place with 20,000 residents than a place with 200,000 residents. The definition of error given above can be broadened to include age, sex, race, and ethnicity. For example, the definition of error for a particular age group i would be $E_i = F_i – CEN_i$.

Without adjustments for population size, errors for places with large populations (or age groups with large numbers of people) would dominate the effects of errors for places with small populations (or age groups with small numbers of people). Thus, the definition of error can be broadened to provide a "relative" perspective as follows: $ALPE = (E / CEN) * 100$; and $APE = \left| (E / CEN) * 100 \right|$.

The ALPE (algebraic percent error) preserves the sign of the percent error; it has a theoretical minimum of -100% and no upper bound, while the APE (absolute percent error) has a minimum at zero and no upper bound. ALPE and APE represent individual forecast errors for the set of geographic areas under study and form a distribution of forecast errors. As before, the definition of relative error given above can be broadened to include age, sex, race, and ethnicity. For example, the definition of relative error for a particular age group i would be $ALPE_i = (E_i / CEN_i) * 100$; and $APE_i = \left| (E_i / CEN_i) * 100 \right|$.

Two common summary measures of relative error are MALPE and MAPE, both of which are arithmetic means.

MALPE is defined as: MALPE = $\sum$ALPE i / n

where

$\sum$ = the summation sign (i=1 to n groups)

ALPE i is as defined above

n = number of groups

MALPE is a measure in which positive and negative values offset each other (ESRI, 2007). Consequently, it is often used as an average measure of bias. A positive MALPE reflects the average tendency for forecasts to be too high and a negative MALPE reflects the average tendency for forecasts to be too low. A zero MALPE would indicate no bias in the set of forecasts, as the sum of the positive percentage errors would equal the sum of the negative percentage errors. A MALPE less than +5% and greater than -5% is considered as an indication that the forecast is not substantially biased. A MALPE greater than +10% but less than +25% or less than -10% but not less than -25% indicates considerable bias and one greater than +25% indicates substantial upward bias (the forecast is way too high) and one less than -25% indicates substantial downward bias (the forecast is way too low).

MAPE is defined as: MAPE = $\sum$APE i / n.

where

$\sum$ = the summation sign (i=1 to n groups)

APE i is as defined above

n = the number of groups

MAPE is a measure in which positive and negative values do not offset each other; it measures the precision of the forecasts by showing the average percent difference between forecasts and actual activities regardless of whether the individual forecasts were too high or too low. MAPE has several desirable properties including reliability; ease of use and interpretation. It also incorporates all of the information in its calculation, but MAPE has a major drawback. Like any average, MAPE is affected by extreme values, but in the case of MAPE, the extreme values most often occur at the high end of the distribution.

Thus, the error distribution of the APEs is often asymmetrical and right-skewed because it is bounded on the left by zero and unbounded on the right. Therefore, MAPE is susceptible to being pulled upward and to overstating the error represented by most of the observations. Given this undesirable property, a zero MAPE would indicate perfect accuracy in the set of forecasts, as the sum of the positive percentage errors would equal the sum of the negative percentage errors. A MAPE less than 5% is considered as an indication that the forecast is acceptably accurate. A MAPE greater than 10% but less than 25% indicates low, but acceptable accuracy and MAPE greater than 25% very low accuracy, so low that the forecast is not acceptable in terms of its accuracy.

Given the propensity for APEs to be asymmetrical and right-skewed, MAPE can be supplemented with MEDAPE, which is simply the median value of the APEs, or, MAPE-R, a measure that minimizes the effect of outliers while preserving more information than MEDAPE about the original distribution (Swanson Tayman and Bryan 2011). One drawback of MAPE-R is that it is much more complicated to calculate than MEDAPE.

The Index of Allocation Error (IOAE) measures the extent that the forecasts misallocate activities over the categories in a given variable, such as age. This measure is also known as the Index of Dissimilarity.

IOAE is defined as: $IOAE = 100*\{0.5* \sum \left| (Fi / \sum Fi) - (CENi / \sum CENi) \right| \}$.

where

$\sum$ = the summation sign (i=1 to n groups)

Fi is as defined above

CEN i is as defined above

IOAE compares the percent distributions of the forecast and census numbers across the categories of a given variable (e.g., age) and measures the percentage that one distribution (i.e. based on the forecasts) would have to be re-allocated to match the other (i.e. based on the census). The IOAE ranges from 0 to 100; a score of zero is means that there is no allocation error, and 100 means that the maximum allocation error exists. This can mean several things, but a common interpretation is that half of the forecast numbers would have to be re-allocated and half of the census counts would have to be re-allocated.

As a simple example, suppose we were forecasting a population divided into two age groups and that the forecast has all of the people in one age group while the census has them in the other. In this case we will have $2 = \sum \left| (Fi / \sum Fi) - (CENi / \sum CENi) \right|$ and IOAE will then equal 100% because $100*(.5*2) = 100 *(1)$. An IOAE of less than five percent indicates a very close match between the two distributions; an IOAE between five and ten percent portrays a reasonable match between the two distributions; and an IOAE greater than ten percent suggests the distributions are quite distinct.

Empirical Data and Evaluation Results

To empirically examine the accuracy of the Hamilton-Perry Method, we selected a sample made up of one state from each of the four Census Regions in the United States. The states selected are Georgia (the South Region), Minnesota (the Midwest Region), New Jersey (The Northeast Region) and Washington (The West Region). We then assembled census data for these four states for each census year from 1900 to 2010 (These data are available in the appendix). The data provide ten points in time at which the forecast intervals can be evaluated, 1920, 1930, 1940, 1950, 1960, 1970, 1980, 1990, 2000, and 2010. This sample provides a wide range of demographic information in terms of variation in population size, age-composition, and rates of change. Table 1 provides an overview of this range by displaying the population of each of the four states in 1900 and in 2010 and decennial rates of population change from 1900 to 2010.

(TABLE 1 ABOUT HERE)

Although we do not show a summary of the changes in age composition by state and census year, they are extensive as can be seen the appendix tables, which provide the age data by state and census year.

We proceed by constructing CCRs over two successive decennial periods (e.g., 1900 and 1910) over the entire period and apply CCRs to the next period, the "launch year" (e.g. 1910) and develop a forecast by age groups for the "target year" (e.g., 1920). The forecasts are then compared to the corresponding census data in an ex post facto test. The differences are expressed in absolute and relative terms in order to the construct three summary measures of error described in the preceding section, MALPE, MAPE, and IOAE.

Because of the way data for the terminal open-ended age group are reported differently over the period for which we assemble census data, we used "75 years and over" for the entire period since it was the common denominator. This means that there are 16 age groups (0-4, 5-9, 70-74, and 75+) used in the empirical evaluation.

We present three tables containing results. The first two of the three tables show results for age groups while the third of the three shows results for total populations. The first of the two tables showing results by age group (Table 2) is organized so that one can see the summary statistics by state across all ten test points. The next one shows results by age group (Table 3) is organized so that one can see the summary statistics by test year. Table 4 provides results for the total population forecasts by state over each of the ten test points. Keep in mind that the total population forecasts are found by summing the forecasts for each age group. The Hamilton-Perry Method does not produce a "direct" forecast of a total population.

(TABLES 2, 3 and 4 ABOUT HERE)

Table 2 shows the summary statistics (MALPE, MAPE, and IOAE) by state for each of the ten test points. Note that we also provide summaries of these statistics at the bottom of the table, where the means, standard deviations, coefficients of variation, and medians are provided for each of the three measures (by state), respectively, MALPE, MAPE, and IOAE.

In examining the state of Georgia (South Census Region), we find that its population increased by almost five-fold between 1900 and 2010 (Table 1). In 1900 it had the largest population of any of the four sample states it retained that position in 2010. Its annual average growth rates (by decade) ranged from 0.0005 between 1920 and 1930 to .0168 between 2000 and 2010. Changes in its age composition are extensive (See Appendix Table 1), with big impacts associated with the great depression, World War II, the baby boom, and immigration to the Sunbelt states more recently.

As can be seen in Table 2, the MALPEs for Georgia range from -7.94 for the 2000 test to 8.12 in the 1930 test. The overall mean of the MALPE is -1.47, with a standard deviation of 5.57 and a median of -2.08. The MAPE scores for Georgia range from a low of 5.04 in the 1920 test to a high of 11.28 in the 1940 test. The mean of the 10 MAPE scores is 7.38 while the standard deviation is 2.49 and the median is 7.52. The IOAE scores for Georgia range from 1.80 in the 1990 test to 6.30 in the 1980 test. The mean of the ten IOAE scores is 3.31 while the standard deviation is 1.34 and the median is 3.31.

In terms of forecasting the total population of Georgia, Table 4 shows that percent errors range from -8.64 in the 2000 test to 9.67 in the 1930 test while the absolute percent errors range from 0.16 in the 1990 test to 9.67 in the 1930 test. The mean of the ten PE scores for the total population of Georgia is -0.6 with a standard deviation of 6.19. The MAPE of the ten APE scores for the total population of Georgia is 5.13, with a standard deviation of 3.18. The median of the ten PE scores is -1.84 while the median of the ten APE scores is 5.32.

The population of Minnesota tripled from 1900 to 2010 (Table 1). Its average annual growth rates ranged from a low of 0.0066 between 1940 and 1950 to a high of 0.0170 between 1900 and 1910, a period when the state was still receiving a large number of immigrants from Europe. As is the case for Georgia, changes in its age composition are extensive (See Appendix Table 2) , with big impacts associated with the restrictions placed on immigration by World War I and by US laws in the early 1920s, the great depression, World War II, the baby boom, and outmigration to sunbelt states in more recent decades.

As can be seen in Table 2, the MALPEs for Minnesota range from -7.57 for the 2000 test to 2.98 in the 2010 test. The overall mean of the MALPE is 0.00, with a standard deviation of 4.86 and a median of 1.28. The MAPE scores for Minnesota range from a low of 2.01 in the 1990 test to a high of 7.57 in the 2000 test. The mean of the 10 MAPE scores is 4.94 while the standard deviation is 2.48 and the median is 5.54. The IOAE scores for Minnesota range from 1.19 in the 1990 test to 8.57 in the 1980 test. The mean of the ten IOAE scores is 3.47 while the standard deviation is 2.35 and the median is 5.54.

In terms of forecasting the total population of Minnesota, Table 4 shows that the Hamilton-Perry Method produced percent errors that range from -10.46 in the 1960 test to 9.54 in the 1980 test while the absolute percent errors range from 0.81 in the 1990 test to 9.46 in the 1960 test. The mean of the ten PE scores for the total population of Minnesota is -0.19 with a standard deviation of 5.98. The MAPE of the ten APE scores for the total population of Minnesota is 4.55, with a standard deviation of 3.58. The median of the ten PE scores is 0.93 while the median of the ten APE scores is 3.57.

For New Jersey, we see that its population grew from 1,879,890 in 1900 to 8,791,894 in 2010 (Table 1). New Jersey had the second highest population in 1900 and again in 2010. Its average annual growth rates ranged from a low of 0.0027 between 1970 and 1980 to a high of 0.0299 between 1900 and 1910. As is the case for Georgia and Minnesota, changes in its age composition are extensive (See Appendix Table 3) , with big impacts associated with the restrictions placed on immigration by World War I and by US laws in the early 1920s, the great depression, World War II, the baby boom, and outmigration to sunbelt states in more recent decades.

Table 2 shows that for New Jersey the MALPEs range from -11.55 for the 1950 test to 21.37 in the 1940 test. The overall mean of the MALPE is 1.92, with a standard deviation of 11.39 and a median of 0.12. The MAPE scores for New Jersey range from a low of 4.14 in the 1980 test to a high of 21.37 in the 1941 test. The mean of the 10 MAPE scores is 9.62 while the standard deviation is 6.10 and the median is 7.78. The IOAE scores for New Jersey range from 1.45 in the 2010 test to 8.47 in the 1980 test. The mean of the ten IOAE scores for New Jersey is 3.92 while the standard deviation is 2.28 and the median is 3.19.

In terms of forecasting the total population of New Jersey, Table 4 shows that the Hamilton-Perry's percent errors range from -13.07 in the 1950 test to 24.00 in the 1940 test while the absolute percent errors range from 1.68 in the 1990 test to 24.00 in the 1940 test. The mean of the ten PE scores for the total population of New Jersey is 2.12 with a standard deviation of 12.55. The MAPE of the ten APE scores for the total population of New Jersey is 9.68, with a standard deviation of 7.64. The median of the ten PE scores is 0.93 while the median of the ten APE scores is 3.57.

In 1900, Washington was largely a frontier state. It had the smallest population (511,844) of any of the four states in the sample. However, by 2010, it had grown to 6,724,540 which surpassed the population of Minnesota in 2010 (Table 1). Its annual rates of population change are somewhat more dramatic than the other states between the 1900-1910 period and the 2000-2010 period. Between 1900 and 1910 it posted an annual rate of 0.0797, the highest of any of the decennial growth rates in the sample. It also posted the second highest rate. Between 1940 and 1950 the state grew at an annual rate of 0.0314. The lowest rate of annual population change (0.0106) is found between 1930 and 1940.

As Table 2 shows, the MALPEs for Washington range from -16.49 for the 1950 test to 77.15 in the 1920 test. The overall mean of the MALPE is 7.66, with a standard deviation of 25.48 and a median of 2.04. The MAPE scores for Washington range from a low of 3.96 in the 1990 test to a high of 77.15 in the 1920 test. The mean of the 10 MAPE scores is 15.34 while the standard deviation is 22.15 and the median is 6.66. The IOAE scores for Washington range from 1.61 in the 1990 test to 7.19 in the 1980 test. The mean of the ten IOAE scores for Washington is 4.19 while the standard deviation is 2.21 and the median is 3.80.

In terms of forecasting the total population of Washington, Table 4 shows that the Hamilton-Perry Method produced percent errors that range from -20.30 in the 1950 test to 88.68 in the 1920 test while the absolute percent errors range from 0.33 in the 1970 test to 88.68 in the 1920 test. The mean of the ten PE scores for the total population of Washington is 8.77 with a standard deviation of 29.33. The MAPE of the ten APE scores for the total population of Washington is 14.26, with a standard deviation of 26.82. The median of the ten PE scores is 2.75 while the median of the ten APE scores is 4.55.

Turning to the results for age groups summarized by year, we can see in Table 3 that MALPE ranges from -7.53 in 1950 to 22.63 in 1920. The standard deviations for the MALPE scores range from 1.04 in 2000 to 36.41 in 1920 and the medians range from -6.79 in 2000 to 5.48 in 1920. In terms of MAPE, the means range from a low of 3.35 in 1990 to a high of 23.57 in 1920. The standard deviations for the MAPE scores range from a low of 0.94 in 1970 to a high of 35.74 in 1920. The median MAPE scores range from a low of 3.63 in 1990 to 11.12 in 1980. For the IOAE scores, the lowest mean is found for the 1990 tests and the highest for the 1980 tests. The standard deviation of the IOAE scores range from a low of 0.29 in 1990 to a high of 1.50 in 1940.

For the total population scores by year, the lowest mean MAPE scores are found for the 1990 test year and the highest for 1920. The lowest standard deviations for the MAPE scores are found for the 1990 test year and highest for 1920. The lowest test median for the MAPE scores by year is found for the 1990 test year and the highest for 1960. Overall, the average MAPE score for the total population forecasts for all states and all years is 8.40 with a standard deviation of 14.16. The median MAPE score for the total population forecasts across all years and all states is 5.23

Discussion

Recalling the standards described in the section on “Measures of Error,” it appears that for the most part, the “bias” scores for the age forecasts indicate acceptable levels of bias in that they are on average less than +/-5% across all states and years. The “precision” scores for the age forecasts indicate that are not the best, but they are acceptable and not “low” In that their average is more than 5%, but less than 10 percent across all state and years. In terms of “allocation error,” the average of the IOAE scores indicates that the Hamilton-Perry Method provides a “close match to the census age distributions in that their average is less than 5% across all states and years. While there is a great deal of variation by state and year in the MALPE, MAPE and IOAE scores associated with the age group projections , we find that on the whole, the Hamilton-Perry Method does a good job in terms of bias, precision and allocation error.

In terms of the total population forecasts, the Hamilton-Perry Method does a good job in terms of bias and precision for Georgia and Minnesota across all years and an acceptable job for New Jersey and Washington. Overall, the method does an acceptable job in terms of precision for all four states across all ten test points.

In discussing these results, we note that two test points are directly related to two major events that significant affected demographic behaviors, 1940 and 1950. The 1940 point encompasses the economic boom experienced in the 1920s and the economic depression during the 1930s and the large scale “baby bust” associated with it. The 1950 point encompasses the depression and baby bust period of the 1930s and the economic recovery stimulated by World War II and the initial part of the large scale “baby boom” from 1946 to 1950. These points, especially the latter one, are well-known in terms of being "unexpected" events, which can be translated to mean that in terms of population forecasting, the task of capturing demographic change associated with them is very difficult.

At this point, we do not suggest using this method beyond a ten-year forecast horizon. This is consistent with observations about the use of the Hamilton-Perry method in general (Smith, Tayman, and Swanson, 2001; Swanson, Schlottmann and Schmidt, 2010) and accuracy findings by Smith and Tayman (2003). As such is not a major limitation. We also suggest that the Hamilton-Perry Method used with care when applied to small populations, such as those found at the county and sub-county levels. While our sample provides a wide range of demographic behavior in terms of size, age composition, and population changes, it is after all a sample of states, which means that some of the extreme conditions found at sub-state levels are not present (Baker Ruan and Alcantara 2011, Swanson, Schlottmann, and Schmidt, 2010). We suggest that further research using this approach would be useful by examining state level accuracy over forecast horizons longer than ten years and by examining the accuracy of smaller populations in conjunction over both longer forecast horizons and more cases, both from a geographic and a temporal standpoint.

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Table 1. The Total Population of each State in 1900 and 2010 and Annual Rates of Change from 1900 to 2010 by Decade*

	STATE				
Census Year	GEORGIA	MINNESOTA	NEW JERSEY	WASHINGTON	
1900	2,209,974	1,747,292	1,879,890	511,844	Population
1910	0.0164	0.0170	0.0299	0.0797	Average annual Rate of Change over the Decade
1920	0.0105	0.0141	0.0219	0.0175	Average annual Rate of Change over the Decade
1930	0.0005	0.0072	0.0247	0.0144	Average annual Rate of Change over the Decade
1940	0.0072	0.0086	0.0030	0.0106	Average annual Rate of Change over the Decade
1950	0.0098	0.0066	0.0150	0.0314	Average annual Rate of Change over the Decade
1960	0.0135	0.0135	0.0227	0.0183	Average annual Rate of Change over the Decade
1970	0.0152	0.0108	0.0167	0.0178	Average annual Rate of Change over the Decade
1980	0.0174	0.0069	0.0027	0.0192	Average annual Rate of Change over the Decade
1990	0.0170	0.0071	0.0048	0.0164	Average annual Rate of Change over the Decade
2000	0.0234	0.0117	0.0085	0.0192	Average annual Rate of Change over the Decade
2010	0.0168	0.0075	0.0044	0.0132	Average annual Rate of Change over the Decade
2010	9,687,653	5,303,925	8,791,894	6,724,540	Population

* The 1900 population totals exclude those for whom age was not reported.

TABLE 2. SUMMARY OF ERROR RESULTS FOR AGE GROUPS (16) BY STATE AND TEST YEAR (ALL NUMBERS ARE EXPRESSED AS PERCENTS)												
	GEORGIA			MINNESOTA			NEW JERSEY			WASHINGTON		
TEST YEAR	MALPE	MAPE	IOAE	MALPE	MAPE	IOAE	MALPE	MAPE	IOAE	MALPE	MAPE	IOAE
1920*	3.65	5.04	2.27	2.42	4.78	3.00	7.30	7.30	2.43	77.15	77.15	7.03
1930*	8.12	8.22	3.11	2.74	4.46	2.46	-6.06	8.25	2.46	-0.76	4.96	2.77
1940	-8.39	11.28	4.29	-3.60	6.35	2.40	21.37	21.37	5.88	2.15	5.59	3.23
1950	-4.13	6.16	3.50	2.06	6.44	3.91	-11.55	11.55	4.04	-16.49	16.49	6.09
1960	-6.36	7.09	3.84	-7.42	7.80	6.13	-9.28	9.28	6.27	11.43	14.86	5.85
1970	-3.41	8.29	3.59	0.11	6.30	4.16	3.56	6.40	3.74	-0.19	7.39	4.37
1980	-0.75	10.86	6.30	7.78	0.10	8.57	19.62	18.97	8.47	2.50	11.38	7.19
1990	0.19	3.29	1.80	0.50	2.01	1.19	-1.36	4.14	1.82	1.93	3.96	1.61
2000	-7.94	7.94	2.39	-7.57	7.57	1.62	-6.01	6.01	2.63	-5.93	5.93	2.12
2010	4.29	5.64	2.01	2.98	3.58	1.28	1.59	2.95	1.45	4.76	5.65	1.63
MEAN	-1.47	7.38	3.31	0.00	4.94	3.47	1.92	9.62	3.92	7.66	15.34	4.19
STD DEV	5.57	2.49	1.34	4.86	2.48	2.35	11.39	6.10	2.28	25.48	22.15	2.21
C.V.	-3.78	0.34	0.41	N/A	0.50	0.68	5.94	0.63	0.58	3.33	1.44	0.53
MEDIAN	-2.08	7.52	3.31	1.28	5.54	2.73	0.12	7.78	3.19	2.04	6.66	3.80

MALPE = MEAN ALGEBRAIC PERCENT ERROR

MAPE = MEAN ABSOLUTE PERCENT ERROR

IOAE = INDEX OF ALLOCATION ERROR (ALSO KNOWN AS THE INDEX OF DISSIMILARITY)

THE POPULATION DATA FOR 1900 TO 1930 EXCLUDE THOSE FOR WHOM AGE WAS NOT REPORTED; NO CENSUS DATA FROM 1940 TO 2010 SHOW ANY PERSONS FOR WHOM AGE WAS NOT REPORTED

TABLE 3 SUMMARY RESULTS BY TEST YEAR												
	MALPE				MAPE				IOAE			
TEST YEAR	MEAN	STD DEV	C.V	MEDIAN	MEAN	STD DEV	C.V	MEDIAN	MEAN	STD DEV	C.V	MEDIAN
1920*	22.63	36.41	1.61	5.48	23.57	35.74	1.52	6.17	3.68	2.25	0.61	2.72
1930*	1.01	5.96	5.90	0.99	6.47	2.05	0.32	6.59	2.70	0.31	0.11	2.62
1940	2.88	13.06	4.53	-0.73	11.15	7.27	0.65	8.82	3.95	1.50	0.38	3.76
1950	-7.53	8.16	-1.08	-7.84	10.16	4.89	0.48	9.00	4.39	1.16	0.26	3.98
1960	-2.91	9.63	-3.31	-6.89	9.76	3.52	0.36	8.54	5.52	1.14	0.21	5.99
1970	0.02	2.85	162.79	-0.04	7.10	0.94	0.13	6.90	3.97	0.36	0.09	3.95
1980	7.29	8.94	1.23	5.14	10.33	7.76	0.75	11.12	7.63	1.09	0.14	7.83
1990	0.32	1.35	4.28	0.35	3.35	0.97	0.29	3.63	1.61	0.29	0.18	1.71
2000	-6.86	1.04	-0.15	-6.79	6.86	1.04	0.15	6.79	2.19	0.43	0.20	2.26
2010	3.41	1.43	0.42	3.64	4.46	1.40	0.31	4.61	1.59	0.31	0.20	1.54

TABLE 4. SUMMARY OF ERROR RESULTS FOR FORECASTED TOTAL POPULATION BY STATE AND TEST YEAR												
	GEORGIA		MINNESOTA		NEW JERSEY		WASHINGTON		ABSOLUTE PERCENT ERROR			
TEST YEAR	PERCENT ERROR	ABSOLUTE PERCENT ERROR	PERCENT ERROR	ABSOLUTE PERCENT ERROR	PERCENT ERROR	ABSOLUTE PERCENT ERROR	PERCENT ERROR	ABSOLUTE PERCENT ERROR	MEAN	STD DEV	C.V.	MEDIAN
1920*	5.38	5.38	3.80	3.80	8.82	8.82	88.68	88.68	26.67	41.39	1.55	7.10
1930*	9.67	9.67	4.37	4.37	-5.20	5.20	-0.65	0.65	4.97	3.70	0.74	4.79
1940	-6.77	6.77	-3.33	3.33	24.00	24.00	2.78	2.78	9.22	10.01	1.09	5.05
1950	-3.86	3.86	0.83	0.83	-13.07	13.07	-20.30	20.30	9.52	8.88	0.93	8.47
1960	-7.45	7.45	-10.46	10.46	-11.84	11.84	11.45	11.45	10.30	1.99	0.19	10.96
1970	-3.52	3.52	1.02	1.02	4.16	4.16	0.33	0.33	2.26	1.87	0.83	2.27
1980	0.55	0.55	9.54	9.54	20.26	20.26	3.89	3.69	8.51	8.67	1.02	6.62
1990	-0.16	0.16	0.81	0.81	-1.68	1.68	2.71	2.71	1.34	1.11	0.82	1.25
2000	-8.64	8.64	-7.99	7.99	-6.04	6.04	-6.62	6.62	7.32	1.20	0.16	7.31
2010	5.25	5.25	3.34	3.34	1.74	1.74	5.40	5.40	3.93	1.74	0.44	4.30
MEAN	-0.96	5.13	0.19	4.55	2.12	9.68	8.77	14.26				
STD DEV	6.19	3.18	5.98	3.58	12.55	7.64	29.33	26.82				
C.V.	-6.48	0.62	30.99	0.79	5.93	0.79	3.35	1.88				
MEDIAN	-1.84	5.32	0.93	3.57	0.03	7.43	2.75	4.55				

OVERALL RESULTS FOR APE	
MEAN	8.40
STDEV	14.16
C.V	1.69
MEDIAN	5.23

MALPE = MEAN ALGEBRAIC PERCENT ERROR

MAPE = MEAN ABSOLUTE PERCENT ERROR

IOAE = INDEX OF ALLOCATION ERROR (ALSO KNOWN AS THE INDEX OF DISSIMILARITY)

THE POPULATION DATA FOR 1900 TO 1930 EXCLUDE THOSE FOR WHOM AGE WAS NOT REPORTED; NO CENSUS DATA FROM 1940 TO 2010 SHOW ANY PERSONS FOR WHOM AGE WAS NOT REPORTED

APPENDIX TABLE 1. DATA FOR GEORGIA

AGE GROUP	1900 CENSUS POPULATION	1910 CENSUS POPULATION	1920 CENSUS POPULATION	1930 CENSUS POPULATION	1940 CENSUS POPULATION	1950 CENSUS POPULATION	1960 CENSUS POPULATION	1970 CENSUS POPULATION	1980 CENSUS POPULATION	1990 CENSUS POPULATION	2000 CENSUS POPULATION	2010 CENSUS POPULATION
Total Population: 0 to 4 years	325,473	376,641	363,229	316,404	313,122	422,486	471,901	421,709	414,935	495,535	595,150	686,785
Total Population: 5 to 9 years	313,524	347,369	382,373	353,910	319,056	355,208	440,198	470,311	446,831	483,952	615,584	695,161
Total Population: 10 to 14 years	277,865	315,217	365,312	338,860	325,009	311,293	411,650	480,924	469,598	466,614	607,759	689,684
Total Population: 15 to 19 years	241,478	280,383	307,549	334,836	328,410	291,806	331,554	442,571	530,773	497,152	596,277	709,999
Total Population: 20 to 24 years	229,199	260,140	272,814	288,126	304,638	276,193	271,211	416,949	516,084	522,634	592,196	680,080
Total Population: 25 to 29 years	172,819	214,250	230,373	222,930	277,500	276,270	251,770	330,790	481,276	589,952	641,750	673,935
Total Population: 30 to 34 years	127,782	169,314	180,749	183,399	236,138	255,385	256,351	273,995	448,765	584,944	657,506	661,625
Total Population: 35 to 39 years	111,711	152,232	185,500	186,959	209,545	254,264	260,063	256,934	356,263	531,619	698,735	698,059
Total Population: 40 to 44 years	97,256	109,644	140,477	151,156	174,120	219,640	244,981	260,140	291,069	484,079	654,773	699,481
Total Population: 45 to 49 years	78,565	85,850	125,849	133,154	156,489	182,855	229,397	252,278	266,793	374,918	573,017	722,661
Total Population: 50 to 54 years	78,307	96,240	106,175	131,455	134,244	153,118	196,204	232,825	261,211	294,033	506,975	668,591
Total Population: 55 to 59 years	46,756	61,442	66,256	84,633	102,773	126,309	161,507	207,126	246,907	259,735	375,651	573,551
Total Population: 60 to 64 years	42,863	55,526	64,125	67,562	83,965	100,096	125,668	175,565	215,869	238,779	285,805	496,006
Total Population: 65 to 69 years	27,942	35,469	44,269	45,142	75,095	95,556	113,144	137,744	188,897	218,078	236,634	356,007
Total Population: 70 to 74 years	18,887	21,911	29,550	33,738	42,732	60,606	81,647	97,362	141,977	169,973	199,061	250,422
Total Population: 75+	19,547	23,349	28,292	34,398	40,887	63,493	95,870	132,352	185,857	266,219	349,580	425,606
Total Population	**2,209,974**	**2,604,977**	**2,892,892**	**2,906,662**	**3,123,723**	**3,444,578**	**3,943,116**	**4,589,575**	**5,463,105**	**6,478,216**	**8,186,453**	**9,687,653**
Age Not Reported	**6,357**	**4,144**	**2,940**	**1,844**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Population including those not reporting Age	**2,216,331**	**2,609,121**	**2,895,832**	**2,908,506**	**3,123,723**	**3,444,578**	**3,943,116**	**4,589,575**	**5,463,105**	**6,478,216**	**8,186,453**	**9,687,653**

2010 data are from Table QT-P1, 2010 Decennial Census

2000 data are from Table QT-P1, 2000 Decennial Census

1990 Data are from Table 19, *General Population Characteristics* ,1990 Decennial Census

1980 Data are from Table 19, *General Population Characteristics* , 1980 Decennial Census,

THE 1900 THROUGH 1970 POPULATION BY AGE DATA ARE FROM TABLE 21 IN "CHARACTERISTICS OF THE POPULATION, VOLUME 1" (BY STATE), 1970 CENSUS OF POPULATION

GEORGIA (VOL 1, PART 12) MARCH 1973

APPENDIX TABLE 2: DATA FOR MINNESOTA

AGE GROUP	1900 CENSUS POPULATION	1910 CENSUS POPULATION	1920 CENSUS POPULATION	1930 CENSUS POPULATION	1940 CENSUS POPULATION	1950 CENSUS POPULATION	1960 CENSUS POPULATION	1970 CENSUS POPULATION	1980 CENSUS POPULATION	1990 CENSUS POPULATION	2000 CENSUS POPULATION	2010 CENSUS POPULATION
Total Population: 0 to 4 years	228,290	226,840	261,394	231,001	230,057	332,460	416,005	331,771	307,249	336,800	329,594	355,504
Total Population: 5 to 9 years	217,447	220,233	248,599	256,751	220,176	267,652	380,650	402,635	296,295	345,840	355,894	355,536
Total Population: 10 to 14 years	192,064	214,402	233,961	253,788	238,918	223,787	324,710	415,021	333,378	313,297	374,995	352,342
Total Population: 15 to 19 years	170,177	215,148	219,609	239,946	257,349	207,460	251,352	373,405	399,818	297,609	374,362	367,829
Total Population: 20 to 24 years	160,674	216,670	217,919	214,432	245,592	213,712	194,883	292,037	393,566	316,046	322,483	355,651
Total Population: 25 to 29 years	148,607	187,438	213,646	193,469	225,097	220,780	193,160	249,516	363,435	381,759	319,826	372,686
Total Population: 30 to 34 years	131,055	153,195	189,778	189,705	204,311	212,765	206,487	206,769	313,104	397,984	353,312	342,900
Total Population: 35 to 39 years	121,193	135,612	168,540	192,934	192,452	205,447	211,163	192,863	246,356	361,274	412,490	328,190
Total Population: 40 to 44 years	100,646	117,256	135,353	172,980	187,196	189,729	204,868	202,710	202,860	304,810	411,692	352,904
Total Population: 45 to 49 years	72,042	105,289	122,435	147,143	182,525	176,212	194,149	202,904	187,051	237,050	364,247	406,203
Total Population: 50 to 54 years	57,896	88,110	105,208	122,171	162,931	170,805	176,190	193,956	193,199	191,410	301,449	401,695
Total Population: 55 to 59 years	45,293	59,272	87,437	100,813	129,941	157,690	159,840	177,011	189,457	173,066	226,857	349,589
Total Population: 60 to 64 years	35,137	45,188	69,827	84,372	103,137	134,854	146,056	155,454	170,638	171,220	178,012	279,775
Total Population: 65 to 69 years	28,251	34,825	45,827	69,079	82,635	105,188	131,315	130,155	149,114	160,036	153,169	202,570
Total Population: 70 to 74 years	19,424	23,536	30,188	48,256	60,455	73,705	102,086	110,251	121,034	134,486	142,656	151,857
Total Population: 75+	19,096	27,696	34,751	46,145	69,528	90,237	120,950	168,513	209,416	252,412	298,441	328,694
Total Population	**1,747,292**	**2,070,710**	**2,384,472**	**2,562,985**	**2,792,300**	**2,982,483**	**3,413,864**	**3,804,971**	**4,075,970**	**4,375,099**	**4,919,479**	**5,303,925**
Age Not Reported	**4,102**	**4,998**	**2,653**	**968**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Population including those not reporting Age	**1,751,394**	**2,075,708**	**2,387,125**	**2,563,953**	**2,792,300**	**2,982,483**	**3,413,864**	**3,804,971**	**4,075,970**	**4,375,099**	**4,919,479**	**5,303,925**

2010 data are from Table QT-P1, 2010 Decennial Census

2000 data are from Table QT-P1, 2000 Decennial Census

1990 Data are from Table 19, *General Population Characteristics* ,1990 Decennial Census

1980 Data are from Table 19, *General Population Characteristics* , 1980 Decennial Census,

THE 1900 THROUGH 1970 POPULATION BY AGE DATA ARE FROM TABLE 21 IN "CHARACTERISTICS OF THE POPULATION, VOLUME 1" (BY STATE), 1970 CENSUS OF POPULATION
MINNESOTA (VOL 1, PART 23) JANUARY 1973

APPENDIX TABLE 3: DATA FOR NEW JERSEY

AGE GROUP	1900 CENSUS POPULATION	1910 CENSUS POPULATION	1920 CENSUS POPULATION	1930 CENSUS POPULATION	1940 CENSUS POPULATION	1950 CENSUS POPULATION	1960 CENSUS POPULATION	1970 CENSUS POPULATION	1980 CENSUS POPULATION	1990 CENSUS POPULATION	2000 CENSUS POPULATION	2010 CENSUS POPULATION
Total Population: 0 to 4 years	206,446	266,942	338,696	329,668	256,264	458,906	642,197	589,226	463,289	532,637	563,785	541,020
Total Population: 5 to 9 years	196,725	242,279	322,958	380,918	280,722	371,826	582,212	692,648	508,447	493,044	604,529	564,750
Total Population: 10 to 14 years	174,347	228,695	291,236	384,342	337,776	290,544	524,380	710,409	605,841	480,983	590,577	587,335
Total Population: 15 to 19 years	166,746	236,541	255,161	364,396	375,112	295,859	396,363	611,831	670,665	505,388	525,216	598,099
Total Population: 20 to 24 years	178,228	250,613	271,042	350,402	376,912	350,403	321,054	509,198	614,828	566,594	480,079	541,238
Total Population: 25 to 29 years	176,408	236,172	286,617	332,810	361,291	409,890	362,373	463,164	574,135	668,917	544,917	553,139
Total Population: 30 to 34 years	158,858	213,082	263,733	331,332	340,976	409,434	435,080	403,475	563,758	691,734	644,123	556,662
Total Population: 35 to 39 years	144,124	199,647	251,252	338,222	322,760	393,917	472,429	413,929	479,749	622,963	727,924	588,379
Total Population: 40 to 44 years	117,887	166,638	207,122	291,871	315,720	357,760	446,139	465,492	400,074	573,696	707,182	649,918
Total Population: 45 to 49 years	92,115	136,295	185,551	246,388	297,595	318,504	406,721	477,978	394,038	466,481	611,357	704,516
Total Population: 50 to 54 years	78,915	112,003	151,688	205,434	259,570	305,235	350,531	439,103	432,520	376,528	547,541	674,680
Total Population: 55 to 59 years	60,248	75,739	108,505	157,128	198,622	263,516	304,112	380,677	430,048	355,677	423,338	565,623
Total Population: 60 to 64 years	49,226	62,678	86,297	124,676	158,024	215,546	262,777	314,045	367,660	363,521	330,646	480,542
Total Population: 65 to 69 years	33,955	45,948	56,135	88,449	119,172	164,921	222,457	245,757	303,670	340,232	293,196	350,972
Total Population: 70 to 74 years	23,186	31,193	38,149	58,951	80,239	109,441	163,149	194,112	227,037	269,960	281,473	260,462
Total Population: 75+	22,476	29,946	39,197	53,643	79,410	119,627	174,808	257,120	329,064	421,833	538,467	574,559
Total Population	**1,879,890**	**2,534,411**	**3,153,339**	**4,038,630**	**4,160,165**	**4,835,329**	**6,066,782**	**7,168,164**	**7,364,823**	**7,730,188**	**8,414,350**	**8,791,894**
Age Not Reported	**1,128**	**662**	**792**	**244**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Population including those not reporting Age	**1,881,018**	**2,535,073**	**3,154,131**	**4,038,874**	**4,160,165**	**4,835,329**	**6,066,782**	**7,168,164**	**7,364,823**	**7,730,188**	**8,414,350**	**8,791,894**

2010 data are from Table QT-P1, 2010 Decennial Census

2000 data are from Table QT-P1, 2000 Decennial Census

1990 Data are from Table 19, *General Population Characteristics* ,1990 Decennial Census

1980 Data are from Table 19, *General Population Characteristics* , 1980 Decennial Census,

THE 1900 THROUGH 1970 POPULATION BY AGE DATA ARE FROM TABLE 21 IN "CHARACTERISTICS OF THE POPULATION, VOLUME 1" (BY STATE), 1970 CENSUS OF POPULATION
NEW JERSEY (VOL 1, PART 32) MARCH 1973

APPENDIX TABLE 4: DATA FOR WASHINGTON

AGE GROUP	1900 CENSUS POPULATION	1910 CENSUS POPULATION	1920 CENSUS POPULATION	1930 CENSUS POPULATION	1940 CENSUS POPULATION	1950 CENSUS POPULATION	1960 CENSUS POPULATION	1970 CENSUS POPULATION	1980 CENSUS POPULATION	1990 CENSUS POPULATION	2000 CENSUS POPULATION	2010 CENSUS POPULATION
Total Population: 0 to 4 years	53,243	108,756	126,434	114,854	121,918	263,326	315,633	280,442	306,123	366,780	394,306	439,657
Total Population: 5 to 9 years	56,423	99,678	128,258	136,013	116,762	203,786	301,051	328,397	296,011	371,093	425,909	429,877
Total Population: 10 to 14 years	48,233	92,802	117,553	138,393	127,842	159,695	275,510	348,892	321,995	337,662	434,836	438,233
Total Population: 15 to 19 years	44,104	99,647	106,485	137,922	146,725	157,695	208,575	329,903	369,023	322,711	427,968	462,128
Total Population: 20 to 24 years	46,403	122,058	111,014	130,401	148,867	175,619	173,804	295,964	400,542	351,680	390,185	461,512
Total Population: 25 to 29 years	46,093	126,074	120,421	120,651	146,594	195,087	166,376	238,704	389,997	411,822	403,652	480,398
Total Population: 30 to 34 years	47,118	106,963	119,446	115,448	134,757	188,636	179,899	193,398	354,645	443,366	437,478	453,383
Total Population: 35 to 39 years	46,368	90,149	117,587	122,833	124,990	180,749	198,495	181,020	273,382	427,690	483,950	448,607
Total Population: 40 to 44 years	37,863	77,286	95,805	118,105	118,525	159,090	189,191	192,828	213,832	376,073	491,137	459,698
Total Population: 45 to 49 years	26,027	64,992	81,764	108,280	117,709	136,714	176,071	203,880	193,473	284,674	454,223	492,909
Total Population: 50 to 54 years	20,754	52,413	69,451	90,223	112,915	125,939	150,495	188,774	198,548	216,869	391,749	495,296
Total Population: 55 to 59 years	14,127	33,661	55,053	69,260	96,698	115,306	129,003	166,878	203,986	191,602	285,505	453,078
Total Population: 60 to 64 years	10,407	24,144	42,352	57,530	77,569	103,916	110,066	138,028	179,037	189,382	211,075	382,087
Total Population: 65 to 69 years	7,195	16,585	27,298	44,440	57,963	86,551	98,659	107,008	151,324	186,679	176,225	270,474
Total Population: 70 to 74 years	4,161	10,374	16,647	30,075	41,943	59,655	80,938	84,335	112,023	149,355	160,941	186,746
Total Population: 75+	3,325	9,614	16,266	26,988	44,414	65,199	99,448	130,718	168,215	239,254	324,982	370,457
Total Population	**511,844**	**1,135,196**	**1,351,834**	**1,561,416**	**1,736,191**	**2,376,963**	**2,853,214**	**3,409,169**	**4,132,156**	**4,866,692**	**5,894,121**	**6,724,540**
Age Not Reported	**6,259**	**6,794**	**4,787**	**1,980**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Population including those not reporting Age	**518,103**	**1,141,990**	**1,356,621**	**1,563,396**	**1,736,191**	**2,376,963**	**2,853,214**	**3,409,169**	**4,132,156**	**4,866,692**	**5,894,121**	**6,724,540**

2010 data are from Table QT-P1, 2010 Decennial Census 2000 data are from Table QT-P1, 2000 Decennial Census	1990 Data are from Table 19, *General Population Characteristics* ,1990 Decennial Census 1980 Data are from Table 19, *General Population Characteristics* , 1980 Decennial Census,

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WASHINGTON (VOL 1, PART 49) JANUARY 1973