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United States Population Future Estimates and Long-Term Distribution

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ABSTRACT The population of the United States has always increased year after year. Even now with decreasing birth rates, the overall population continues to grow when looking at conventional models. The present study specifically examines what would happen to the U.S. population if we were to maintain the current birth and survival rates into the future. Our research shows that by 2050, the U.S. population will become much older and cease to grow at all.

INTRODUCTION

Throughout the history of the United States, we have never had a year that presented us with a lower population than the year prior. This can be attributed to women on average having more than two live births during their lifetime [7]. Having two children on average means that the rate of birth is equal to the rate of death, with the two children replacing their parents as far as population is concerned. In a practical sense, this means that with no change in mortality rates, we could maintain the current population.

When we look at survival rates, people have begun to live much longer. Particularly over the last 35 years, there has been a continuous rise in life expectancy (see Figure 1). This creates a larger net population with fewer people exiting the equation year after year.

Therefore, with increasing life expectancy and enough children being born to increase the overall population, we have experienced significant growth as a nation.

We also see a noticeable impact on the population from immigration and emigration. The United States receives far more immigrants than the number of emigrants which is yet another reason for the consistent increase in the overall population [6, 8, 9].

It is interesting to note that before 1960, fertility rates were much higher than two children per woman creating a large net growth in overall population. Between 1960 and 1974, however, there was a steady decline in the birth rate. During the next 40 years, fertility rates, while

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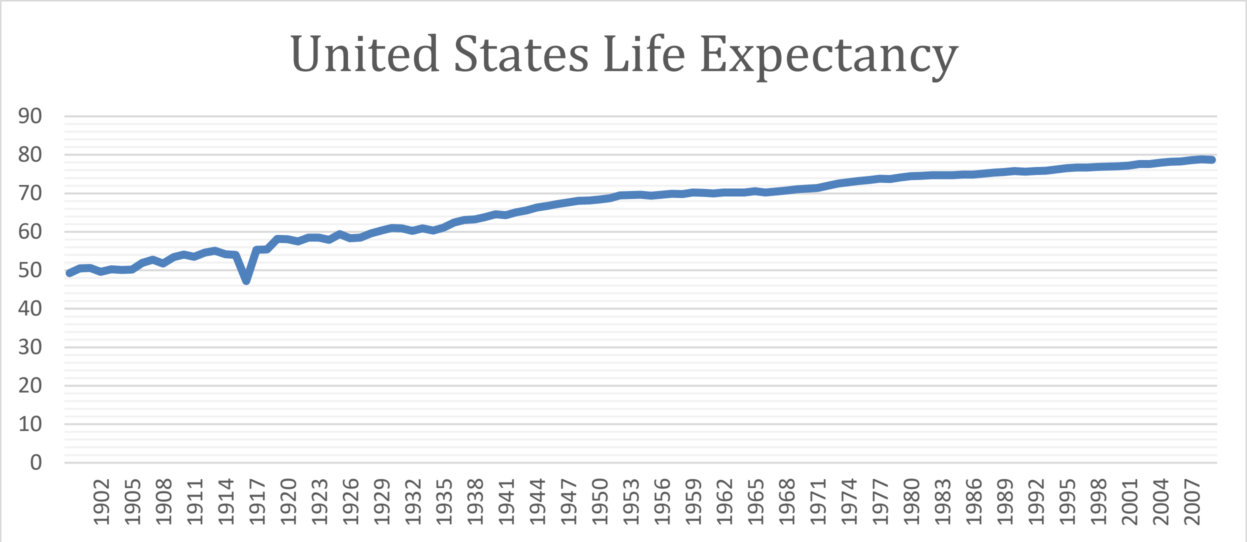

Figure 1. United States Life Expectancy

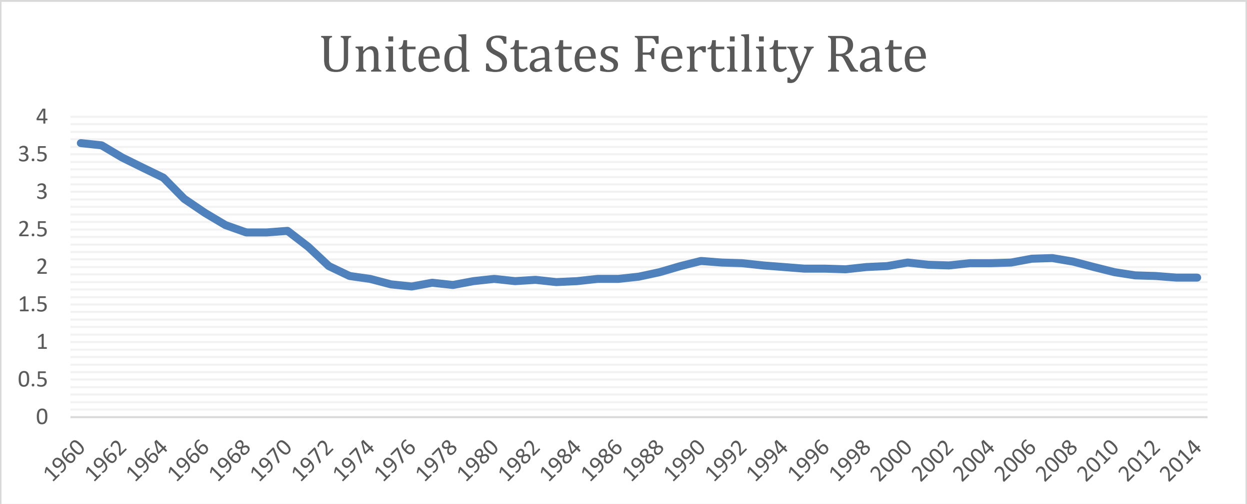

Figure 2. United States Fertility Rate

much lower, did not change significantly (see Figure 2). As of 2014, the birth rate was down to 1.86 births per woman, which is lower than the required replacement rate of 2.0. However, we have yet to see a decrease in population which raises the question: Should we be concerned by the lower birth rate? The point of our research was to discover what would happen in the long term if the current birth, mortality, and immigration rates remained consistent.

METHODS

We decided to use a matrix model to predict future growth due to both its simplicity and its versatility (see Table 1). A matrix can be thought of as a mathematical spreadsheet. Statistical data is provided for the given rows and columns. Then by taking a set of known data, such as the US population from a certain year, and applying it to the matrix, future predictions can be made.

For example, position (2,1), with the value 0.9956273, represents the number of people from the 0 to 9 age grouping that will move on into the 10 to 19 age grouping after one iteration. This is effectively stating that 99.56273% of people live through the first 10 years of their life. Similarly, position (1,3) represents the number of children

	0 to 9yrs	10 to 19yrs	20 to 29yrs	30 to 39yrs	40 to 49yrs	50 to 59yrs	60 to 69yrs	70 to 79yrs	80 to 89yrs
0 to 9yrs	0.03	0.0613	0.4620	0.3795	0.0275	0.0020	0	0	0
10 to 19yrs	0.9956	0.03	0	0	0	0	0	0	0
20 to 29yrs	0	0.9976	0.03	0	0	0	0	0	0
30 to 39yrs	0	0	0.9953	0.03	0	0	0	0	0
40 to 49yrs	0	0	0	0.9928	0.03	0	0	0	0
50 to 59yrs	0	0	0	0	0.9850	0.03	0	0	0
60 to 69yrs	0	0	0	0	0	0.9680	0.03	0	0
70 to 79yrs	0	0	0	0	0	0	0.9301	0.03	0
80 to 89yrs	0	0	0	0	0	0	0	1.3720	0.03

Table 1. Population Matrix Model (10-year distribution)

that will be born based on the current size of the 20 to 29 age group. This means that 46.2% of the 20-29 age grouping will have a child that will be added to the new 0 to 9 group after one iteration.

A matrix model works well here since we are attempting to see what would happen if current trends were to continue. If our birth rates or mortality rates were to be calculated by some means which would change them with each cycle, this would no longer be the best approach.

Splitting the population into 10-year age groups and accounting for immigration, we used a 9 x 9 matrix with age groups 0-9, 10-19, 20-29,…,70-79, and an 80+ category which will be discussed in more detail later. We pulled data from several government sources ranging from the U.S. Census Bureau to the CIA [1, 2, 6].

Birth rates were calculated by individual age grouping using data from 2014 as we were trying to see what would happen if those rates remained consistent.

We took our mortality rates from 2007, as those were the most up-to-date figures published in age groupings of 10 years.

Finding accurate figures on immigration into the U.S. is a difficult task, and the numbers vary based on the source being used. We looked at the average number of legal immigrants coming to the United States on a yearly basis. To keep the figures consistent with our model, we then found a correlation between the number of immigrants and our total population.

This was preferable since the only other option would have been to simply add a base figure at the end of each period. Adding a static number, while accurate for the period from which it was taken, would create inaccuracy in the long term since historically, as the world's population has increased, immigration has also increased.

Therefore, by basing our immigration on the current U.S. population for each period, we maintain accuracy because the figure updates dynamically with the rest of the population.

We found that over the last 20 years the U.S. generally gained an immigrant population of approximately 0.3% of its total population each year. This means that if the U.S. had a total of 300 million citizens, it would gain 900 thousand citizens through legal immigration by the end of the year. Since we were working in 10 year gaps for our model, we added 3% of the total population to each interval.

In reviewing the data in Table 1, it may seem contrary that one of the age groups is passing along 137.2% to the next age group. The reason this was done was to account for those individuals who are older than 89 years of age.

If we were to simply calculate the likelihood of survival from age 80 to 89, that group would fall off the end of the model after one more iteration. This would have been fine if we were using mortality rates from the 1950s or 1960s, as the population ignored would have been negligible. However, in modern times, it is extremely likely for someone to live well into their 90s, and therefore, we needed to account for this.

To calculate this, we took the survival rate of individuals with ages 70-79, which is 83.84%. We then added this to the survival rate from age

70 to age 89 which is 53.37%. As a result, we brought over 137.21% of the last age group.

*survival 70-79 +(survival 70-79*survival 80-89)*

This figure includes the people from the 70-79 age grouping that will make it into their 90s. We could futher use this method to include people who are 90+ years of age; however, the rates become so small, we chose to ignore them.
In running our model, we started with three different population distributions. We took the U.S. populations from 1970, 1980, and 1990 and multiplied these vectors, which are based on age groupings, through our matrix to determine what that population would look like in 10 years. We did this in all cases until the year 2050. We also determined the steady state of the matrix to see what the long-term distribution of the population would look like.

RESULTS

In viewing Figure 3, it can be seen that the population prediction initiated with the 1980 population figures is within 3% of the actual 2010 populaton and the prediction initiated with the 1990 figures is within 2% of the actual 2010 population.

It was not surprising that the numbers calculated by starting with the 1970's population were less accurate when compared to the predicted 1980's and 1990's population numbers (see Figure 4). This can easily be attributed to the higher fertility rates that were seen during the early 1970s (see Figure 3).

We had expected that the population would eventually go down due to the low birth rate in the model, but what we had not initially anticipated was the change in the overall population distribution.

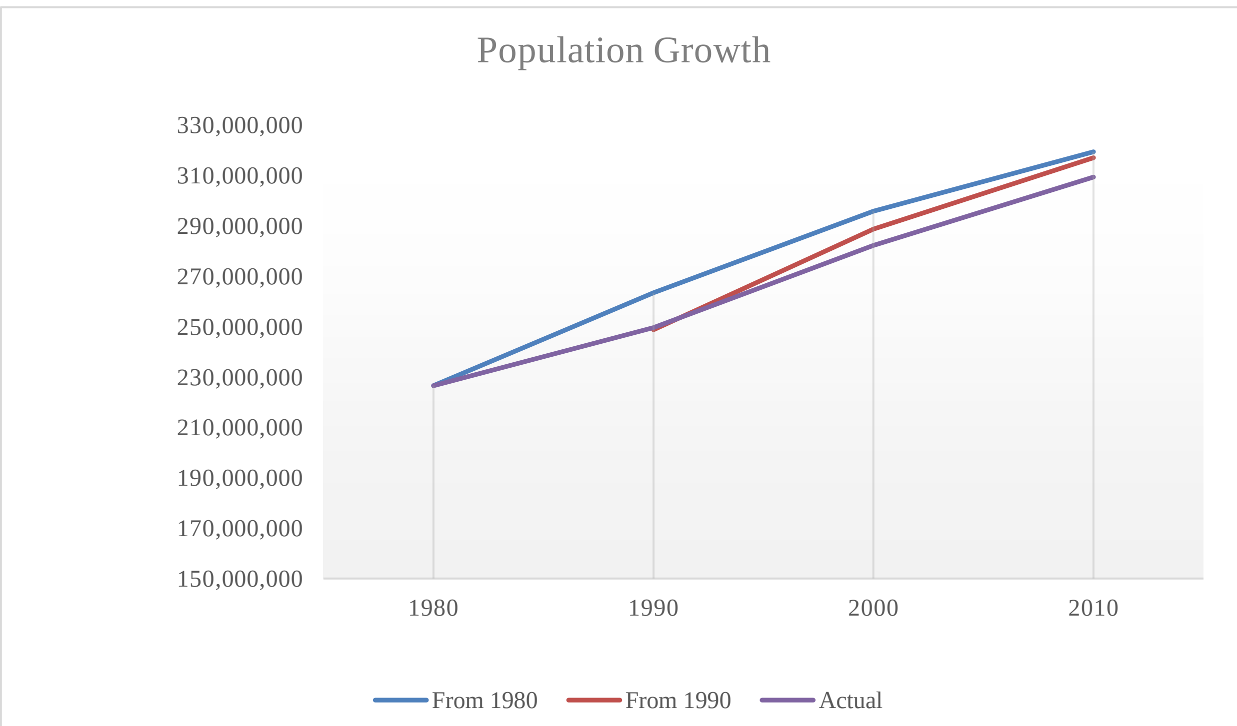

Figure 3. Predicted vs Actual Growth to 2010

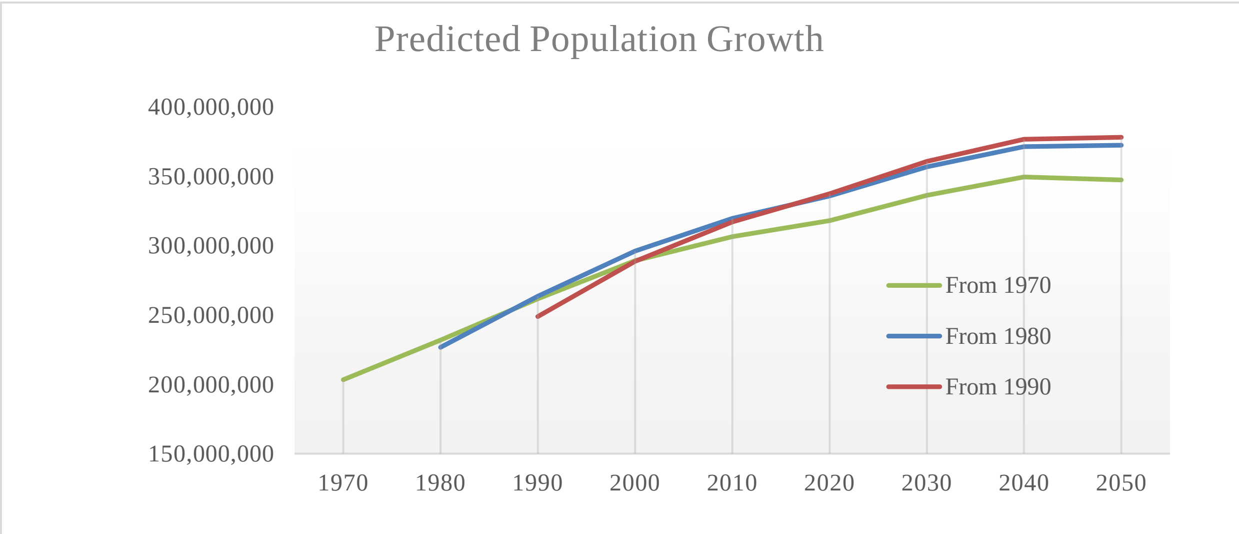

Figure 4. Predicted Growth to 2050

In comparing the actual 1970 age distribution in Figure 5 to the predicted 2050 age distribution in Figure 6, a dramatic shift is observed. While the birth rate in the late 1960s and early 1970s was the largest contributing factor to the actual population in the 1970s, the very high survival rate is the main contributing factor to the 2050 predicted population.

In 1970, 0-9 and 10-19-year-olds made up 37.87% of the population, while in the 2050 prediction, they only comprise 20.51% of the population. The 80+ age group only constituted 1.87% of the population in 1970, but in the 2050 prediction, they comprise 15.39% of the population.

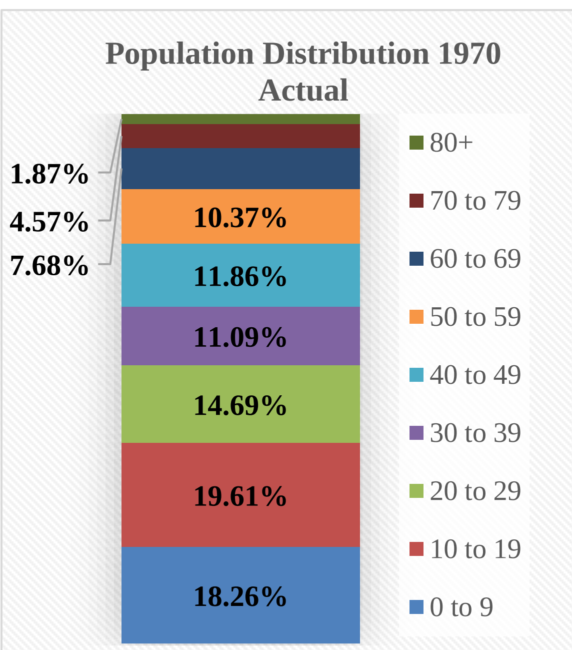

Figure 5. Actual Population in 1970 broken down into age groupings of ten years.

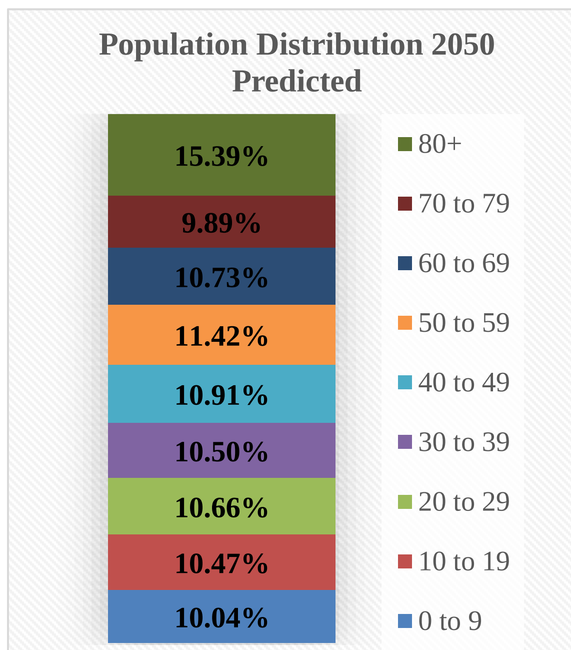

Figure 6. Predicted 2050 population distribution using actual population from 1980 and our matrix

By the year 2050, more people will be 80+ years of age than in any other single category. The long-term distribution found with the dominant eigenvector and its steady state is also quite astounding (see Figure 7).

Age	% of Total
0 to 9yrs9yrs	10.27%
10 to 19yrs	10.47%
20 to 29yrs	10.69%
30 to 39yrs	10.89%
40 to 49yrs	11.06%
50 to 59yrs	11.15%
60 to 69yrs	11.05%
70 to 79yrs	10.52%
80+ yrs	13.89%

Figure 7. Longterm distribution

According to our model, by 2050, we could expect to see a population which is comprised of more seniors than children.

DISCUSSION

So, what has our research shown? For one, we see that lower birth rates will indeed, as we would have predicted, lead to a shrinking population in the long term. Secondly, we see that a matrix model can predict the population over a short period of time very accurately. The data from 1970 shows that any long-term accuracy is difficult unless the birth, survival, and immigration rates are changing dynamically. From 1980 to today, however, these numbers have maintained a very small delta (variation/change over time). This is the reason for the nearly 40-year accuracy of the model. Thirdly, and most importantly, we see that we can expect the population to become much older in the coming years. This is quite concerning. If we look only at the number of people who would be either below the current legal working age or above the current average retirement age, we reach 46.5% of the population. Add in the fact that, as of right now, more than 40% of working age Americans (16-64 years of age) are unemployed [5], and the picture gets even more frightening with a combined 68% of the population not working. That means that 32% of Americans would be supporting the other 68%. That is in no way sustainable.

Increases in Social Security and other government programs would be inevitable. Unfortunately, that would force a tremendous tax burden on the working 32% of Americans. This raises the question: At what point do taxes become so onerous that they discourage people from working? Without the benefit of gaining wealth, why would most Americans continue to work? Add to this current studies which report that approximately 70% of U.S. workers do not feel engaged in their jobs [3, 4]. These issues could exacerbate an already alarmingly high unemployment rate.

While no politician wants to talk about the possibility of cutting benefits or delaying retirement age, it is becoming increasingly necessary to address these issues. Kicking the can down the road, although convenient for people who are only concerned about re-election, does nothing for the American people. We're potentially heading towards a cliff. With shifting demographics, we are facing a new reality for our country. In the long run, there will be increased suffering if promised retirement benefits are not deliverable when people are counting on them the most. Reforms should be initiated immediately to prepare for the dramatically different future that is fast approaching.

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