Lesson 16
(Optional Lesson)
The United States Census Models and the Recursive Model

The linear model (Lesson 8)? The exponential model (Lesson 9)? The recursive model (Lessons 10 – 12)? Which model is the most accurate?

Consider models designed to forecast the weather. It is not uncommon that when a major storm is eminent (for example, a hurricane), different weather models are used to forecast the severity and the path of the hurricane, along with the possible impact on people living in its path. Often weather models do not agree on these predictions. For example, a severe hurricane was predicted by one weather model to follow a path into highly populated cities. If accurate, this model indicated major damage to property and danger to people living in its path. Evacuations of people from their homes would be required if this model's forecast was accurate. Another model, however, predicted this same hurricane would follow a path over the ocean and would not require evacuating people. The hurricane did not follow the path that was forecast by the first model. Evaluating the best model, however, was based on the actual path of the hurricane and then looking back at each model's forecast.

Population models are also designed to look into the future. The ultimate evaluation of the best model would be to compare the predicted counts to the actual counts in 2050. This type of evaluation requires us to stick around until 2050 and compare each model's estimates with the actual count in 2050.

The United Census Bureau has several projection models that are different than the models studied in this module. Their models are continuously evaluated and revised over shorter periods of times due to their access to data. The United Census Bureau evaluates projections based on data collected each year regarding immigration, emigration, deaths, and of course, birth rates. It builds these ongoing factors into their models. The Census Bureau also designs and interprets various models at the same time. Some of the models are described as robust as higher birth rates and immigration rates are applied. Other models are less robust as lower birth rates and immigration estimates are applied. Evaluations of the models are then examined when a census has been completed.

Lesson 16 – Problems

Handouts needed to complete the projects in this lesson:

Handout 9: The United States Project Worksheet
Handout 10: Kenya Project Worksheet
Handout 11: Japan Project Worksheet

Spreadsheet files to use for exploring the projects in this lesson:

USA Recursive Model.xlsx

Kenya Recursive Model.xlsx

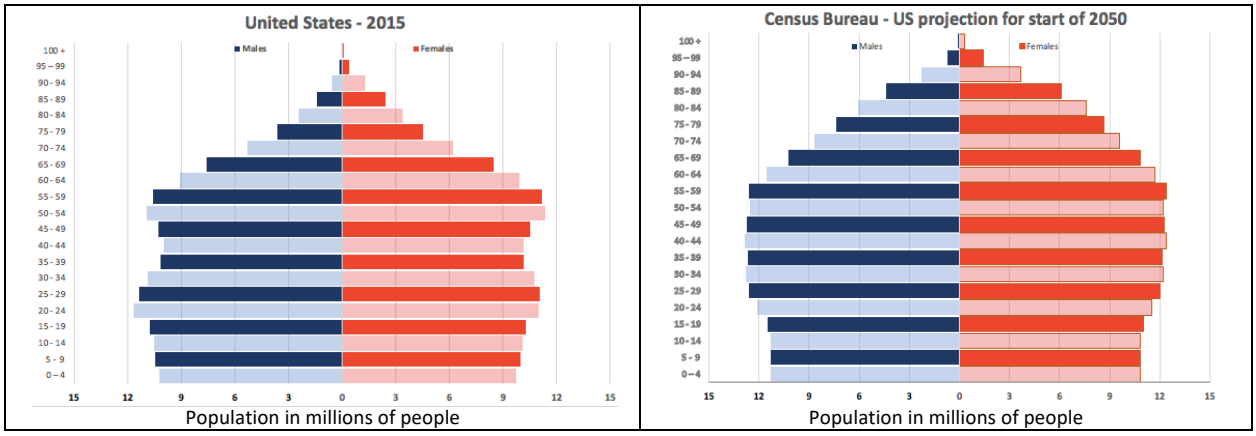
Japan Recursive Model.xlsx

The first lesson of this module included the 2015 population pyramid graph of the United States compiled by the International Data Base (IDB) of the United States Census Bureau. This lesson was followed with problems that also analyzed the 2015 pyramid graphs of Kenya and Japan. The pyramid graphs for these countries are also included in this lesson.

This lesson, however, forecasts the future counts of these countries. The population pyramid graphs for 2015 and 2050 were obtained from the Census Bureau. The first pyramid graph for each country is the familiar one used in several previous lessons that indicates the best estimates of the actual counts of people in 2015. The second pyramid graph is the estimate of the 2050 counts based on a population projection model used by the International Data Base (IDB) of the United States Census Bureau.

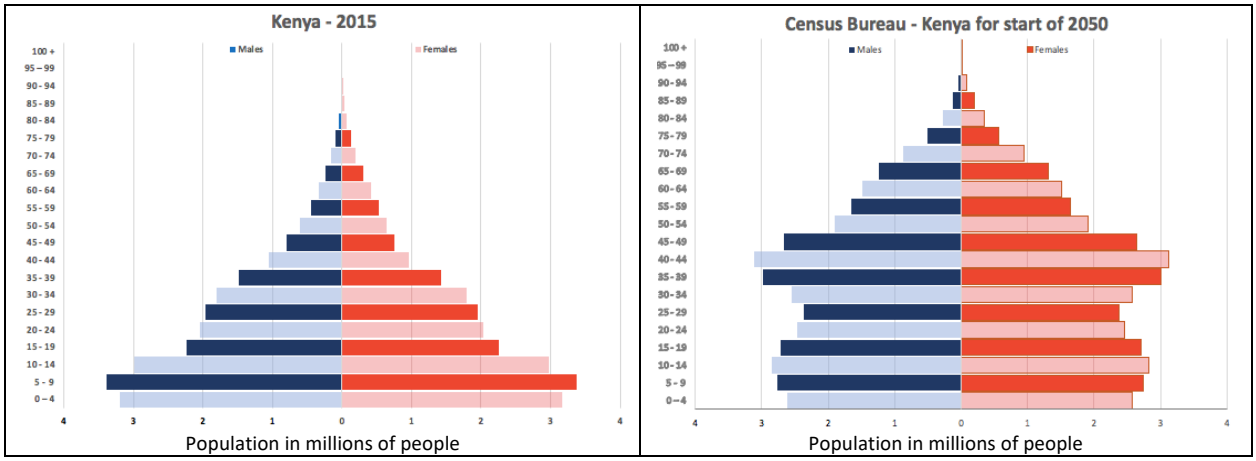
The United States

The 2015 United States Population and the 2050 Projections for the United States (data from the IDB):



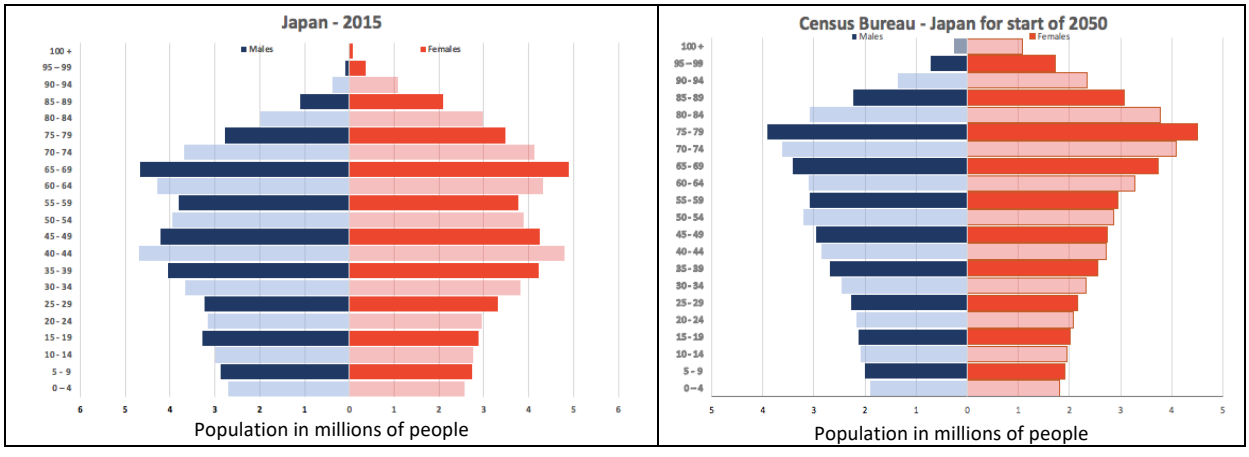
Kenya

The 2015 Population of Kenya and the 2050 Projections for Kenya (data from the IDB):

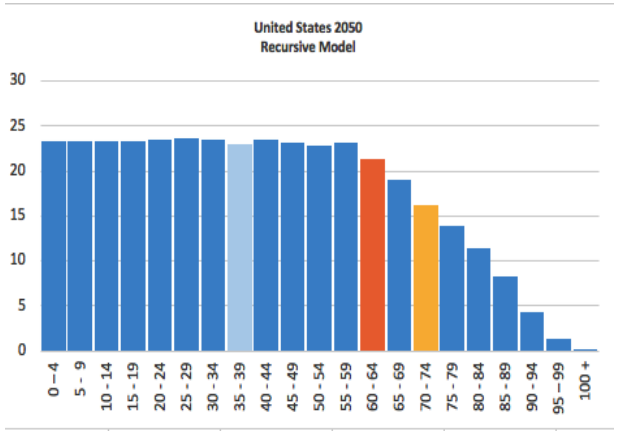
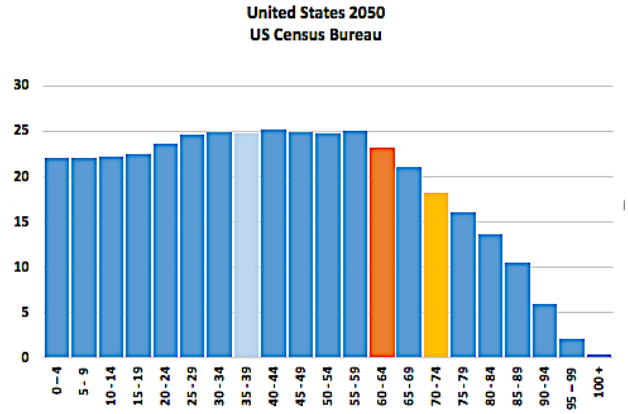


Japan

The 2015 Population of Japan and the 2050 Projections for Japan (data from the IDB):



The following histograms were prepared from the recursive model's estimates and the United States Census Bureau's estimates of the 2050 population of the United States (https://www.census.gov/programs-surveys/international-programs/about/idb.html) and are presented below. The histograms combine the counts of males and females in each of the age groups. Are the estimates of the recursive and the Census Bureau models similar? If not, what are the differences in the models' predictions and the implications for the countries? These questions are investigated in this lesson.

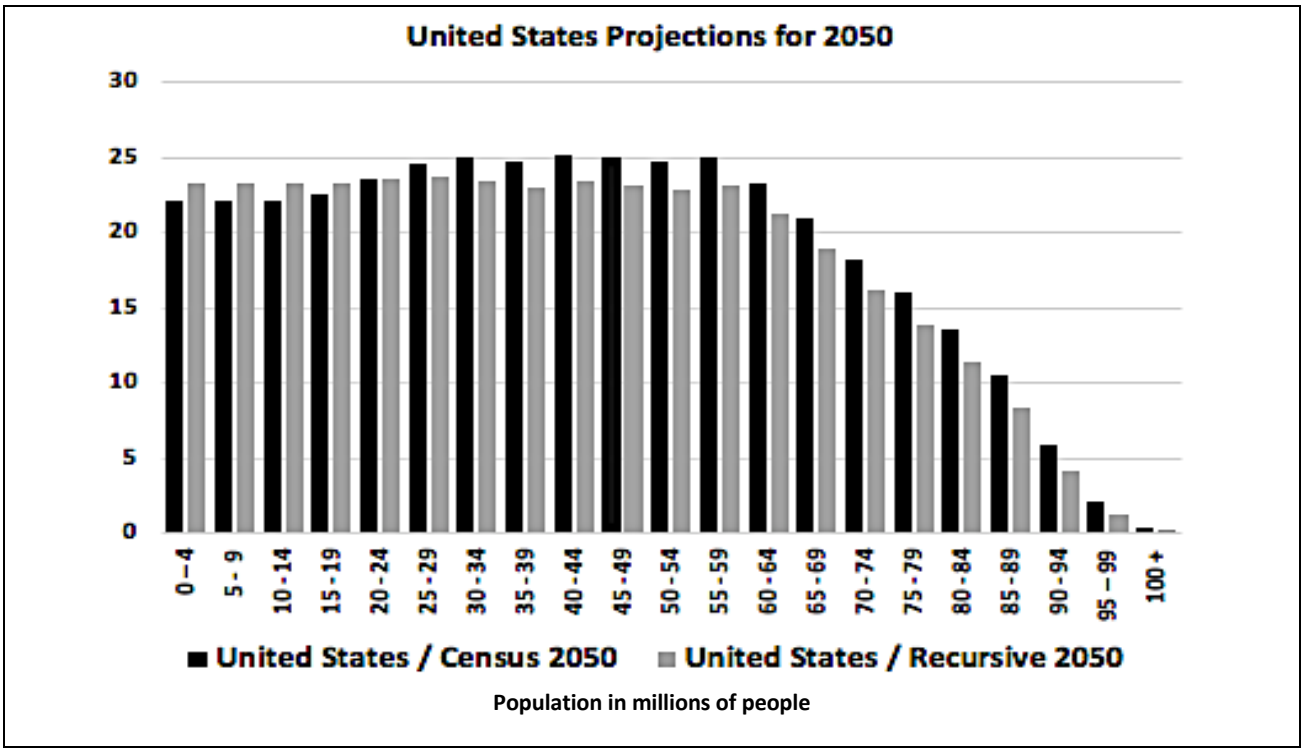
Recursive Model Projections for 2050	Census Projections for 2050
	
Total population projected to be 375.67 million people	**Total population projected to be 398.33 million people**

1. Do you think the recursive projections and the Census projections are similar? Explain your answer.

2. Of the two models, which model projects the largest estimated population for the United States in 2050? What is the population projected by that model?

3. What is the percent increase of the Census model's prediction compared to the recursive model's prediction?

The following graph is designed to compare the estimates of each model by age groups:



4. Study the age group estimates of the two models. Identify at least 3 age groups in which the recursive model's projections (color coded in light gray) are greater than the Census Bureau's projections (color coded in black).

5. Identify at least 3 age groups in which the recursive model's projections (color coded in light gray) are less than the Census predictions (color coded in black).

What assumptions did the Census Bureau consider that are different than the assumptions organized in the recursive model? The goal of the next several problems is to revise specific assumptions built into the recursive model and observe if these revisions result in projections that are closer to the projections of the Census model for 2050.

Before making specific changes to the recursive model, analyze the impact on the 2050 projections if **one** of the population factors are increased. Use **Handout 9: The United States Project Worksheet** to complete the following problems**.** This handout has blank cells for each of the projections after 2015 and blank cells for the population and foundation factors. Use this handout to record the domino effect that results when one population factor of an age group is altered.

Note that the recursive model projections for 2050 are less than the Census model projections for several of the middle age groups (25 – 29 years old age group up to the 55 – 59 years old age groups). Consider the following change in the recursive model that might increase the counts in these age groups by 2050. Place a "+" in the cell of the Population Factor for the age group 35 – 39 years old. The "+" indicates that this factor will be increased in the recursive model. How does altering this factor change other cells of this population model?

Age Groups	Population Factors
0 – 4	
5 - 9	
10 - 14	
15 - 19	
20 - 24	
25 - 29	
30 - 34	
35 - 39	+

6. What if we increase the population factor for the 35 – 39 years old age group to the 40 – 44 years old age group? Place a "+" in the location of this population factor on **Handout 9** as illustrated below. How does this change affect the counts in 2020? Answer the following questions related to this change of one population factor:
   a. Why will the estimated count for the 40 – 44 years old increase in 2020? Place a "+" in the 40 – 44 years old age group indicating that the count in this age group will be increased as a result of increasing the population factor.

35 - 39	+	20.08	20.31	
40 - 44		20.91	20.16	+

   b. Why will the total count of the population also increase if we increase the population factor for people 35 – 39 years old? Place a "+" in the 2020 column representing the count of the total population.

7. Why will the estimated count for the 0 – 4 years old also increase in 2020? On **Handout 9**, place a "+" in the age groups representing the 0 – 4 years old. The "+" indicates that the count in this age group will also increase as a result of increasing the population factor of people who are 35 – 39 years old to 40 – 44 years old.

Age Groups	Population Factors	2010	2015	2020
0 – 4		20.19	19.91	+

At the beginning of this lesson, the recursive model's estimate of the count for 0 – 4 years old was greater than the estimate from the Census Bureau. The decision to increase the population factor for the 35 – 39 years old results in an unintended consequence of further increasing the 0 – 4 years old count summarized on the recursive model. In addition, other age groups that also had greater counts than the estimates from the Census Bureau will further

increase after 2020 due to this decision. Decreasing the count for the 0 – 4 years age group and other age groups will be addressed in problems 15 to 17.

8. More age groups are affected than just the three identified in 2020. The increases represented by the "+" in 2020 also result in increases in the 2025 counts. Place a "+" in the age groups for 2025 that will increase as a result of the increases predicted in 2020.

9. Continue this process. Place a "+" in the age groups of the table for 2030 to 2050 that will increase in the recursive model as a result of increasing the population factor for the 35 – 39 years old age group.

10. Summarize what age groups are projected to increase in 2050 as a result of the increase in the population factor of the 35 – 39 years old age group to the 40 – 44 years old age group.

11. Will an increase in the age groups identified by the "+" suggest a closer match to the projections reported by the Census Bureau? Identify the age groups in 2050 that will increase in count and as a result more closely match the Census Bureau's projections.

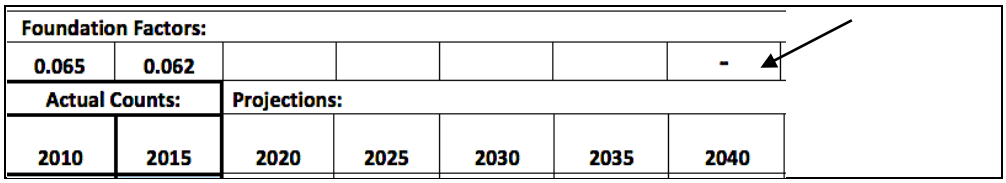
What if an increase in the population factor of the 70 - 74 years old age group is considered?

12 In the same way that a "+" was used to indicate an increase for the 35 – 39 years old age group population factor, place a "+" in the population factor cell for the 70 – 74 years old age group population factor.

13. Why was an increase in the population factor for 70 – 74 considered?

14. What additional age groups are increased as a result of increasing the population factor for the 70 – 74 years old population factor? Place a "+" in the age groups of the handout if the count of the age group will increase. If an age group already has a "+", place a second "+" next to it, or a "++" indicating two changes will increase the count in this cell. Will the increase in the 70 – 74 years old population factor result in a closer match to the Census model? Explain your answer.

15. Several of the younger age groups had a greater count in the recursive model than in the Census model. Let's consider decreasing the Foundation Factor in 2040 from the estimate used in the recursive model.
    a. Place a "-" in the location of the Foundation Factor for 2040. This indicates that a new foundation factor will be considered and that this factor will be less than the 6.2% used in the recursive model to derive the count of 0 - 4 years old.



Foundation Factors:						
0.065	0.062					-
Actual Counts:		Projections:				
2010	2015	2020	2025	2030	2035	2040

    b. By decreasing the Foundation Factor, what age group is affected in 2040?

    c. Although not an age group, what other count decreases as result of decreasing the 2040 foundation factor? Place a "-" in that location.

    d. What additional age groups in 2045 will be impacted by a reduced count of 0 – 4 years old in 2040? Place a "-" in each age group in **Handout 9** that will decrease if the foundation factor for 2040 is decreased. For age groups that were previously identified as "+" or "++", add a "-" next to the list, or "+ -" or "+ + - ".

16. Consider also reducing the Foundation Factors for 2045 and 2050.
    a. Place a "-" in the two locations of the Foundation Factors for 2045 and 2050. Also place a "-" in the age groups of 2045 and 2050 that will decrease as a result of decreasing the foundation factors in 2045 and 2050.

    b. Although not an age group, what else will decrease in count when the foundation factor for 2045 and 2050 is decreased? Place a "-" in each of these locations.

Age groups that are identified in **Handout 9** for 2050 with a "+" or "++" are estimated to increase in counts. Age groups that are identified as "-" are estimated to decrease in counts. Age groups that have a combination, or "+ -" or "+ + -", could increase or decrease depending on the value of the factors entered.

17. Use a completed **Handout 9** to answer the following questions regarding the revised estimates for the 2050 age groups.
    a. What age groups will increase?

    b. What age groups will decrease?

    c. What age groups are unclear whether or not they will increase or decrease?

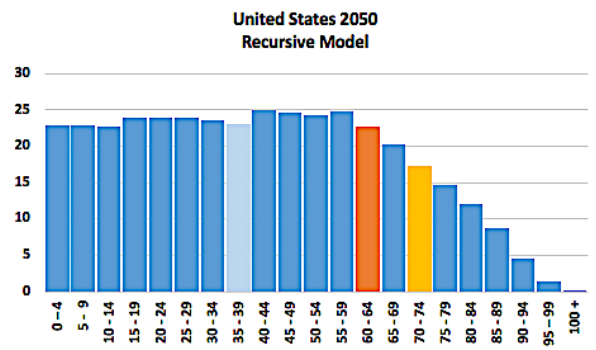
    d. If an age group remains blank, what does that indicate about the estimated count in 2050?

Open up the Excel file ***USA Recursive Model.xlsx,*** enter the following revisions to the recursive model:

Change the Population Factor for the 35 -39 years old to 1.055
Change the Population Factor for the 70 – 74 years old to 0.900
Change the Foundation Factors for 2040, 2045, and 2050 to 0.059.

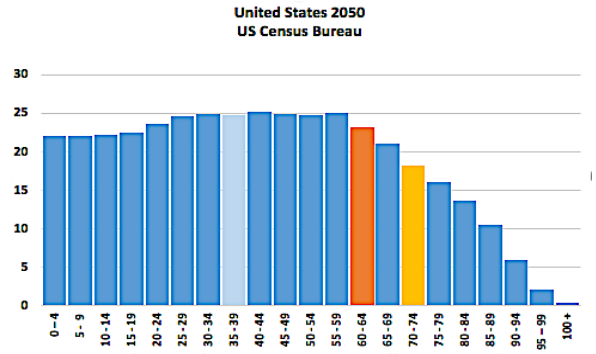
The 2050 projections resulting from these revisions and the 2050 Census projections are summarized below:

Recursive model projections for 2050 with revisions:



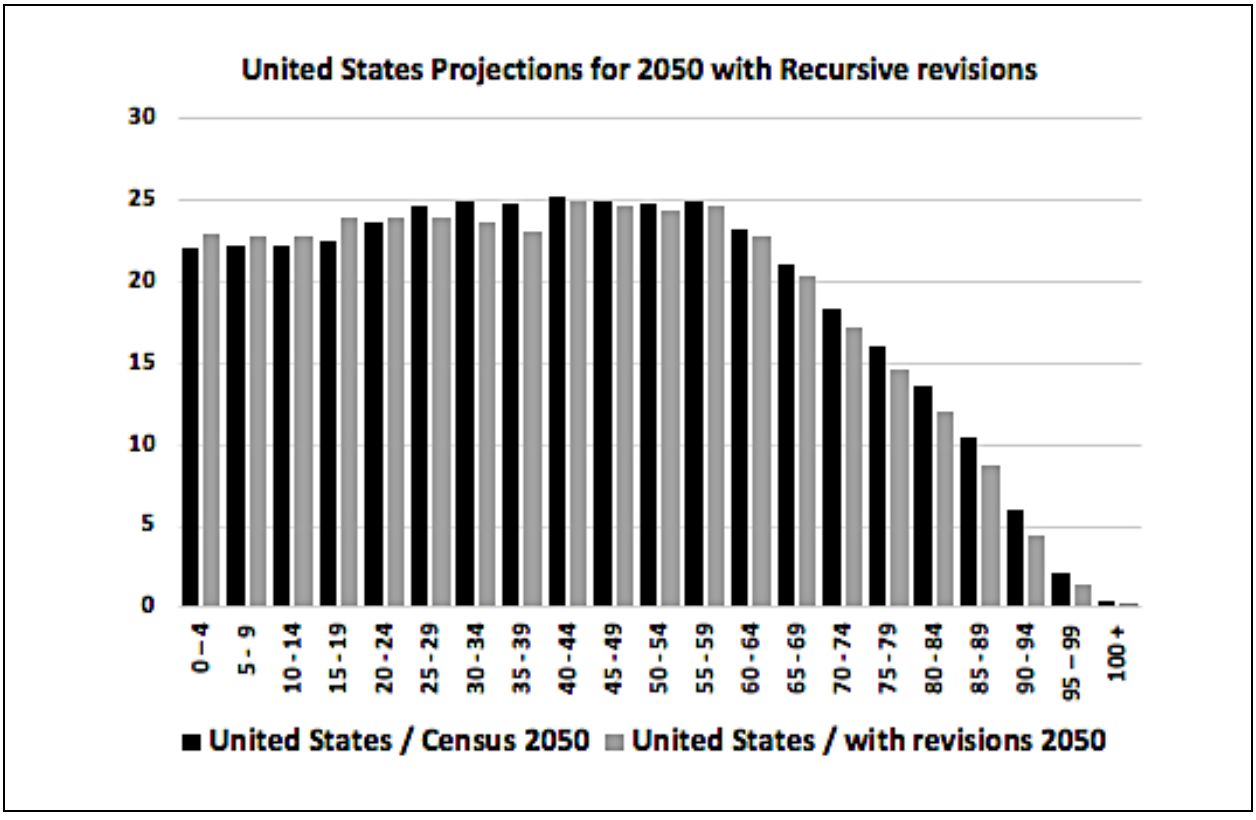
Total population: 387.5 million people

Census model projections for 2050:



Total population: 398.33 million people

The following graph combines the above histograms to help us compare the two models. This graph compares the two models **afte**r the revisions were made to the recursive model.



18. Answer the following:
    a. Identify the age groups that have nearly equal projections.

    b. Identify the age groups where the recursive projections (color coded light gray) are noticeable greater than the Census projections (color coded black).

    c. Identify the age groups where the recursive projections are noticeable less than the Census projections.

    d. Did the changes in the population and foundation factors result in a better match of the recursive model to the Census model? Explain your answer.

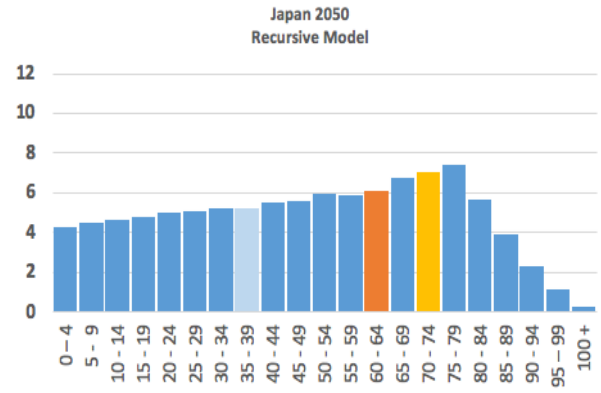
19. Provide an explanation of events in the United States that would result in the changes entered in the recursive model.

Consider other changes to the recursive model that you think will result in a closer match to the Census projections. If you have access to the spreadsheet file, revise either the population factors or the foundation factors that you think will result in a closer match of the two models. Keep track of your changes.

Japan

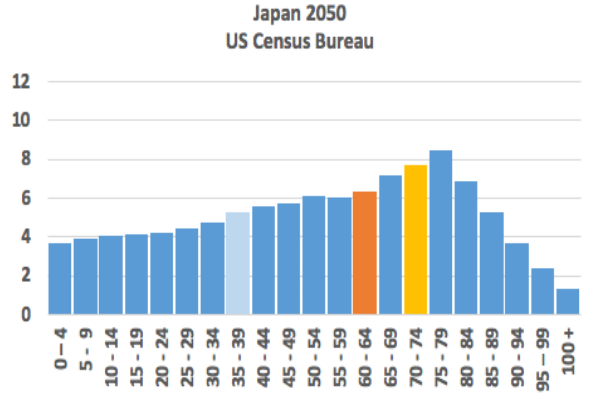
In a similar way, compare the projections from the recursive model to the projections of the United States Census Bureau's model for Japan's population:

Recursive model projections for Japan in 2050:

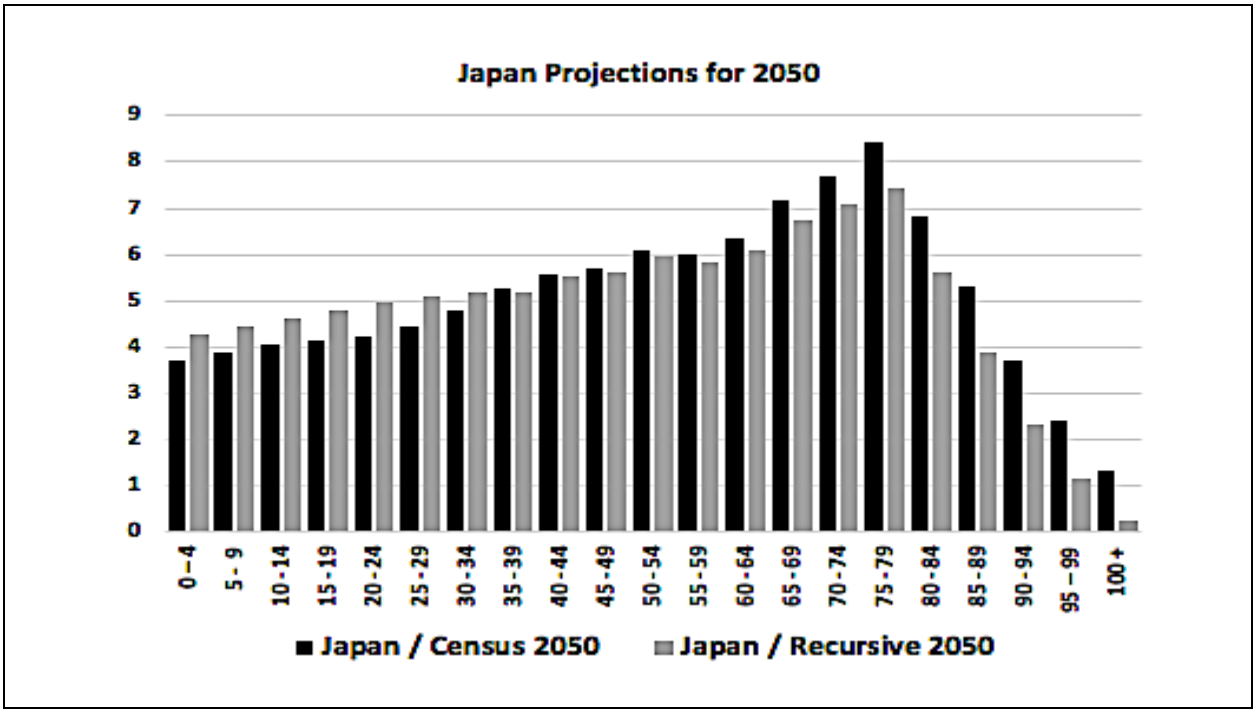


Total population: 102.14 million people

Census model projections for Japan in 2050:



Total population: 107.21 million people



20. Compare the two projection models of Japan's population in 2050 represented in the above histograms. Do you think the recursive projections and the Census projects are similar? Explain your answer.

21. Derive the percent increase of the total population in Japan projected by the Census model to the total population projected by the recursive model.

22. Identify at least 3 age groups in which the recursive model projections (color coded in light gray) are greater than the Census Bureau's projections (color coded in black).

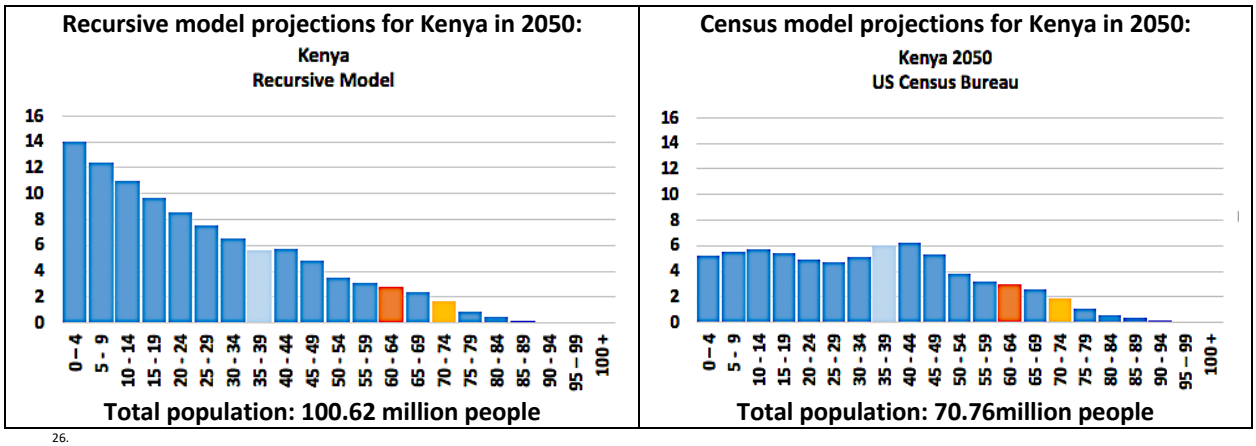
23. Identify at least 3 age groups in which the recursive model projections (color coded in light gray) are less than the Census projections (color coded in black).

24. Given the option to change the population factors or the foundation factors in the spreadsheet **Japan Recursive Model**, identify and enter revisions to the recursive model that you think will result in similar projections to the Census projections.

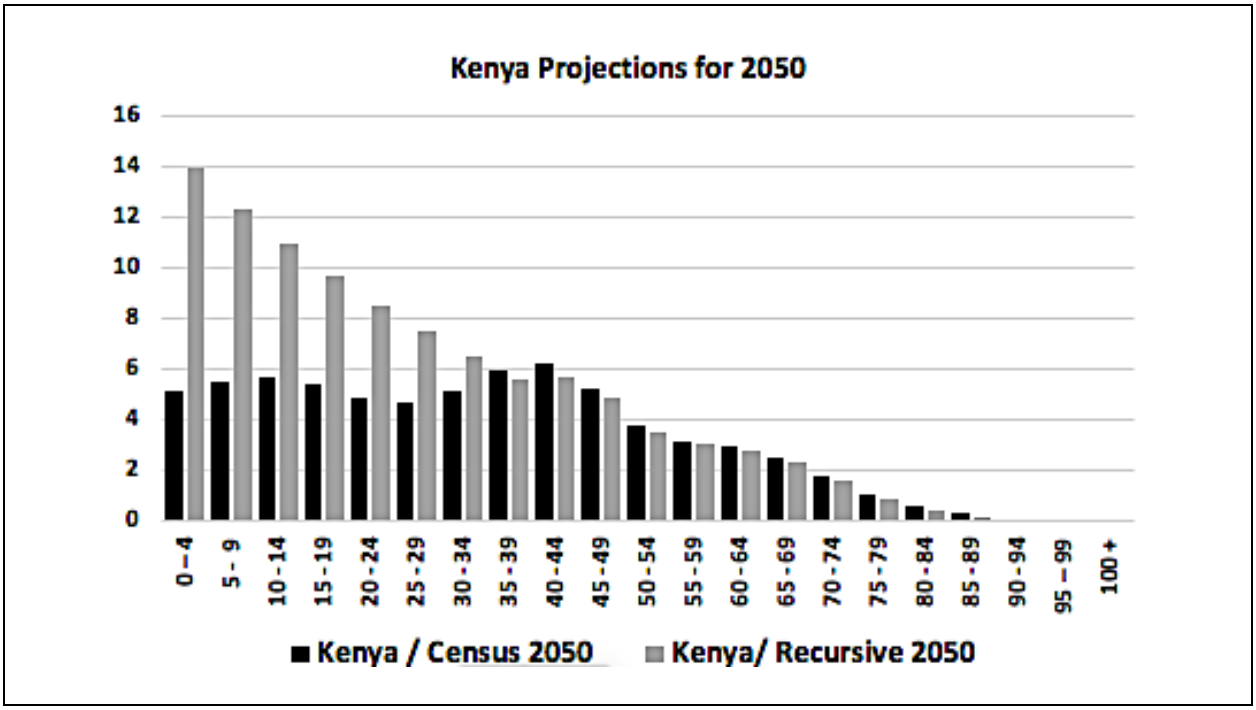
25. Based on the changes you proposed to the recursive model, what assumptions are you altering that you think will result in a better match to the Census Bureau's projections from 2020 to 2050 for Japan?

Kenya

Finally, compare the projections from the recursive model to the projections of the United States Census Bureau's model for Kenya's population:



26.



26. Compare the two histograms of Kenya. The first histogram was prepared from the estimates of the recursive model. The second histogram was prepared from the projections of the Census Bureau. Are they similar? Explain your answer.

27. Given the option to change the population factors and the foundation factors in the spreadsheet **Kenya Recursive Model**, what changes do you think will result in a better match of the recursive model and the Census model in 2050?

28. Based on the changes you proposed to the recursive model, what assumptions are you making that are different from the original assumptions in the recursive model from 2020 to 2050?

29. Clearly the recursive model and the Census Bureau model differ the most for the Kenya predictions. Why do you think that the predictions by the Census Bureau for Kenya are different from the recursive model for Kenya?

Population projection models consider several other factors than just the population and foundation factors designed in the recursive model. Data obtained from surveys, death and birth records, health records, and several other data resources are also considered when building a population model. Each year in which the United States Census is conducted, a short survey is also distributed to a sample of households. This additional set of questions is referred to as the long-form. The questions people are asked vary from census to census. In addition, the questions are often met with political controversy.

30. Think of at least two questions you would include on a survey that might impact the assumptions included in a projection model. Indicate why you think the questions are related to projecting the future population counts.

Final problem for this project:

Identify and describe 3 reasons why an accurate population projection is important.