

If a series of nuclear explosions were to wipe out the material equipment of the world but the educated citizens survived, it need not be long before former standards were reconstituted; but if it destroyed the educated citizens, even though it left the buildings and machines intact, a period longer than the Dark Ages might elapse before the former position was restored.

Lionel Robbins

Demographics Visualization

Demography is the quantitative study of human populations. Demographers use *vital statistics*: data on people such as their number, births, and deaths. *Vital* means of the utmost importance and it is true that counting the number of people in a place (called a *census*) and how many were born, died, or moved are some of the oldest and most fundamental statistics.

We end by coming full circle, returning to the beginning of statistical science by exploring data on population. We will use a remarkable data visualization that has come to be known as a *population pyramid*. By showing the number of people by age and sex, this graph not only conveys information about the current situation, it also predicts the future.

First, we will show how population pyramids are made and interpreted using hypothetical examples. Next, we will explore real-world population pyramids. Finally, we will take a close look at two key statistics: the male-female birth ratio and the dependency ratio.

Accessing the Excel Workbook

STEP Go to tiny.cc/busanalyticsexcel and click the *Excel Workbooks* link (top right). Click *PopulationPyramids.xlsm* to download it. Move the file from your download folder to a folder on your computer or network.

The file's *xlsm* extension means it is a macro-enabled Excel workbook. When you open it, you must enable macros to get full functionality from the file.

STEP Open *PopulationPyramid.xlsm*, read the *Intro* sheet, and be sure to click the button. You may have to adjust your security settings as described in the *Intro* sheet.

Population Propagation

STEP Click the button at the bottom of the *Intro* sheet.

A new sheet is revealed called *PlanetX*. Here is the explanation for this puzzling name.

It is January 1 several centuries from now and humans are, once again, populating a new world. A group of 600,000 adults have arrived on PlanetX. The chart and data below it shows that there are 20,000 people of each age from 15 to 44.

Not surprisingly, culture and language have changed a great deal. The people on PlanetX are androgynous, wear the same clothes, and there is only one pronoun, himo (borrowed from Pulaar before it disappeared).

Although the Technological Revolution triggered by AI in the 21st century was breathtaking, science has been unable to grow humans outside a natural womb. What were called females are now Productive (P) people. The sheet shows that each age has 10,000 non-productive (NP) people and 10,000 P.

Over the course of a year, the population will change. The inhabitants will each age one year and some of them will, sadly, pass away. On the other hand, new people (still called babies) will be born. This equation captures these events:

$$Population_{t+1} = Population_t + Births_t - Deaths_t$$

How many births and deaths will occur during the year? That depends on the age-specific fertility and deaths rates.

STEP Hover your mouse over cells E15 and F15 and read the definitions of the ASFR and ASDR in the comments that pop up. You can also *Show All Comments* in the *Review* tab. Scroll down to see that the values for the ASFR are all 0.1.

A constant ASFR of 0.1 is not at all close to our fertility rates today. Usually, the age-specific fertility rate rises as teenage girls mature, reaching a peak in their 20s, and then falling again. Women can and do give birth past age 45 so the zeroes after age 44 are also unrealistic.

Unlike the completely fake ASFRs, the ASDRs are roughly those experienced by the United States in the early 21st century. The 0.006 value in cell F16 is called the *infant mortality rate*. It expresses the chances that a baby born will not survive to their first birthday. There is some good news in that infant mortality rates are much lower than they used to be and they have also fallen in many other countries.

We could have made this hypothetical example more realistic by giving ASDRs for NP and P people. In our current times, females outlive males by several years, on average, in all countries. We will assume, however, that on PlanetX, NP and P people experience the same age-specific death rates.

Notice how the age-specific death rate declines after the first year and then starts to rise after the teenage years. The value of 0.049 in cell F96 means that an 80 year-old has a 4.9% chance of not surviving to the next year. At the bottom row (101), the value becomes unrealistic because everyone dies at 85.

Before we continue, note that the cells in column B are minus 10,000 only so that those values are plotted in the blue rectangle (to the left of zero) on the chart above.

STEP In cell H3, enter the formula $=-SUM(C16:C101)+SUM(D16:D101)$ to add up all of the people at the beginning of the year.

Cell H3 should display 600,000 which is the starting number of people on PlanetX. To compute the number of people born during the year, we use Excel's SUMPRODUCT function.

STEP In cell H5, enter the formula $=SUMPRODUCT(D31:D60,E31:E60)$.

SUMPRODUCT multiplies (hence the PRODUCT in the name) two or more arrays and then adds them up (hence the SUM). So, it takes the value in cell D31 and multiplies it by E31. This is the number of children (1,000) produced by the 15 year-old Ps. Then it multiplies D32 by E32 and so on. Finally, it adds up the products giving 30,000.

STEP In cell H6, use SUMPRODUCT to compute the number of deaths. You will need two SUMPRODUCTs added together and the NP one needs to have a minus sign in front of it. Unlike births, we use the entire range from row 16 to 101 because there could be deaths at every age.

STEP Check your work by clicking the button.

You are now in a new sheet called *Propagate* (which means to spread out or expand). The first few columns are the same, your computations for births and deaths are replicated (or you can see how to use SUMPRODUCT for deaths), and we now see new data for Year 2.

Cell H7 applies the population propagation equation from above. It takes the starting population, adds births, and subtracts deaths.

The percentage change in the population of 4.89% in cell H8 is extremely high. The Rule of 70 tells us that we would get doubling in roughly 15 years ($70/5 = 14$, but we are a little below 5%). That is extremely fast for human population growth.

STEP Look carefully at the Year 2 chart. Do you see the thin red and blue strips at the base of the chart? Those are the 30,000 newly born babies.

We made another simplifying assumption in that half of babies are NPs and the other half are Ps. Most people think there are equal chances of getting a boy or girl, but this turns out to be incorrect.

STEP You can also see the newborns in cells L16 and M16. Click on these cells to read the formulas used. By multiplying by 0.5, we split the babies into equal amounts of NPs and Ps.

It is extremely difficult to see, but the adults no longer form a rectangle. We need more years to make this clear.

STEP Click the button.

A new year appears with the previous year's births, deaths, and net increase in population computed. A second line has been added at the base of the chart. Last year's babies are one year older and have moved up. The adults are also all moving up.

STEP Click the button again.

There are fewer babies than the previous year because some of the Ps died during the year. The data below the chart make this clear.

STEP We can speed up the propagation by using the button. Click it, read what it says, enter 20, and then press OK. Scroll right, looking at the data and charts as you scroll, until you reach the final year.

In year 24, your chart looks like Figure 10.1. It is now easy to see the tapering of the rectangle at the top as the older original settlers do not survive until 85. Also, the children of the original settlers have started having children. The space in the middle reflects the fact that there were no children (ages 0 to 14) at Year 0.

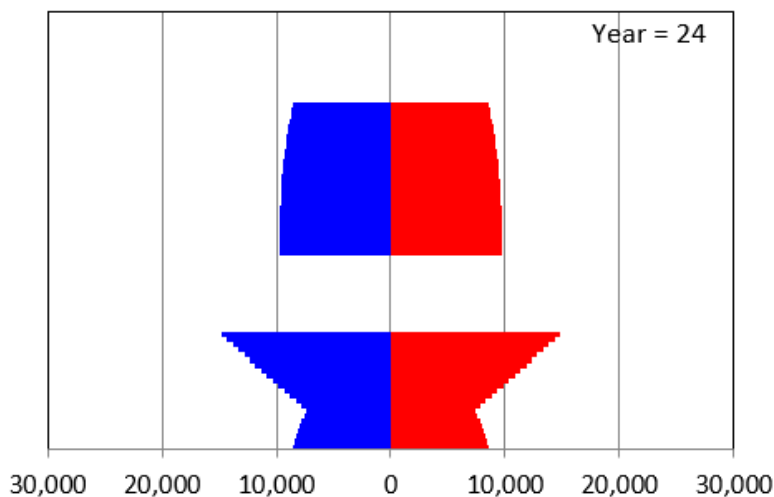


Figure 10.1: Population Age-distribution in Year 24 on PlanetX.

STEP From any year, click the button.

You are taken to the beginning of the sheet and the years from 0 to 24 are displayed, like a moving picture. It is clear that the chart has an upward motion built into it as time goes by.

STEP Add enough years to your sheet (using the button) to get to 100. Excel may take a while to display all of these years so you may have to be patient (depending on your computer's speed). Scroll right to Year 100. Your chart should look like Figure 10.2.

At Year 100, it is clear why this chart is called a *population pyramid*. The triangle (pyramid) shape of many human populations, with few old and many

young people, was quite common when it was first introduced by Francis Amasa Walker, an economist who was the head of the US Census in 1870.

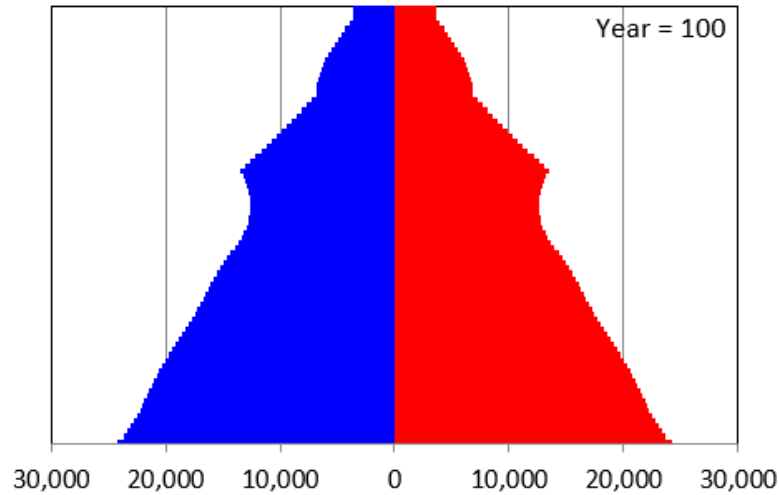


Figure 10.2: Population Pyramid in Year 100 on PlanetX.

The chart is also known as an age-distribution graph or age pyramid and even more technically, it is a bilateral histogram. But no matter what you call it, the amount of information it delivers is impressive. Not only does it give a static snapshot, once you know that it will scroll up as time passes, it provides insight into the future population age-distribution.

It is important to understand that the pyramid shape was produced by the ASFR and ASDR values.

STEP

Takeaways

References

The epigraph is from p. 205 of Robbins, L. (1963). *The Robbins Report. Higher Education Report of the Committee appointed by the Prime Minister under the Chairmanship of Lord Robbins 1961-1963*. London: Her Majesty's Stationery Office.

Full text at education-uk.org/documents/robbins/robbins1963.html.

On page 16 of the second edition of *An Essay on the Nature and Significance of Economic Science*, Robbins gave a modern definition of economics as “the science which studies human behavior as a relationship between given ends and scarce means which have alternative uses.” This book was originally published in 1932 and the second edition is available online at www.mises.org/books/robbinessay2.pdf.