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Let's Put Demography Back into Economics: Population Pyramids in Excel

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All comments welcome.

Abstract

The economics curriculum today does not emphasize the study of population. This needs to change immediately because we are in the midst of another demographic sea change, slamming on the brakes right after a rapid acceleration during the last half of the 20th century. Instead of glibly tossing a dependency ratio onto a slide, this paper offers an easy way to improve demographic literacy using *population pyramids*. Simulation is used to explain the pyramid and its dynamic properties, and then real-world data are presented. Microsoft Excel's ability to act as a browser and download data with a single click of a button provides a flexible, powerful tool to explore historic, current, and predicted age distributions of various countries. Download *PopPyr.xlsm* from https://archive.org/details/PopPyr.

JEL Codes: A10, A20, J10

Keywords: demographics, simulation, age-distribution, cohort, fertility, migration

1.0 Introduction

There is no doubt that we are in the midst of a stunning demographic revolution. As longevity continues its upward climb, birth rates in most countries around the world—regardless of income level and development—are in free fall. This rapid decline in fertility is all the more impressive since it comes on the heels of the greatest increase in world population in human history. Many people alive today will easily remember the dire warnings about explosive population growth, epitomized by Ehrlich's 1968 best-seller, *The Population Bomb*, but it is becoming painfully clear that population contraction can be more damaging to an economy than expansion. Thus, it is time, once again, to put demography back into a prominent position in the economics curriculum.

While the complicated relationship of demography within the history of economic thought is not the primary purpose of this paper, it is worth pointing out that population used to be a key factor in classical economics. Malthus (1798) lived during a rapid and notable increase in the number of people in Britain and *An Essay on the Principle of Population*, with its catastrophic predictions of famine and misery, formed part of the core of political economy. Marshall's (1890) *Principles of Economics* (the Mankiw of the day) had a chapter on the growth of population (with tables of data). Eventually, however, demography would fade to the periphery of economics, and Stigler (1960, p.36) would lament that, "In 1830, no general work in economics would omit a discussion of population, and in 1930, hardly any general work said anything about population."

It is true that the Solow Model has population growth as an exogenous variable and there are models of labor supply (not to mention an entire *JEL* category, J1, *Labor and Demographic Economics*), but the demographic literacy of today's economics students is woefully inadequate. They do not know basic facts, such as what rate of population growth is fast or slow (1% per year was common in the last century, while twice that is extremely fast) or the distribution of people on the planet. A typical student is unaware of exactly how population aging will affect publicly provided education, health, and retirement programs. The dependency ratio, the number of people younger than 15 and older than 64 divided by the number of working-age adults, has risen in Japan from under half to over two-thirds in the last 20 years. The implications of this changing population composition for the economy and society are staggering, but economists do not emphasize this in the classroom. Not only will students not see repeated demographic applications or examples throughout the economics curriculum, it is likely they will not be exposed to population data outside of a labor economics or development course.

Given the vast and deep nature of demography, along with many worthy competing ideas for scarce class time, what is an economics professor interested in exposing students to population issues to

do? This paper provides an answer: *population pyramids*. This clever display (also known as an age-distribution graph or bilateral histogram) was first used by Francis Amasa Walker in 1874. It offers an eye-catching snapshot that reveals historical episodes and points to future outcomes. Less well known is that it is also amenable to simulation. The population pyramid is relatively simple to understand and can be used both at the introductory level and in more advanced courses.

The next section demonstrates how the population pyramid works using hypothetical data. This is followed by downloading real-world data and reviewing several examples. Section 4 uses labor force participation and migration to extend the basic pyramid, while section 5 offers teaching suggestions and strategies. A single, macro-enabled Microsoft Excel workbook is used to deliver all content.

2.0 Simulating the Population Pyramid

Download *PopPyr.xlsm* from https://archive.org/details/PopPyr and open the file with Windows Excel 2007 or greater, making sure to enable macros. The file can be opened with Mac Excel, but it uses Visual Basic code that may not be fully supported on a Mac. The workbook is designed to explain itself so not every button and cell will be meticulously described. A rudimentary set of ideas and demonstrations are presented below, with emphasis on how to present the material in a lecture.

Instead of showing the student a fully-formed pyramid based on real-world data, the *Fake* sheet begins with an odd scenario designed to show how the pyramid works: we assume an existing, initial set of 20,000 adults at each age cohort from 15 to 44 who will produce 15,000 boys and 15,000 girls, given the age-specific fertility rates (ASFR) in column C. These 30,000 newborns form the lowest bar on the population pyramid to the right in Figure 1, and the first row of data under the chart.

Figure 1: The Initial Position.
Source: *Fake* sheet in *PopPyr.xlsm.*

In Year 1, the two shaded areas in Figure 1 are rectangles because there are exactly the same number of males and females at each age. A population pyramid displays the number of people in each age cohort, usually vertically stacked (although horizontal displays are also used). The white space above and below the shaded areas indicate that in this case there are no people younger than 15 and older than 44 years of age.

The Year 2 chart (on the right in Figure 1) does not have the resolution to show that some of the adults did not survive to the second year. In Excel, scroll down (below the Year 2 chart) to see how the age-specific death rate (ASDR) determines how many people die. As shown in cells C31 and D31, there are initially 10,000 males and 10,000 females who are age 15. From column F, we see that 0.02% of these 15 year-olds will die, so next year there are only 9,998 males and 9,998 females who are 16, as shown in cells L32 and M32.

Click on cells L16 and M16 to see their formulas. The number of children born is the product of the number of women of each age times their corresponding ASFR. Each age cohort of 10,000 women had 1,000 babies (500 males and 500 females) because the ASFR is 0.1 for women aged 15 to 44. This is unrealistic because the male-female birth ratio is not one, but around 1.05, and women's fertility is not constant across different ages. For example, Hamilton, et al. (2017, p. 2) report that the general fertility rate (GFR) for all women aged 15-44 in the United States is 62.0 per 1,000 in 2016, which is a 1 percent decrease from the previous year and the lowest it has ever been. They also show that fertility rates in the United States in 2016 rise as young women get older, reaching a peak of slightly over 100 per 1,000 (or 0.1) for the 30 to 34 age cohort and then fall rapidly, roughly 50 per 1,000 for 35-39 year-olds and 10 per 1,000 for 40-44 year-olds (Hamilton, et al. 2017, p. 7)., The GFR is a weighted average of the ASFRs (which is the same as the arithmetic mean in this case since the weights, the number of females in each age group, are equal) and is displayed in cell H10 as a rate per thousand.

Click on cell L32 to see that the number of 16-year old males in the second year is the product of the proportion of 15-year old males surviving to the second year (1 – ASDR) times the number of 15-year old males. A spreadsheet is especially useful for understanding the data generation process because the formulas are visible. In the *Formulas* tab, click *Trace Precedents* to see how cells C31 and F31 are involved in cell M32. To clear the screen, click *Remove Arrows*.

The formulas in columns L and M (under the Year 2 chart) implement the propagation of the number of males and females over time, which can be expressed by the following equations:

$$Births_{t+1} = Population_{Age=0,t+1} = 0.5 \times \sum_{Age=15}^{44} NumberFemales_{Age,t} \times ASFR_{Age,t}$$

$$Population_{Age+1,t+1} = \sum_{Age=0}^{84} Population_{Age,t} \times \left(1 - ASDR_{Age,t}\right)$$

Once we know the total number of births and deaths during the year, we can compute the total population in the coming year (cell H7) and the percentage change in the total population (cell H8). From Year 1 to Year 2, the population grew by 4.89% (which is quite fast by historical standards). In cell H9, a user-defined function computes the long run growth rate for this set of ASFRs and ASDRs.

Given the number of men and women at each age, the population pyramid is created by using a *clustered bar* chart type, with zero gaps. Male population for each age is inputted as a negative number in the table to provide the side-by-side comparison with female population that is the hallmark of the population pyramid. The chart's *x* axis is formatted as #,##0;#,##0 to suppress the negative sign. Click on the red or blue area in the chart to highlight the cells that are being graphed.

Proceed by clicking the ‎1 Year‎ button. A new set of columns and chart for the next year is displayed. Notice that a new set of births in Year 3 has been generated that is slightly smaller than before because there were no females aged 14 years in Year 1 turning 15 years old in Year 2 and having children in Year 3. In addition, a few of the women of reproductive age died in the transition from Year 1 to Year 2. Notice also that some of the children aged zero (born in Year 2) did not survive to the next year. Finally, notice that the block of adults is literally moving up the chart (and down the data table) as time goes by. This is a crucial property of the population pyramid.

Click the ‎? Years‎ button and enter 25 years. Scroll right to see the evolution of the pyramid. The dynamic nature of the pyramid is laid bare. At Year 15, fewer children are being born (the bottom of the chart is narrowing) for several reasons: (1) there were no children (aged 0 to 14) in Year 1 to mature into mothers (this produced the white space in the middle of the Year 15 chart); (2) 30 to 44 year-old women in Year 1 have grown older than 44 years of age and no longer produce children; and (3) 15 to 29 year-old women in Year 1 are still of child-bearing age in Year 15, but not all of them survived to Year 15.

Scroll right to the end to see how the pyramid continues moving upwards. As girls in Year 15 age, they start to have children of their own. This is reflected in the widening of the base at the bottom of Year 28 in Figure 2.
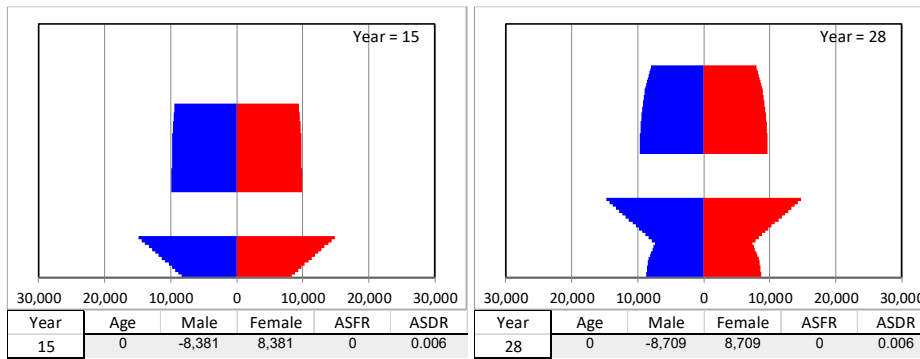
Figure 2: Years 15 and 28.

Source: *Fake* sheet in *PopPyr.xlsm* after using the ? Years button.

To emphasize the dynamic nature of the pyramid, click the Animate button. Each chart is moved on top of the first chart in sequential order and at the end all of the charts are returned to their original positions. Animation time depends on computer speed and may take a while. The year number is displayed in the top-right corner of the chart and in Excel's status bar (bottom left of the screen). Stacking the charts provides a strong visual effect that reinforces the iterative mechanism at work.

Does this process have some kind of final resting position or might it undulate forever? That is an excellent question that can be answered via simulation. Click the ? Years button and enter 200 years. Scrolling right reveals how the age distribution moves over time. By Year 50, there is another baby boom as the second generation enters its prime reproductive years. The answer is clear: by the 100th year, the pyramid seems to be settling down. Unfortunately, the population has grown so that it no longer fits on the chart. Click the Common X Axis button to set the *x* axes of all of the charts on the sheet to the same scale so they can be compared easily. Now it is quite clear that by the 200th year, a stable, roughly triangular shape has taken hold (as shown in Figure 3). Notice how the %ΔPop has converged to the LR %ΔPop of 1.29%. This value depends critically on the ASFR and ASDR parameter values and the fact that they have not changed.

Figure 3: Years 100 and 200.
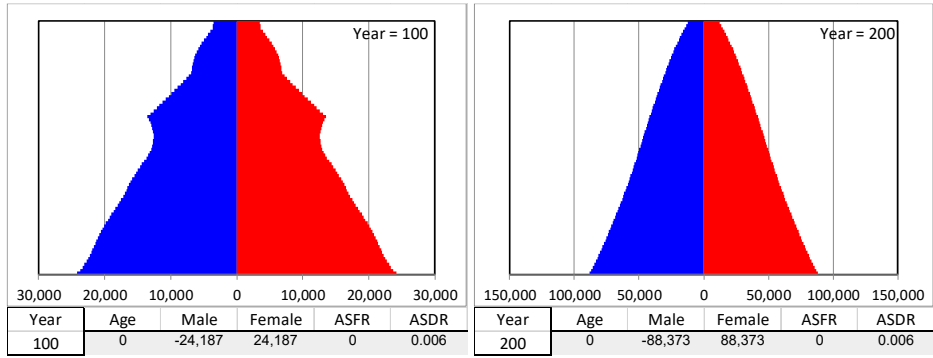
Source: *Fake* sheet in *PopPyr.xlsm* after using the [? Years] and [Common X Axis] buttons.

To demonstrate the importance of age-specific fertility and death rates, simply change them and watch what happens. In Year 100, for example, suppose ASFRs fell by half. Change Year 100's ASFR (in row 31) to 0.05 and fill down row 60. With ASFR values of 0.05 for each age cohort from 15 to 44, click the [Common X Axis] button to standardize the *x* axes. The effect of decreased fertility can be immediately seen as the pyramid's base shrinks. Scroll right to see that the population continues to rise as long as births outnumber deaths, but the narrow base means there are more elderly than younger people (see left graph in Figure 4). This is potentially devastating for the economy. By Year 200 (right graph in Figure 4), the pyramid is still inverted and has yet to settle down to an equilibrium shape.

Will it ever stabilize? Again, simulation offers an effective, simple method to answer this question. Click the [? Years] button and run the process for an additional hundred years. The percentage change in the population approaches its long run growth rate, but it is negative so the answer becomes clear: the ASFR and ASDR parameter values are such that this society will disappear.
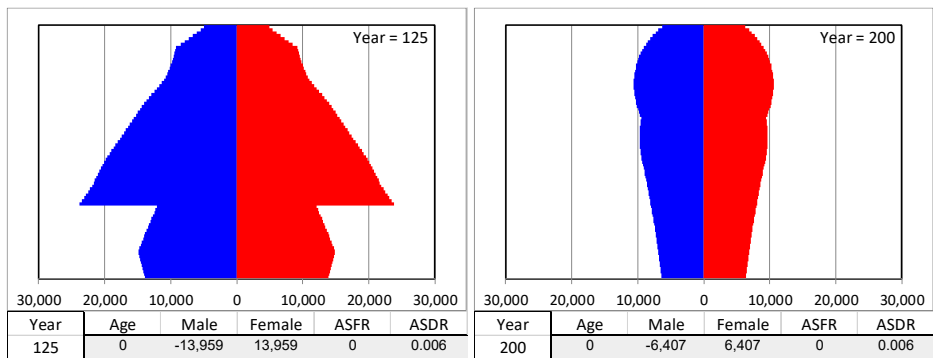

Figure 4: Years 125 and 200 after halving ASFRs.

Source: *Fake* sheet in *PopPyr.xlsm* after using the [? Years] and [Common X Axis] buttons with ASFR=0.05 in Year 100.

Return to the beginning of the sheet and click the [Reset] button to wipe the slate clean. Click the [Example 2] button to put down a new hypothetical scenario. This hypothetical example is composed of the population pyramid of Afghanistan in 2014, with Egyptian ASFRs and American ASDRs. Click the [More on ASFR & ASDR] button to learn more about the data. Gouges in the pyramid are usually evidence of a traumatic event, such as war, disease, or famine. Afghanistan's pyramid, however, can be used to show that not all population data are equally reliable. Low-income countries lack adequate and complete vital registration systems that count all births and deaths; and all countries struggle with accurate migration statistics. Pinney (2012) points out the immense difficulties in measuring Afghanistan's nomadic peoples and the fact that it is likely to be the only country to have never completed a census. With tumultuous movements in refugee returns and exodus, it remains unclear why birth cohorts in 2002 and 2003 were so small.

Turn your attention to the bottom bar of the Year 2 chart. As is clear, if we apply ASFRs from Egypt to the women of reproductive age in Afghanistan, we would produce many fewer children than were born in the previous year. Population is rising fast, however, because US ASDRs are so low. What would happen if these ASFR and ASDR values remained constant over time? We can run a simulation to answer this question. Click the [? Years] button and run this process for 200 years. With high (Egyptian) fertility and low (American) death rates, we see convergence to a fast population growth rate of almost 2% per year. This is unrealistic in the sense that neither fertility nor death rates will remain constant. Death rates fall as technology improves, but predicting fertility rates is a demographer's biggest challenge. They depend on economic and social conditions, with quick, unexpected movements.

Since we have the evolution of the population age-distribution readily available, we can use it to find a set of ASFRs (for the given ASDRs) that would produce an unchanging population. One approach to finding this replacement fertility rate is to enter the formula "=E31" in cell E32 and fill it down to cell E60. This makes all of the ASFRs 0.01 and the resulting general fertility rate of 10 (reported in cell H8) is extremely low. Scrolling far right makes it clear that the population will vanish. Changing cell E31 changes the ASFRs for every age and provides an easy way to control the general fertility rate. Try different values in cell E31 (or bring up Excel's Solver, use Excel's Help if needed, and click Solve) to converge to the replacement fertility rate of roughly 68 (0.068 in cell E31), which is higher than the 62 per 1,000 GFR the United States experienced in 2016. Of course, the *Fake* sheet has no migration and unrealistically holds constant fertility and death rates.

The *Fake* sheet offers an easy, interesting introduction to the population pyramid. Because the charts are live, they update instantly when the underlying cells are changed. The user can enter values under any chart to create new examples or use data from a particular historical period. Paste in initial population (in columns C and D) and ASFR and ASDR values (in columns E and F), then simulate to explore and forecast. Copy the *Fake* sheet as many times as needed to preserve scenarios.

The strong visuals and ability to see the evolution of the pyramid provides a strong foundation when we examine real-world data. Working with hypothetical data emphasizes that the shape of the pyramid reveals the age-distribution at a quick glance. Simulation, however, makes clear that the AFSRs and ASDRs are critical parameters that determine the evolution of the population pyramid, producing rising, falling, or zero population growth. Tuljapurkar (2008) provides an introduction and overview of the dynamic properties of this basic model, known as stable population theory. Lotka's renewal equation and key results are presented formally. *PopPyr.xlsm* is open-source and the Visual Basic code can be accessed by interested readers, including documentation on how the long run growth rate is computed.

3.0 Real-world Population Pyramids

Before Francis Amasa Walker would go on to become a nationally prominent economist (he was the first president of the American Economic Association) and president of MIT, he was superintendent of the US census in 1870. As editor of the *Statistical Atlas of the United States*, Walker (1874) published a series of population pyramids that helped establish his reputation as a statistician. Today, the US Census Bureau continues this tradition of data visualization by maintaining an online International Data Base (IDB) at www.census.gov/population/international/data/idb. Most users download data, then open it in Excel (or other software) for analysis, but this fails to take full-advantage of Excel's ability to act as a browser and directly access data.

The *PopPyr* sheet in *PopPyr.xlsm* offers a simple interface to download data from the IDB straight into Excel and display the population pyramid. Notice the usage notes in column Q. Click the *Select a Country* control and choose the United States, and then click the [Get IDB Data] button to produce a chart like Figure 5. This shape looks more like a house and is typical of a developed, rich country. It does not reflect the usual triangular pyramid that gave the graph its name and is emblematic of developing, poorer countries with high fertility and death rates producing many more children than adults. The current US age-distribution of roughly equal numbers of people at each age until it finally

starts tapering off around age 70 depends on previous cohort sizes (including immigration), fertility, and death rates. Unlike the *Fake* sheet, ASFRs and ADSRs have not remained constant and will almost certainly change in the future.
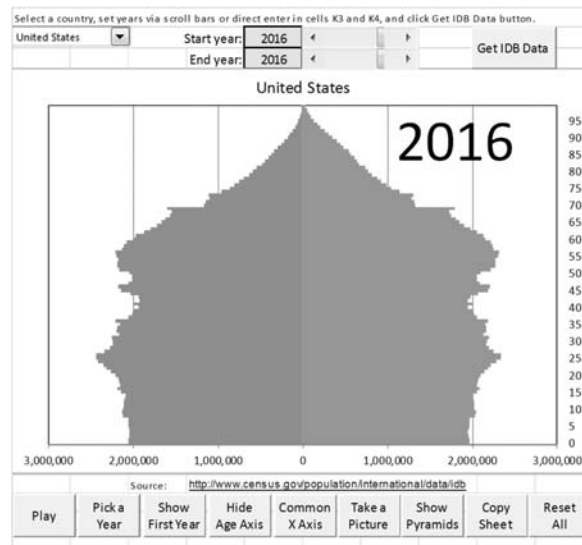

Figure 5: US Population Pyramid.
Source: *PopPyr* sheet in *PopPyr.xlsm* after selecting United States
and clicking the [Get IDB Data] button.

Click on the colored area in the chart to get a pop-up message that displays the number of people in the cohort clicked. Click OK and click a different colored area of the chart to display information about another cohort. This is convenient for identifying indentations or sudden changes in cohorts. The [Hide Age Axis] button is a toggle that displays the age of each cohort on the right-hand side of the chart.

Change the *End Year* (in cell K4) to 2030 and press enter. Click the [Get IDB Data] button to download US Census Bureau population projections for these years. This may take some time, depending on your computer and connection speed. If downloads are too slow for live demonstration in class, access the data and copy the sheet to create a series of pre-prepared examples. Scroll down to see the age-distribution data for each year in table format.

Return to the chart and click the [Play] button. Excel animates the chart and shows a dynamic version of the pyramid. It is clear that the age-distribution of the US population is expected to be fairly stable, although the top cohorts will grow, reflecting increased longevity (especially for women). Note that the [Pick a Year] button can be used to display any given year.

In addition to the chart, the data can be used in computations. The sum of all of the age cohorts in a given year is the total population, almost 324 million people in 2016, produced by entering this formula in an empty cell: =-SUM(C3:C103)+SUM(D3:D103).

The M/F ratio at birth is about 1.05 (via the formula = - C3/D3) and this can be filled down to get M/F ratios for all age cohorts. Men have higher death rates and by their late 30s, women begin to outnumber men. Scroll down to find that there are four times as many women over 100 years old as men in the United States in 2016.

While the greater longevity of women is no surprise, a value greater than one for the M/F ratio at birth will puzzle most students, who expect an equal number of male and female births. They will be interested to hear that, in perhaps the first paper using data for statistical inference, Arbuthnot (1710) said the male-female imbalance showed that God determined sex at birth, not chance. He also managed to somehow conclude that this showed that polygamy is unnatural. Today, we know that males are more likely at birth, around 1.05 to 1, but this is not constant and depends on environmental factors. The exact mechanisms at work remain unclear. Click on the Trivers-Willard Hypothesis link in the *Fake* sheet for more.

For some countries, for example, India and China, the M/F birth ratio is quite high (over 1.1) and is indicative of sex-selective abortion and female infanticide. Sen (1990), who would go on to win a Nobel Memorial Prize in Economic Sciences in 1998, pointed out that "A great many more than a hundred million women are simply not there because women are neglected compared with men." Missing women remains as important a global public health issue today as when Sen first called attention to it (e.g., Hesketh and Zhu (2006)).

Another statistic that can be easily computed is the dependency ratio: the number of dependents (ages 0 to 14 and 65 and older) to the number of working-age adults, 15 to 64. The data show about 110 million dependents in the United States in 2016, using this formula: = - SUM(C3:C17) + SUM(D3:D17) -SUM(C68:C103) + SUM(D68:D103). The formula = -SUM(C18:C67) + SUM(D18:D67) yields almost 215 million adults aged 15 to 64 so the dependency ratio is a little over 0.5. A slightly different gauge is the old age dependency ratio (OADR), the number of people 65 and older divided by working-age adults. In 2016, this ratio is roughly one-quarter. Support ratios (the reciprocal of dependency ratios) are measures which show the number of people of working age per dependent.

To see how these dependency ratios compare to other countries, click the Copy Sheet button to save the work on the United States and then return to the *PopPyr* sheet and click the Reset All button. Download age-distribution data for Japan from 2016 to 2030. The narrow base shape, shown in Figure 6,

predicts continued strong headwinds for the Japanese economy and society. Animating the chart shows that old people will increasingly outnumber young people. The dependency ratio, already a high 0.67 in 2016, is expected to rise to over 0.75 by 2030. The OADR will increase from 0.46 to a staggeringly high 0.57.
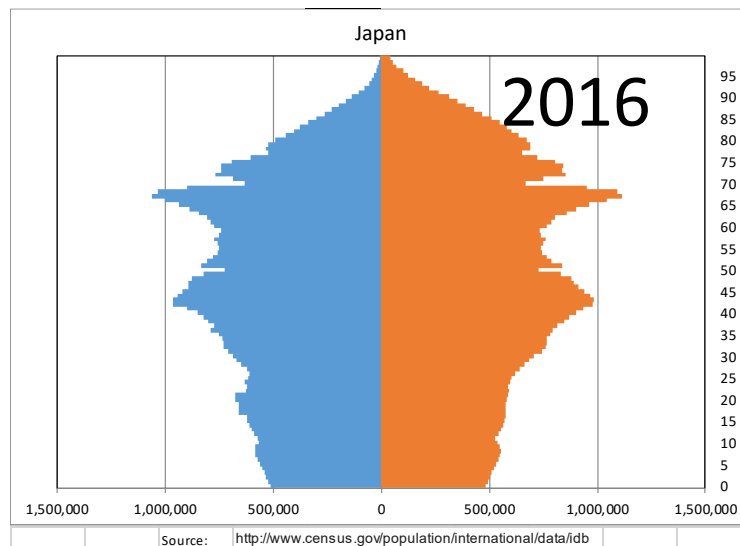

Figure 6: Japanese Population Pyramid.
Source: *PopPyr* sheet in *PopPyr.xlsm* after selecting Japan
and clicking the [Get IDB Data] button.

It is no secret that the Japanese economy has not responded to standard interventions by policy makers. The ineffectiveness of central bank and fiscal stimuli is surely partly rooted in Japan's unfavorable demographic environment. The inverted pyramid and its march up as time goes by contains information about critical economic factors. Housing construction, for example, might suffer from low demand, while health care expands. In class, a discussion about the economic implications of a sharp fall in the number of Japanese children and large increase in elderly people should elicit interesting and perhaps even original contributions.

One consideration that may not be mentioned and offers a segue into other aspects of macroeconomics is the role of expectations. Keynes (1936, Ch 12:VII) highlighted animal spirits, "a spontaneous urge to action rather than inaction," as a key element in understanding fluctuations in a market economy. Investment, the main driver of the business cycle, depends on subjective estimates of future prospects. Investment, and thus the economy, is volatile precisely because we swing from periods of optimism to pessimism. In good times, a positive outlook and belief in a better tomorrow produces high levels of investment spending. With malaise comes a lack of business and

consumer confidence, and like a self-fulfilling prophecy, the economy plummets. For Keynes, the dynamics of market psychology is the critical factor in the market system's roller coaster ride and his medicine for the Great Depression relied primarily on changing expectations and restoring confidence.

Applying these ideas to Japan is not comforting. A society of old people is not a hopeful, upbeat place (for those who enjoy adding a little spice to their classroom or prefer teaching via film, *Children of Men* is an option, www.imdb.com/title/tt0206634). Stimulating aggregate demand through traditional means (reducing interest rates, increasing government spending, and cutting taxes) has not given the Japanese economy the jolt it needs, Keynesian logic would argue, precisely because the demographic headwinds are so strong.

The eagle-eyed reader may notice that the Japanese population pyramid also shows two indentations. One is clearly a consequence of World War II, but the other is for 50 year-olds in 2016. Did something unusual happen five decades ago in Japan? In fact, yes, births fell by several hundred thousand from the previous year. Haberman (1987) explains what happened:

> In 1966, relatively few Japanese wanted to have children because the zodiac signs had cautioned against it. . . . Few years are worse than those known in Japanese as hinoe uma, when fire and horse fall upon each other. According to a widely held belief, women born in the Year of the Fire and Horse are destined upon reaching adulthood to marry and then kill their husbands. The last hinoe uma was 1966. Japanese parents were taking no chances that year, and so the number of births plummeted by nearly 25 percent from 1965.

The Year of Fire and Horse occurs every 60 years and the next hinoe uma is in 2026. It is unclear whether and to what extent Japanese society at that time will be influenced by this tradition.

As a final example, return to the *PopPyr* sheet, clear any existing data and download Cuba's population cohorts. Figure 7 shows a remarkable view of recent Cuban history. The bulge reflects a baby boom after Fidel Castro took power in 1959. Fertility then declined, slowly at first, then quite quickly.

Click on the deep gouge in the center, show the age axis, or scroll down in the data to see that there are two age-cohorts, 35 and 36 year-olds, with much smaller populations than those before and after them. While this coincides with the 1980 Mariel boatlift, when 125,000 Cubans left the island, they were not especially concentrated in these two age-cohorts so this is an unsatisfactory explanation. A better account for the sharp reduction in population of these cohorts lies in the iterative process of population dynamics.
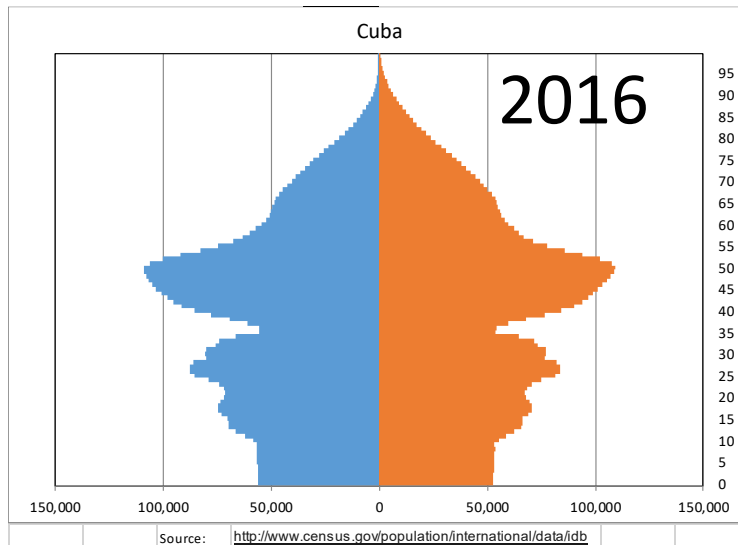
Figure 7: Cuban Population Pyramid.
Source: *PopPyr* sheet in *PopPyr.xlsm* after selecting Cuba
and clicking the Get IDB Data button.

Look again at Figure 7, but this time focus on how the second, smaller bulge is an echo, a product of the baby boomers (the big bulge above) having children. It is much smaller because the baby boom women had much lower fertility rates than their parents. In the 1970s, access to contraception and deteriorating economic conditions led to rapidly falling birth rates. More recently, Cuban fertility has absolutely cratered, reflected in the narrow base of the pyramid. While other countries in Latin America have also experienced marked declines, Cuba's drop is spectacular. Spooner and Ullmann (2014, p. 39) cite World Bank data showing "a dramatic drop in birth rates, from an average of 4.18 births per woman in 1960, the year after the Revolution, to 1.46 in 2012."

No analysis of Cuba's economy or prospects for future growth should ignore its demography. With a dependency ratio of 0.4 in 2016, the situation seems calm, but the dynamic nature of the pyramid points to difficult times ahead. The peak of the baby boom wave, those who are 50 years old in 2016, will be retiring soon and there will be a marked decrease in people replacing them. "The Cuban birthrate is the lowest in the Americas, and one of the lowest in the world, as women simply choose not to have babies, despite the availability of at least a basic level of prenatal and pediatric care." (Spooner & Ullmann, 2014, p. 7). Unlike Japan, which can count on savings and an advanced economy, Cuba will face its demographic challenges with low levels of GDP per person in a society transitioning to a market system.

These three examples, the United States, Japan, and Cuba, are the tip of the iceberg. Population pyramids for China and India (especially focusing on M/F ratios) are fascinating. For China, the Cultural Revolution, one-child policy, and other shocks are strikingly evident in the age-distribution graph. India's classic pyramid with huge numbers of young people is changing fast and will certainly grab your attention. Animating India to 2050 is instructive because the scale—steadily adding over 20 million people each year—really matters. If IDB downloads prove to be too slow for lecture display, consider using web-based, animated pyramids, e.g., www.worldlifeexpectancy.com/cuba-population-pyramid.

Every country has a demographic story (e.g., Bahrain). To see the big picture, click the Show Pyramids button. A new sheet is revealed, with population pyramids for every country in the IDB. This also provides quick checking if students are assigned specific countries as homework or presentations.

4.0 Labor Force and Migration

The basic pyramid can be augmented to highlight subgroups within the population. This section shows two examples of this approach: labor force participants and immigrants.

The *LFPR* sheet opens with the age-sex distribution of the population of the United States in 2016, along with information about labor force participation rates (LFPR) by age and sex. This information is used to compute the number of men and women in the labor force, which is then added to the chart. Figure 8 shows the result: a population pyramid with an additional core area that represents the labor force.
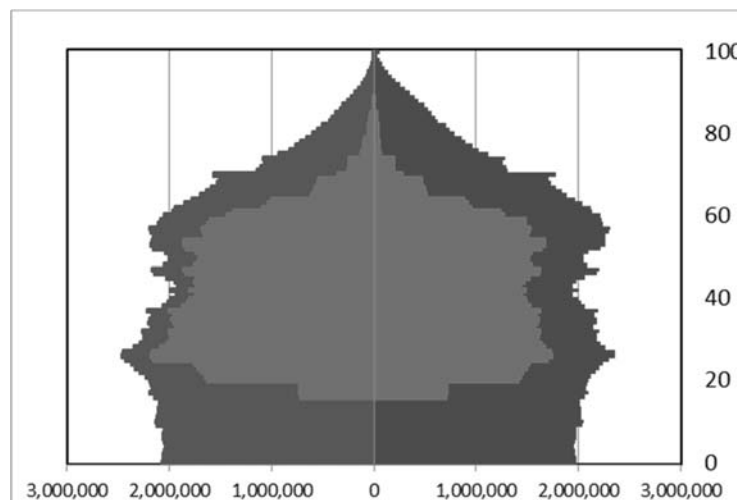

Figure 8: United States Population Pyramid with Labor Force.
Source: *LFPR* sheet in *PopPyr.xlsm*.

Notice how higher male labor force participation rates extends the core farther out (seen most clearly for middle age) for males than females in Figure 8. At the top, as workers retire and leave the labor force, the inner core narrows faster than the population; while, at the bottom, people under 16 years of age are not counted as being in the labor force at all.

As with the basic population pyramid, comparisons of countries with presentations by students would be interesting and informative. To do this, simply replace the population in columns C and D with data downloaded from the *PopPyr* sheet. LFPR by age and sex or many countries is available from stats.oecd.org.

Proceed to the *Mig* sheet for a similar example that focuses on immigrants in the United States. Immigration is, of course, always in the news and the population pyramid offers a novel approach to understanding the data and issues. The *Mig* sheet uses 5-year cohort data from the Migration Policy Institute (www.migrationpolicy.org) to show pyramids of the total population of the United States and breaks it down into native and immigrant (non-native) populations.

By embedding immigrants within the total population, as shown in Figure 9, a different perspective is gained. Non-natives in the United States are about 13 percent of the total population and predominantly middle-aged. To be clear, the pyramid does not tell us when these immigrants arrived, simply that these people were not born in the United States. The pyramid also says nothing about the geographic distribution of immigrants—perhaps focusing on pyramids for different states (including those with the highest immigrant populations: California, Texas, New York, and Florida) would be a fun, educational class project.
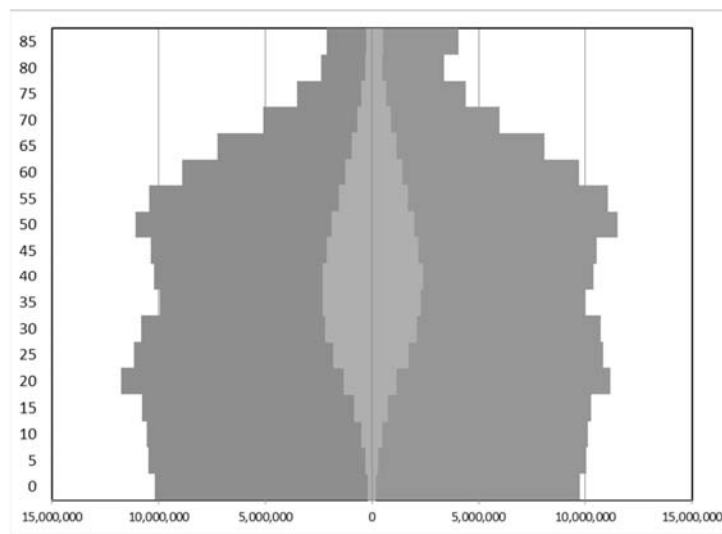

Figure 9: United States Population Pyramid with Immigrants.
Source: *Mig* sheet in *PopPyr.xlsm*.

Both of these examples introduce complications and questions beyond the scope of this paper. Like ASFR, LFPR is changing rapidly and begs the question of how we can project future rates. For immigration, data are difficult to find and the issue of illegal migration presents special challenges. However, the concept of displaying a subgroup within a total population produces an eye-catching graph that displays quite a bit of information. Both the *LFPR* and *Mig* sheets can be used as templates: copy the sheet and populate it with your own data, modifying the chart as needed.

5.0 Teaching Tips and Strategies

In its most basic application, population pyramids can be inserted as a one-off lecture in any course. *PopPyr.xlsm* can be projected in class as part of a lecture. Walk through the simulation in the *Fake* sheet and download real-world data as described in the previous sections. Pyramids and animations for individual countries can be prepared before class and saved in individual sheets (click the Copy Sheet button). Pictures are easily pasted into class handouts or slides (click the Take a Picture button).

Remember that the charts are live so that any change to the data is instantly displayed on the population pyramid. Thus, for example, it is easy to convey the effect of traumatic events such as wars by simply changing the underlying data—halving the population of 20 and 21 year-old males will produce a gouge in the pyramid for those cohorts.

A more advanced use, but still encased as a single module or class, involves distributing the file to students (simply email the link to the Excel workbook or post it in a course management system). In a computer lab or as homework, individual students or groups can be assigned specific countries or allowed to choose a country. Student presentations are an easy way to share knowledge, and discussion can generate novel, interesting ideas.

For even more advanced work or as an independent study project, get ASFRs and ASDRs for a country and predict future population. The results can be compared to US Census Bureau projections. Scenarios for high, medium, and low fertility rates can be produced. Research into fertility and death rates will reveal that the former are quite volatile and exceedingly difficult to predict.

Once demography is on the radar, single variables that serve as a catchall can be disaggregated. For example, instead of including a single mortality rate in a model, ASDRs applied to an age distribution will provide a richer depiction of the dynamic process. Likewise, replacing a single population growth

rate parameter in a Solow Model with cohorts of working age people over time offers an intriguing and accessible research project.

6.0 Conclusion

This paper argues that economics students should be exposed to demography. The population pyramid offers an engaging, accessible way to do this, even in introductory economics. There are, obviously, many additional concepts, graphs, and statistics, but the material included in *PopPyr.xlsm*, can be presented in a single lecture, with follow-up homework, lab, or class presentations. The *Lessons* sheet offers a list of key ideas to help students organize the material. It also includes a chart of college graduates in the United States in a population pyramid. This shows that a population pyramid can be applied to a variety of situations and data. For more advanced classes, the *PopPyr.xlsm* workbook provides a platform from which many additional topics and policies can be explored.

Using Excel (see Barreto (2015) for the pedagogical advantages of using spreadsheets) to evolve the age distribution over time quickly displays the dynamic nature of the pyramid as cohorts are seen marching up the chart. Downloading data from the IDB directly into Excel offers a one-click solution to exploring the demographic story of any country.

Choosing course content is a difficult optimization problem, with many worthy options from which to select. The fundamental argument for including the population pyramid in the curriculum and elbowing aside other important material lies in the critical role demographics will play in the future of every economy. Today's screeching halt to the incredibly fast population growth of the second-half of the 20th century should not be ignored by economists—in their research or in the classroom.

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