Economics 623: Age Composition and Population Dividends

Age Composition

Today we will discuss the age structure of the population from a demographic perspective. On Thursday we will discuss the age structure from an economics perspective.

The age structure or composition of a population is the *distribution* by age of the population. (The age and sex composition of a population is the distribution by age and sex of the population.)

Age is a central concept in demography for two reasons: (1) demographic behavior varies systematically with age, and (2) populations are one age are systematically connected with the population at subsequent ages.

From the life table, mortality rates varies strongly with age, and after about age 75 increase visibly with age. And fertility rates vary with age. Fertility is (relatively) low before age 20, reaches a peak in the mid-20s to mid-30s (in developed countries) and declines through the mid-30s till it drops to zero by the mid-40s. Migration is an activity primarily of the young. That all of this is obvious does not reduce its importance. To have a clear understanding of demographic behavior we have to keep track of age.

The second reason is equally simple, perhaps too simple it is less obvious. We saw from the life table that the population at age $x + 1$ equals $\ell_{x+1} = \ell_x - d_x$. The life table assumes that the population is closed to immigration. So, all people alive aged at least 1 year last birthday at mid-year $t + 1$ were already born at mid-year t. Thus, the population at age $x + 1$ in period $t + 1$ equals the population at age x in year t less mortality plus the number of (in) migrants, $P_{x+1,t+1} = P_{x,t}(1 - q_{x,t}) + N_{x,t}$, where $N_{x,t}$ is net migration. Knowing the size of the population age x at time period t gives us plenty of information on the size of the likely size of the population age $x + 1$ at time $t + 1$. And more generally for intervals longer than a year (where we have to adjust the mortality rate for the longer interval, ${}_nq_{x,t}$ magnitudes of populations remain structured.

Recognizing these linkages across ages and periods lies at the heart of formal demography. The **Lexis Diagram** connects cohort and periods. The horizontal axis of the Lexis Diagram is time (moment of birth in years) and the vertical axis is age. A birth cohort runs along a diagonal line

(45 degrees). The shaded area (P) represents period data, that is P–data combine different ages over a calendar period. Similarly, (A) (age data) combine different birth periods to summarize by age. And cohort (C) measures can be visualized along the diagonal. The Lexis diagram is useful to disconnect the time–period–cohort effects. Period effects – things unique to a specific (calendar) time, e.g., business cycle. Age effects – things common to an age (e.g., menarche). While cohort effects measures things specific to particular birth cohorts (e.g., Baby–boomers). Weeks gives the example of lung cancer mortality to distinguish the three effects. Survivorship of lung cancer declines with age (the elderly are more susceptible, the age–effect), but mortality rates may vary widely when the was diagnosed (period effect) as medical treatment vary with (calendar time, 2005 versus 1965). Smoking patterns vary with cohorts, so variation in calendar time also reflects cohort differences.

However, as is transparent to many $period = cohort + age$ the three effects are linearly related. And statistically without other assumptions, can only separately distinguish two of the three. The structure of the available data sometimes dictates the analytical structure. For example, may have information only for a narrow set of birth cohorts, so it would be natural to assume cohort effects are zero. Yet our behavior theories (e.g., theory of permanent consumption, life cycle model of savings and investment) imply key differences by age, so it is most common to allow age difference.

Finally, to see the importance of the age structure consider differences by sex. For many behaviors and outcomes, there are large differences by sex, most especially mortality. Thus, greater accuracy requires that we disaggregate the analysis by sex — calculate rates separately for women and men. (This is not true of nuptiality.) We can think of a multitude of factors that may give rise to different demographic behavior (e.g., race, education, geographic location, etc.). For accuracy, we should disaggregate for each important factor, and the analysis by age within each subgroup. If we are interested in population totals, we simply sum events across subgroups by age. The age structure links the population size today with the population size tomorrow.

Age Pyramid

The age pyramid is the standard graphic method depicting the age structure of a population or sub–population. The horizontal axis is the proportion or count of the population while the vertical axis lists five–year age intervals, from age 0 to 85 or 100. Recall that it is common to plot males on the left and females on the right (women are always right). The pyramids are useful because they give a quick snapshot of the age and sex structure of the population. They are called pyramids because the classic society with high fertility and high mortality appears as pyramid with a large base and sharply sloped sides (cf Nigeria in Figure 8.4 of Weeks). Mexico's pyramid shows the reduced fertility (shorter base and longer sides), whereas the low fertility and low mortality of the U.S. and Canada "rectangluarize" the pyramid. Notice the difference between U.S. and Canada — U.S. has fertility at replacement, while Canada's is below (with roughly the same mortality regime).

Stable Population Theory

To understand the effects of changes in mortality and fertility, demographers use **stable** population theory. Stable population theory is the demographic analogue of equilibrium analysis within economics. A stable population is a formal demographic model in which the age–specific birth rates and the age–specific death rates have not changed for a long time. A population is stable if its age and sex distribution does not vary with time (aka "in equilibrium"). The life table a population with zero growth, but a stable population may be increasing in size, the key is that its age structure is time invariant.

The idea is much like studying steady states in macro economics. There is an initial equilibrium which we perturb (e.g., change monetary or fiscal policy). In steady–state analysis we do not investigate the *transition* from one equilibrium to another, but rather compare equilibria (i.e., after the completion of the adjustment process). Figure 8.5 of Weeks is a cool graph of age pyramids showing the effect increasing life expectancy at birth from 20 years (pre–modern) to 50 years (modern).

Be careful as some authors express the base of the pyramid in terms of relative frequency while others as a share (or percentage). A decline in mortality that influences all age groups is likely to have large effect on the age structure simply because all age groups are affected. Yet, if fertility does not decline in response to the lower mortality rate, the population growth rate will increase. Thus, if the population is in steady state and mortality declines by three percentage points, population growth will increase from zero to three percent (assuming no migration). A three percent growth rate implies (from our discussion of doubling times early in the fall) that the population size will double in approximately a generation (twenty–five years). Quantities matter. Local school boards have to build schools to accommodate the number of students, not the share of the population.

Dependency Ratio

Another index commonly used to measure the social and economic impact of different age structures is the **dependency ratio**.

$$\text{Dependency ratio} = \frac{\text{(population 0-14)+(population 65+)}}{\text{population 15-64}}$$

The ratio measures the size of the dependent population relative to the independent. The dependency ratio is widely used and has the advantage that it is a scalar. Yet, for many settings the policy consequences will vary by which segment of the dependent population is growing. Again, the material from the Population Reference Bureau includes the dependency ratio for a range of countries. Will discuss more thoroughly on Thursday when we consider Weil's paper.

Population Dividends and Momentum

Two important concepts *population dividends* and population momentum. The first you may see discussed in the media, the second is important for understanding the long run consequences of the population structure.

As populations shift from high mortality and high fertility (pre–modern) to one of low mortality and low fertility (modern) the age pyramid will shift from the classic large–base steep sloped sides to one with a barrel shape like Canada's (barrel because of the declining fertility creates small populations at young ages, with mortality trimming the top of the pyramid). During the transition there will be a period when it collapses in at younger ages and there will be a bulge in the younger adult ages. This "bulge" can be a burden or a dividend depending on the society and its circumstances.

The age bulge may be a burden if the economy is not working well, and there is high unemployment, especially among young men in the "bulge". Some (see Weeks) argue that the young men may become disenfranchised and turn to criminal activity or otherwise generate social unrest. The group can tear at the social fabric and make for difficult and costly social solutions.

David Bloom (among others) has made much of the "dividend" accruing to the age structure in the United States. The "windfall" or "dividend" is that the large stock of young productive workers can concentrate on market activity with relatively few dependents (elderly and children) to support. The gains of mortality have not been felt by the elderly so the elderly population is still relatively small, while reduced fertility levels decrease the number of children. Adults represent an increased share of the population and are available for market work. Bloom and others claims the "dividend" is an important source of economic growth. The policy issue is whether countries "spend" or "invest" their dividends.

Although much in the press lately, the notion of the population dividend is simply an example of the notion of **population momentum**. Populations change their age and sex structures with **glacier like speed**. It takes time (predictable) for large (or small) birth cohorts to work their way through the age structure. At its simplest terms, momentum captures the idea that population growth depends on fertility and mortality processes and **the existing population age structure**. In its technical formulation, the term refers to the fact that a closed (to migration) population may continue to grow even when fertility is at the "replacement" level. The number of births and deaths depend on birth and death rates and the population base. Large age groups reflect prior periods of high fertility. Even if these large age groups reduce their fertility to replacement levels, the entire (large) age groups will have to pass through the remainder of their reproductive careers before the population stops growing.

Importantly for Europe, momentum also works in reverse — years of fertility far below replacement means that absent migration their populations will decline as it will take years of above–replacement fertility to produce enough births to offset deaths among the larger older cohorts (at a point in time older age groups correspond to earlier birth cohorts).