Population momentum is the tendency for changes in population growth rates to lag behind changes in childbearing behavior and mortality conditions. Momentum operates through the population age distribution. A population that has been growing rapidly for a long time, for example, acquires a "young" age distribution that will result in positive population growth rates for many decades even if childbearing behavior and mortality conditions imply zero population growth in the very long run. Population momentum is important because of the magnitude and duration of its effects.

An Example

Consider the population of Nigeria, estimated at 114 million persons at mid-year 2000. Life expectancy rose from 36 to 51 years over the past half century, while completed family size remained at around 6 children per woman. In consequence, population grew very rapidly, with an average annual growth rate of 2.7 percent. (Statistics here and below are from United Nations 2001a unless otherwise indicated.)

Rapid population growth implies a "young" age distribution because larger numbers of persons were born in the recent past than in the more distant past. During 1995-2000, for example, 22 million children were born in Nigeria, as compared with only 8 million during 1950-1955. Even if everyone in the earlier cohort had survived, there would have been far fewer persons aged 45-49 than persons aged 0-4 in the year 2000.

Because of this young age distribution, the population of Nigeria will tend to grow rapidly in the future even if fertility declines rapidly to replacement level. The relatively large numbers of women and female children in and approaching reproductive age will generate large numbers of births, while the smaller numbers of persons at older ages will generate small numbers of deaths. The resulting population growth will slow as the population ages, but this will occur only over the many decades it takes for young persons to become old.

The United Nation's "instant replacement" population projections show that even with two-child families from the year 2000 forward, the population of Nigeria would have grown from 114 million in 2000 to 183 million persons in 2050, an increase of 60 percent (United Nations 2001b). The same projections show that the less developed world as a whole would have grown from 4.9 to 7.1 billion persons, an increase of 2.2 billion persons, even with an immediate fall of fertility to replacement level in 2000.

Momentum and World Population Growth

The importance of momentum as a cause of future world population growth has increased as fertility levels throughout the world have declined. Bongaarts (1994) estimated that population growth due to momentum could account for nearly half of world population increase during the 21st century. He pointed out that this growth could be reduced without any change in completed fertility by raising the average age of childbearing. This is a consequence of the "tempo effect" identified by Ryder (1983), whereby shifts in the timing of births result in a bunching up or thinning out of births during the years in which the shifts occur.

For populations with very young age distributions, however, reducing population growth due to momentum may lead to undesirable changes in the population age distribution. The "constant stream of births" model proposed by Li (1989) is useful in this connection. Fertility declines that produce a constant stream of births will result in age distributions for which numbers of persons decline slowly with increasing age through old age. More rapid fertility declines will result in age distributions in which numbers of young persons in younger age groups are lower than numbers of persons in older age groups.

Returning to the example of the population of Nigeria, suppose that fertility declines after 2005 in such a way as to maintain numbers of births constant at the level observed during 2000-2005. On this assumption, the population would grow from 114 million persons in 2000 to 250 million in 2050. The later number is only slightly less than the median variant projection of 279 million. Further reduction in population growth would require more rapid fertility decline.

To eliminate growth during 2005-2010, for example, it would be necessary to reduce the number of births from the 26 million projected in the medium variant to 8.4 million, the projected number of deaths. This precipitous decline in births would be followed by similarly precipitous falls, after a delay of 5 or 6 years, in the numbers of persons entering primary school, in numbers of persons entering the labor force after a delay of 15 or 20 years, and so on through the life cycle.

Some decline in numbers in these age groups might be advantageous, but such extreme declines would be problematic. The most obvious difficulty—ultimately transient, but prolonged and severe for many decades—would be that of supporting a large population of old persons with a greatly reduced working population.

Generality of the Momentum Concept

Population momentum is most often thought of in the context of fertility declining to replacement level, but the concept applies to all changes in childbearing behavior and mortality conditions. Consider for example a population that has a very old age distribution as a result of an extended period of population decline resulting from below replacement fertility. Should fertility rise to and remain at replacement level, population decline would continue for many decades. Large numbers of persons in post-reproductive ages would generate relatively large numbers of deaths, because deaths rates in old age are high, but no births. Population decline would slow only as the large cohorts of older persons die out, so that the population age distribution ceases to be “old”.

To illustrate momentum resulting from changes in mortality conditions, imagine an hypothetical population in which 1,000 children are born every year and in which everyone dies on reaching their 60th birthday. Total population is the product of the annual number of births and life expectancy at birth, 60,000 persons. Suppose that at some time t mortality conditions change in such a way that persons alive at time t die only when they reach their 70th birthday. Then no deaths will occur for 10 years, during which period the population will grow from 60,000 to 70,000 persons. This growth is due to population momentum.

The constant stream of births model may be used to generalize the concept of momentum to populations that do not reproduce biologically. Consider for example the population of Ph.D. degree holders in the United States, for which new Ph.D.’s constitute “births” and “age” may be understood as time since Ph.D. The number of degrees granted annually grew from 1 in 1870 to just under 30,000 in 1970 (U. S. Bureau of the Census 1975: Series H 751-765, pages 385-386), with an average annual growth rate of 7 percent. Because of this very rapid growth, the population in 1970 had a very young age distribution, and therefore a strong tendency to future growth. On the assumption that there were 330,000 Ph.D. holders in 1970 (the precise number is not pertinent for this example), holding the annual number of degrees constant at 30,000 after 1970 would result in a population of about 1.2 million Ph.D. holders in 2010, an increase of over 360 percent.

Definition of Population Momentum

The definition of population momentum requires three concepts from stable population theory. First, a population that experiences fixed age schedules of fertility and mortality will over time approach a stable state in which the age composition (the proportions of persons in each age group) and population growth rate (which may be positive, zero, or negative) are constant. Second, this age composition and growth rate are determined by the age schedules of fertility and mortality. They do not depend on the initial population age distribution. Third, two age distributions (giving numbers of persons in each age group) are *asymptotically equivalent* with respect to given age schedules of fertility and mortality if the ratio $P_1(t)/P_2(t)$ approaches 1 as t gets large, where $P_1(t)$ and $P_2(t)$ are the total populations projected from the two age distributions.

Given any age distribution and any age schedules of fertility and mortality, let two stable age distributions may be calculated, both with the age composition implied by the age schedules of fertility and mortality, but with different total populations. Let the total population for the first stable distribution equal the total population for the given age distribution. Let this number be denoted P_1. Let the total population for the second stable distribution be chosen so that the second stable distribution is asymptotically equivalent to the given age distribution. Let this number be denoted P_2. The *momentum* of the given age distribution with respect to the given age schedules of fertility and mortality is the ratio P_2/P_1. This formulation originated with Vincent (1945) following Lotka's seminal monograph on stable population theory (1939).

A necessary condition for momentum effects is that risks of birth or death vary with age. If age schedules of birth and death are constant over age, the age distribution does influence numbers of births and deaths and population dynamics are fully described by crude birth and death rates. The population growth rate will equal zero (assuming no migration) for any period in which birth and deaths rates are equal.

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