On "Weak" and "Strong" Population Momentum

Thomas J. Espenshade and Analia S. Olgiati

Office of Population Research
Princeton University

Abstract

Population momentum is the term usually given to the additional population growth (or decline) that occurs after fertility moves permanently to the replacement level. It is typically measured as "the ratio of the size of an ultimate stationary population to that of an initial population when the initial population undergoes an immediate shift in fertility to replacement level" (Kim and Schoen, 1997). The amount of momentum contained in a population's age composition depends on deviations below the oldest age of childbearing between the proportionate age distributions for the initial population and the long-run stationary population (Preston and Guillot, 1997).

This paper is built on the notion that a population's age distribution imparts residual momentum to population growth or decline whenever the observed age distribution differs from the *stable* age distribution implied by an indefinite continuation of underlying fertility and mortality. The argument is then used to decompose total population momentum into two constituent parts. "Weak" momentum is the subsequent addition to (or subtraction from) initial population size as the observed age distribution converges to the stable age distribution, holding fertility and mortality constant. It is measured as the ratio between the size of the stable equivalent population at time $t = 0$ (Q_0) and the size of the initial population (P_0). Then starting with the stable equivalent population, "strong" momentum is the subsequent growth or decline in population size

after fertility goes immediately to the replacement level. It is measured by the ratio between the size of the long-run stationary population (S_0) and the size of the stable equivalent population (Q_0).

The initial population and its stable equivalent at $t = 0$ are asymptotically equivalent both with respect to current fertility and mortality and with respect to replacement fertility and mortality (where replacement fertility is produced by a proportional change in fertility rates at all ages). It follows that total population momentum (S_0/P_0) can be decomposed into weak momentum (Q_0/P_0) and strong momentum (S_0/Q_0). In particular, total momentum is the simple product of weak and strong momentum.

The paper begins with two numerical illustrations. First, we take the current population of Indonesia, lower its fertility immediately to replacement, and project the closed female population until a stationary population is reached (with size S_0'). In addition, we derive Indonesia's stable equivalent population and project it forward using the same constant replacement-level fertility and mortality assumptions until a stationary population (of size S_0'') is achieved. We show empirically that $S_0' = S_0''$. Second, we consider the case of Japan whose fertility is substantially below replacement. Using identical procedures, we demonstrate that Japan reaches the same long-run stationary population size whether the initial population is projected with replacement fertility or its stable equivalent population is first found and then the stable equivalent population is projected using the same replacement-level fertility and mortality assumptions.

The second part of the paper considers the general case of closed female populations. It proves analytically that an initial population with arbitrary age

composition, fertility, mortality is asymptotically equivalent to its stable equivalent population with respect to *replacement* fertility and mortality. The same long-run stationary population is achieved whether the initial population or its stable equivalent is projected forward using the same (constant) replacement-level fertility and mortality assumptions. In other words, we show that $S_0' = S_0'' = S_0$.

The final part of the paper calculates weak, strong, and total population momentum measures for the 175 countries in the U.N. Population Division's database for 2006. The distribution of total population momentum is bimodal, with clusters around 1.0 and 1.5. Values for weak momentum are almost universally above 1.0, suggesting that relatively recent fertility declines have outrun the ability of their accompanying age distributions to catch up and fully adjust in the short term. The largest values for weak momentum range close to 2.0 with the maximum occurring for South Korea (1.97). Values of weak momentum are near zero only for initial populations that are relatively stable and have not experienced substantial fertility declines. Many of these countries are in sub-Saharan Africa (for example, Chad—0.98; Niger—0.98; Somalia—1.00; and Zambia—1.00).

By contrast, strong momentum ranges between values considerably below 1.0 to values substantially larger than 1.0. The smallest values for strong momentum are registered by countries whose current fertility is below replacement. Typical low values include those for Italy (0.61), Japan (0.59), and Poland (0.57). The lowest value for strong momentum is recorded by the Ukraine (0.48). High values generally range between 1.5 and 1.6 and are associated with countries with high fertility, including Ethiopia (1.54), Gambia (1.56), and Yemen (1.58). Extreme values are obtained for

Guatemala (1.63) and Timor-Leste (1.75). For countries whose fertility is already close to replacement, values of strong momentum are near unity. Examples include Chile (0.97), Iceland (0.96), and Iran (0.99).

In general there is an inverse association between values for weak and strong momentum. When they are plotted together, most of the points fall within or near the two parabolic equations, $xy = 1$ and $xy = 1.5$. To a very rough first approximation, many countries in the developed world have high values for weak momentum and values below one for strong momentum. Developing countries are typically found in the lower-right-hand part of the scatter diagram, where weak momentum is not too far from 1.0 and strong momentum ranges up to 1.5.

One contribution this paper makes to formal demography is its decomposition of total population momentum into two constituent and multiplicative parts, thereby showing more clearly how age composition interacts with fertility and mortality to add or subtract momentum to population change. Beyond that, the paper brings together into a unified framework several seemingly disparate strands of the population momentum literature. In particular, early versions of weak momentum have been proposed by Espenshade and Campbell (1977) and Schoen and Kim (1991). And strong momentum—at least the aspect that involves a drop in fertility to replacement—is another version of "Keyfitz" momentum (Keyfitz, 1971). Here we show how the various kinds of momentum fit together into a single picture.