More Realistic Best Estimates for Mortality Improvement

ANNUITY PROVIDERS AND PENSION FUNDS rely heavily on projections of future mortality improvements. As a rule of thumb, underestimating the future lifetime of annuitants or pensioners by only one year increases the overall benefit payments by 3 to 4 percent. For most populations in the past, actual improvements often turned out to be significantly higher than assumed, causing mortality projections or improvement scales to be revised accordingly. For this reason, it's worthwhile to take a closer look at typical standard mortality projections.

Figure 1 shows a heat chart for German males. It displays annual mortality improvements, i.e., percentage changes in mortality rates from one year to the next, for ages 0 to 100 and years 1957 to 2060. Bright colors like yellow or orange represent large mortality improvements; darker colors stand for small improvements or even mortality deterioration. Up to 2008, observed mortality improvements for the German male population are depicted; thereafter, best-estimate improvements according to the standard mortality table DAV 2004 R for annuity business in Germany are shown.

The information prompts several interesting observations:

- There's a structural break between historical and forecast mortality improvements. In reality, however, the transition will almost certainly be smooth.
- The projection assumes a rapid slowdown in mortality improvements over the next years that can't be derived from the historical data.
- The historical data contain significant diagonal structures that aren't extrapolated into the future. These diagonal structures are caused by so-called cohort effects, i.e., mortality improvements that depend on year of birth.

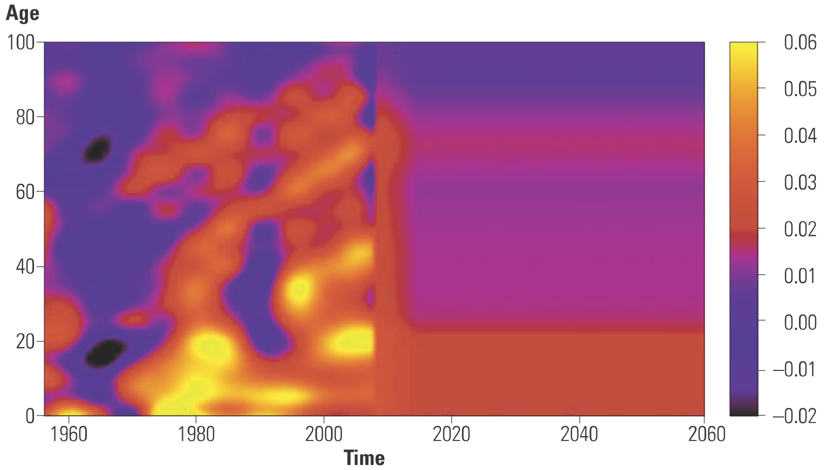
Very similar observations can be made for German females, but also for other populations we looked at and their respective standard mortality projections, such as projection scale AA for the United States.

Given the observations from Figure 1, there's a clear need for alternative projection methodologies that can provide more realistic best estimates. Such methodologies should fulfill the following rather general requirements:

1. Smooth transition between observed historical mortality improvements and projections for the future; this includes the extrapolation of cohort effects in particular, which are accounted for in only very few of the currently used mortality projections.
2. Projection of mortality improvements that—in magnitude—are in line with improvements in the historical data and are plausible in the long run.
3. Coherence between projections for males and females; projections for males and females usually have been derived independent of each other, which can cause inconsistencies in long-term forecasts.
4. Coherence between populations from closely related countries; besides the issue of inconsistencies in long-term forecasts, data from other populations can provide valuable information with respect to whether observed trends and patterns for a given population are sustainable or only temporary.

A projection methodology that fulfills these requirements was used to derive the mortality projection for German males as shown in Figure 2. When comparing this projection with the current standard projection in Figure 1, the improvement is clearly visible. In particular, cohort effects are extrapolated into the future, and the magnitudes of forecast mortality improvements appear more plausible. The slight structural break between the historical and the projected improvements in Figure 2 is due only to different degrees of smoothing in the respective parts of the heat charts and to adjustments that are necessary to obtain coherent projections for males and females.

FIGURE 1: Historical and projected mortality improvements for German males: historical improvements derived from data in the Human Mortality Database (HMD) and smoothed; projection according to mortality table DAV 2004 second order (best estimate).



SOURCE: AUTHOR

FIGURE 2: Historical and projected mortality improvements for German males; projection based on new methodology

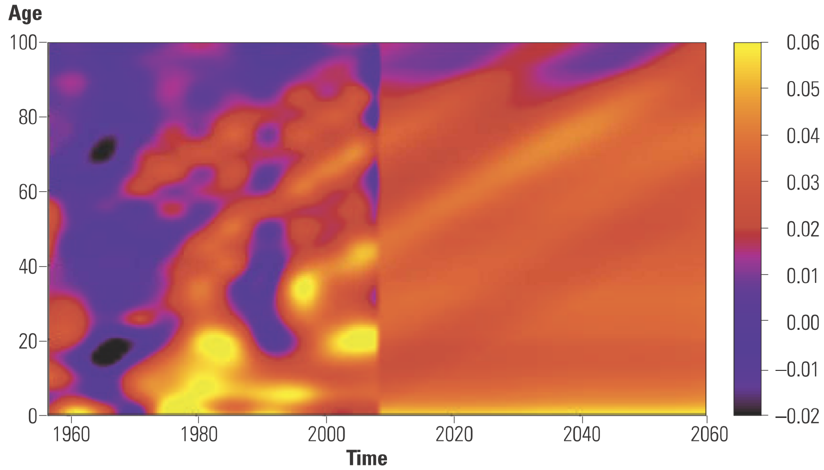


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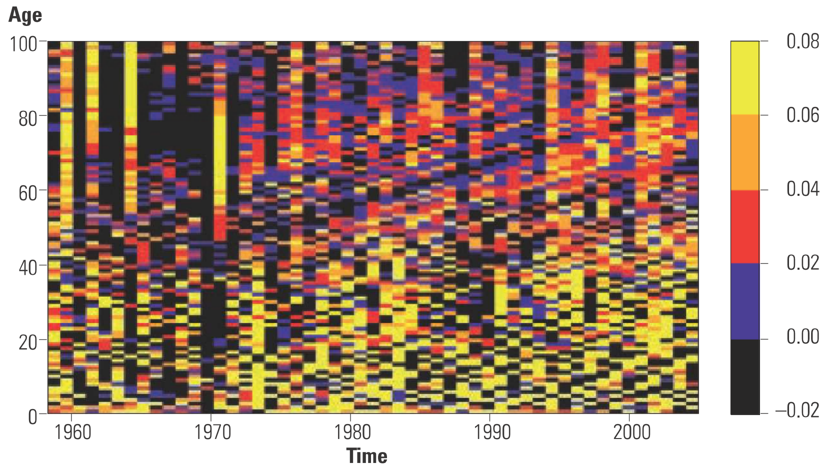
FIGURE 3: Raw mortality improvements for German males



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In what follows, I will outline the key steps in the projection methodology used to derive Figure 2, show how it fulfills the aforementioned requirements, and illustrate its application to the example case of German males. It's important to note, however, that the projection methodology isn't designed specifically for this particular case but can be applied to basically any population. A detailed description of the methodology is given in "Coherent Projections of Age, Period, and Cohort Dependent Mortality Improvements" (see Resources).

Projection Model Structure

First, let's look closer at the basic structure of the projection model. The model equation needs to consider all relevant patterns in the historical data. Figure 3 shows raw mortality improvements for German males, and we can see that they depend on calendar year and cohort. A dependence on age isn't obvious from that figure, but it usually can be observed once the data is smoothed (see Figure 1). As the same dependencies hold for most other populations as well, it seems reasonable to project mortality improvements by the well-known Age-Period-Cohort model (APC model):

$$v(x,t) = a_x + p_t + c_{t-x}$$

The mortality improvement $v(x,t)$ for age x and calendar year t is derived as a linear combination of three components: an age parameter a_x, a period parameter p_t, and a cohort parameter c_{t-x}.

The APC model can be fitted to historical data, and the resulting age and cohort parameters can be used for projecting (period parameters will be discussed in the next section). This implies that the age and cohort "structure" of future mortality improvements is similar to that of historical improvements. In practice, the age and cohort parameters should be smoothed before projecting to eliminate random fluctuations. Moreover, slight adjustments to the age parameters might be necessary to achieve coherence between the projections for males and females. Since the age parameters prevail until infinity, significant differences between the age parameters for males and females would imply that future mortality rates will diverge in the long run. Obviously, such a scenario would not be plausible for a best-estimate projection.

Magnitude of Projected Improvements

Given the age and cohort parameters, the magnitudes of projected mortality improvements for future calendar years are then determined by the period parameters. In order to fix these parameters, I would suggest building on life expectancy extrapolations. Life expectancies typically exhibit stable patterns since they are aggregated mortality statistics. They also often follow clear trends.

Figure 4 shows period life expectancies at birth for males in several European countries as well as for the total male population of all those countries. There's clearly a linear trend that can easily be extrapolated. Once a life expectancy is projected for each calendar year, the period parameters can be determined to obtain the forecast life expectancies. This approach automatically yields a reasonable magnitude for future mortality improvements in the short term and in the long run. In case you are particularly interested in a projection for older ages, the remaining life expectancy at, say, age 65 could be extrapolated instead of the life expectancy at birth.

The concept of deriving mortality projections based on life expectancy extrapolations has several additional appealing features. In general, it's difficult to say whether an average mortality improvement of some percentage number is conservative or aggressive for a given population. In contrast, the corresponding graph for the future life expectancy evolution is typically much more informative because you can observe directly how the historical life expectancy trend is extrapolated. Also, different projection scenarios can be derived easily just by altering the life expectancy extrapolation. For instance, you could increase the slope of a linear life expectancy trend and obtain safety margins in the mortality improvements that increase with time and thus uncertainty.

Coherence Between Males and Females

This approach for extrapolating life expectancies also can be used to derive coherent projections for different populations, e.g., males and females. If life expectancies are forecast coherently, the resulting improvement projections will also be coherent at an aggregate level. The blue lines in Figure 5 show life expectancy forecasts for European males and females that might be regarded as coherent.

FIGURE 4: Historical life expectancies for males in various European countries and for the total male population in these countries; data again obtained from the HMD

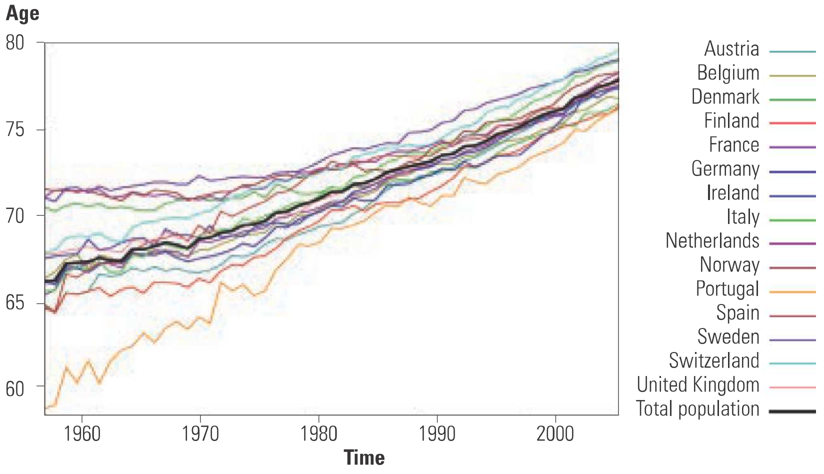

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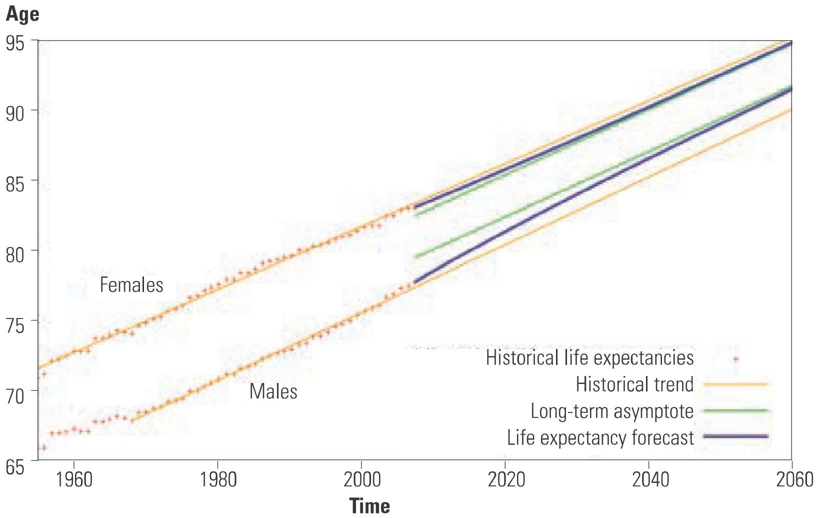
FIGURE 5: Coherent life expectancy forecasts for European males (below) and females (above)



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The general linear trend in the historical life expectancy evolution (yellow lines) is extrapolated, as well as the reduction in the gender gap starting in the 1990s. Since it appears rather unrealistic that the gender gap will shrink to zero, a long-term gap of three years is assumed (distance between the green lines). For other countries/regions—the United States, for instance—the corresponding figure might look significantly different. However, the general concept of extrapolating historical trends and determining a plausible best-estimate scenario for the long-term gender gap would be the same.

Coherence Between Closely Related Populations

Extrapolations like those in Figure 5 could, in general, be derived for any country separately. In many cases, it's more informative to look at a larger reference population first, e.g., the European total population, and then establish a relation between the reference population and the population of interest. The choice for the reference population obviously depends on the population of interest. For the United States, for instance, you might want to consider the Western industrialized countries.

FIGURE 6: Differences in life expectancies between the male population in selected countries and the European male population

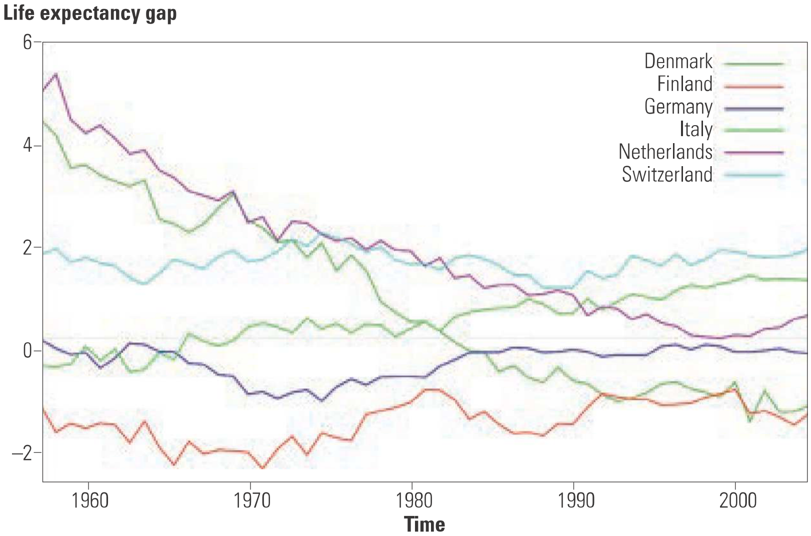

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Figure 6 shows the historical differences between life expectancies for the male populations in selected countries and the total male population. Even though there clearly is a common trend for all populations (see Figure 4), the differences are mostly significant and follow distinctive patterns.

The life expectancy of Swiss males throughout has been longer than the European average life expectancy, with the difference constant at about two years. Thus, the life expectancy trend in Switzerland is the same as in Europe as a whole, just at a higher level. A projection for Swiss males could be derived by simply shifting the European life expectancy projection upward by two years. In the case of Finland, the European life expectancy projection would have to be shifted downward by slightly less than two years for analogous reasons. Dutch males have been close to the European average over the past 10 years, so it would be reasonable to adopt the European life expectancy projection without adjustment.

Of particular interest are Denmark and Italy. Life expectancy in Denmark was about four years above average and is now 1.5 years below—in contrast with Italy, whose life expectancy was below average and is now about one year above. Here, we clearly see the benefit of considering a larger reference population first. Independent trend extrapolations for Denmark and Italy would constantly drive both countries away from the European average (in opposite directions). Such a scenario can hardly serve as a plausible best estimate. For both countries, it would appear more reasonable to assume a long-term trend as for the total population, but shifted downward by 1.5 years or upward by one year, respectively.

For German males, a downward shift by 0.3 years appears to be a reasonable assumption given the rather constant differences between German and European life expectancies from the 1980s onward. This was assumed in deriving period parameters for future years and the projection in Figure 2.

Flexible and Applicable

New projection methodologies are available that can overcome typical shortcomings in existing mortality projections. I outlined key aspects of such a methodology for a particular case, but it's important to note that this methodology can be used to derive projections for basically any population. In contrast with most statistical projection models, it requires some case-specific input beyond the choice of a particular data set. But this makes the proposed methodology very flexible and more applicable generally. It's less convenient than a statistical model in the sense that a projection isn't derived automatically from a given data set. In return, the adequacy of a projection is ensured as part of the derivation process and need not be checked later. □

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Resources

Börger, Matthias and Marie-Christine Aleksic "Coherent Projections of Age, Period, and Cohort Dependent Mortality Improvements," ifaULM, 2014. www.ifa-ulm.de/fileadmin/user_upload/download/forschung/2014_ifa_Boerger-Aleksic_Coherent-Projections-of-Age-Period-and-Cohort-Dependent-Mortality-Improvements.pdf