The cohort effects that never were

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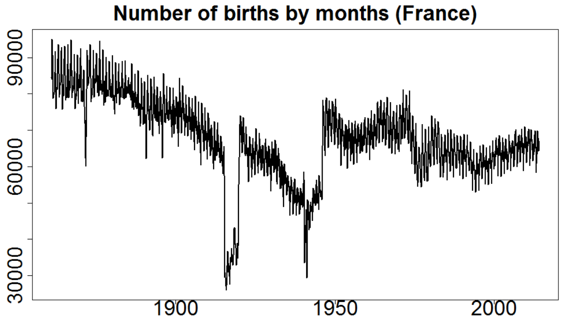
The analysis of cohort effects has long fascinated the actuarial community; these effects correspond to the observation that specific generations can have longevity characteristics different from those of the previous and the following ones. The cohort effects have been incorporated in the forecasts by so-called cohort parameters added to classical stochastic mortality models, such as that of Lee & Carter (1992).

However, Richards (2008) conjectured that these cohort effects might be errors caused by sudden changes in fertility patterns. Figure 1 shows the specific example of France, although the phenomenon is universal. The most significant fluctuations in the monthly birth counts can be seen when birth rates fall dramatically during periods of war, such as World War I, and then spike afterwards.

FIGURE 1: BIRTH SHOCKS

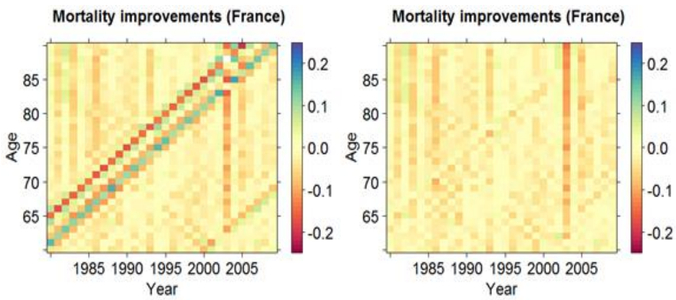


To understand the impact of these fluctuations in births, we must consider the quite different natures of the numerator and the denominator in population mortality rates: for a given year and age, the mortality rate is the ratio of the number of deaths and the so-called exposure-to-risk. The number of deaths at a given age is captured using death certificates, but the exposure-to-risk requires a detailed assessment of the total exposure period during which individuals live a given year with a given age. In the absence of continuous observation of the population, the exposure-to-risk is approximated using annual records extracted from the census. In a sense, the definitions and calculations of “age” differ between the numerator and the denominator. The standard (but erroneous) assumption underlying the calculation is the uniform distribution of births, leading to an approximation of the exposure-to-risk by age as the average between the populations by age at the beginning and at the end of the year. However, Figure 1 shows that this linear approximation used in practice is inexact, and can lead to false cohort effects.

Following Cairns et al. (2016), Boumezoued (2016) highlighted the universal nature of these false cohort effects, which were present in most period tables in the Version 5 of the Human Mortality Database (HMD). The HMD has worked on its own approach to this problem and released a Version 6 update in February 2018, including a revision of exposure calculation based on monthly birth counts when available. Further mathematical developments have been proposed by Boumezoued et al (2018, 2019), who provide improved estimators and a related theory for death-rate inference.

The impact of the correction is shown in Figure 2 (France), which shows the removal of false cohort effects that were previously present in the mortality improvement rates data.

FIGURE 2: IMPROVEMENT RATES FOR FRANCE BEFORE AND AFTER CORRECTION OF EXPOSURE DATA



The correction of national mortality rates, especially for the generations born in periods with high fertility volatility, has implications for actuarial risk assessments. Eliminating apparently false cohort effects changes the level of mortality rates, upward or downward, for the generations considered. If actuaries use general population mortality rates, say for setting mortality-improvement assumption, then these will be affected. For France, the magnitude of these changes is particularly high; the order of relative change can reach up to 6%. But France is not the only country with high-order errors; we see them in the data of England & Wales, Italy, Germany, and the United States, among others. As false cohort effects are eliminated, actuaries need to revisit the models they use to produce forecasts, especially those with a cohort component. Only true cohort effects can be allowed to remain. There are other consequences beyond changes in mortality level - the corrected historical *volatility* of mortality-improvement rates over the last 30 years shows a significant reduction from those based on uncorrected mortality tables, especially at ages over 60. Observed volatility is reduced when artificially high and low levels of mortality are corrected. This will change the calibration of stochastic mortality models, such as those used for value-at-risk assessments under Solvency II.

These changes are likely to create a shift in the paradigm of the classical use of stochastic mortality models. For example, the APCI model of the CMI Bureau includes a cohort component, which aims especially to capture the behavior of the so-called Golden Cohort pattern in the UK, a cohort effect which remains after correction. However, it may also translate diagonal variations from the crude mortality table into deviations in the cohort parameter estimates. A smoothing procedure is also applied when calibrating the model, in the form of a roughness penalty. It is now to be investigated how the cohort parameter estimates are modified using the corrected estimates and to what extent such a smoothing method is required using the new corrected mortality rates. In addition, the ranking of stochastic mortality models based on statistical criteria can be reversed using corrected mortality tables, because the likelihood decreases for mortality models including a cohort component, whereas that of standard age x time mortality models such as Lee & Carter (1992) increases. The cohort effects are indeed less prominent in the new mortality tables. Again, the true cohort effects remain, while the false cohort effects in the form of significant and isolated diagonal patterns disappear.

The revised HMD data is a welcome step forward, but there are consequences for the life-insurance sector and related securitization markets. Actuaries need to use this corrected data and revisit their calculations for mortality and longevity risk. However, existing deals in the securitization markets may have been defined in ways that will continue to use flawed measurements by using the classical death rate estimator. Therefore, the projection of these deals may need to recognize how they will operate, even if we have a better understanding of the underlying reality.

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