# HOW WRONG IS YOUR MORTALITY PROJECTION MODEL?

BY **STUART MCDONALD**

Mortality assumptions are central to the valuation of pension funds and life insurance portfolios. Typically, they comprise two parts:

- Assumptions about mortality rates today
- Assumptions about how mortality rates will change in the future

While the first of these assumptions can often be tackled in a relatively data-driven manner, the second requires significant judgement.

Actuaries typically use mortality projection models to analyse past trends and extrapolate these into the future. Different models can produce materially different forecasts, so it is important that actuaries understand the assumptions that they are making, whether explicitly or implicitly, when they choose and parameterise a particular model.

Models are by necessity a simplification of reality. As the statistician George Box said, 'all models are wrong, but some are useful'. Model risk arises when a model is not fit for purpose and leads to decision-making which is not optimal.

The Netherlands provides an interesting case study to understand the materiality of model risk in respect of mortality projection models. This is because there are two different industry-wide models in use, both produced by well-respected actuarial organisations, which give very different projections.

## PROJECTIONS LIFE TABLE

The Projections Life Table produced by the Koninklijk Actuarieel Genootschap (the Royal Dutch Actuarial Association) is widely used by Dutch pension funds and by primary insurance companies. The latest version of the model, **Projections Life Table AG2024** ('AG2024') was released in September 2024. Its predecessor '**AG2022**' was released in 2022. >

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> George Box

## CMI MORTALITY PROJECTIONS MODEL

The CMI Mortality Projections Model ('CMI model') is produced by the Continuous Mortality Investigation, and has widespread usage in the UK. The core model is calibrated to data for England & Wales, but the model can be calibrated to other populations. This is often the starting point for global reinsurers looking at different markets, and some reinsurers active in the Dutch market use mortality assumptions informed by the CMI model. The latest version of the model , CMI_2023, was released in May 2024.

At the time of writing, the CMI has announced plans to consult on the next version of the model, CMI_2024, which is due to be released in March 2025.

Since there is no 'official' CMI model for the Netherlands, the analysis in this article is based on a calibration of the model produced by the author and colleagues at LCP. Pre-2022 data was obtained from the Human Mortality Database. 2022 and 2023 data are estimated based on provisional data from the Short-term Mortality Fluctuations database.

## COMPARING MODEL FORECASTS

The impact of the different projections on life expectancies varies by age and sex, and also depends on how much weight is placed on 'post-pandemic' data (2022 and 2023) when using the CMI model. Since this is a subjective choice, the charts and table below show the full range of forecasts that can be obtained by varying the weight parameter. No weight is placed on data from 2020 or 2021 to prevent the exceptional mortality from distorting the trend.

*Figure 1* shows that the forecasts for male mortality rates from the AG2022 and AG2024 models are similar to the forecast obtained from the CMI_2023 model when no weight is placed on data for 2022 or 2023. As more weight is placed on 'post-pandemic' data the CMI_2023 model projects slower improvement in mortality. >

FIGURE 1: COMPARISON OF PROJECTED MORTALITY RATES – MALES

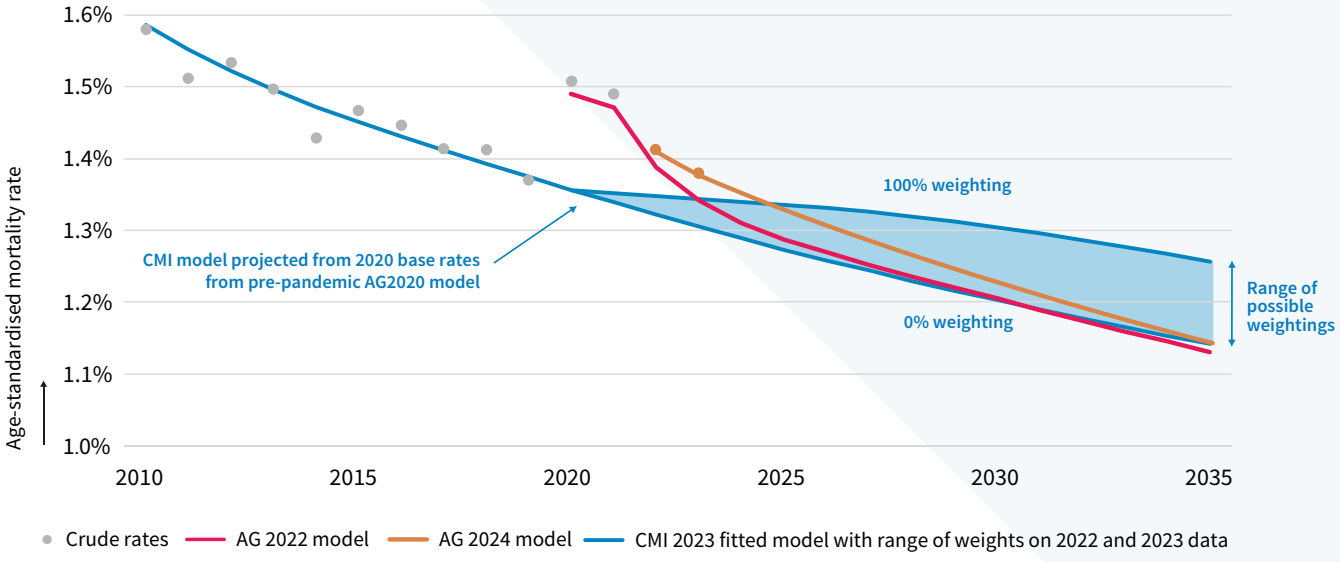

FIGURE 2: COMPARISON OF PROJECTED MORTALITY RATES – FEMALES

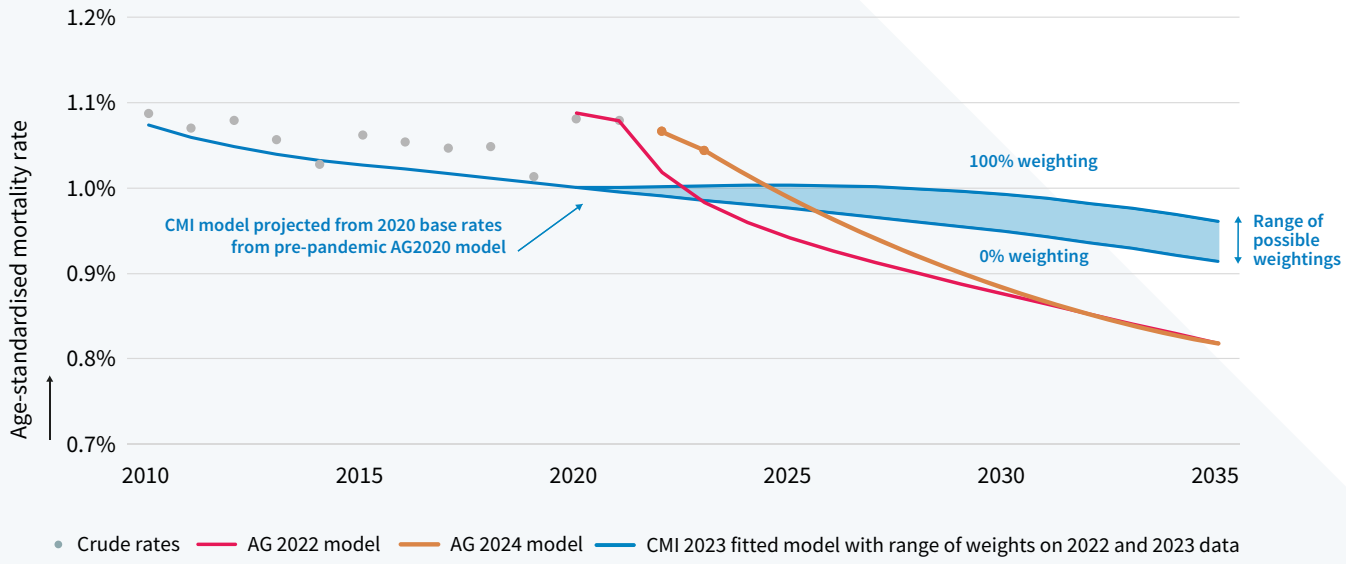


*Figure 2* shows that the forecasts for female mortality rates from the AG2022 and AG2024 models are very different from the forecast obtained from the CMI_2023 model, irrespective of the weight placed on data from 2022 or 2023. The CMI model projects materially slower mortality improvement, and hence higher mortality rates.

*Table 1* sets out the impact of the different mortality projections on life expectancy (cohort life expectancies, which allow for future changes in mortality). For a male aged 65, CMI_2023 produces life expectancies which are between 1.4% and 4.9% lower than the AG2024 model. For a female aged 65 the CMI_2023 life expectancies are between 5.3% and 6.7% lower.

These life expectancy differences illustrate the materiality of the model risk. The differences between the AG and CMI models are far larger than the differences recently seen between successive versions of either the AG model (life expectancies fell by 0.1% for males and 0.2% for females between AG2022 and AG2024) or the CMI model (life expectancies at age 65 fell by 0.4% for males and 0.2% for females between CMI_2022 and CMI_2023).

## UNDERSTANDING THE DIFFERENT MODELS

The explanation for the large difference between the projections is relatively simple.

The AG2024 (and AG2022) projection assumes that excess mortality seen since the Covid-19 pandemic will run off very quickly, with annual improvements in mortality quickly reaching a stable rate for the long-term. This rate varies by age and is based on the trends seen in selected European countries over the previous five decades. It is much higher than the rate of mortality improvement seen >

TABLE 1: COMPARISON OF COHORT LIFE EXPECTANCIES

| Life expectancy (years) in 2024 | AG2024 model | CMI_2023 (no weight on 2022/23 data) | CMI_2023 (full weight on 2022/23 data) |
|---|---|---|---|
| Male; Age 65 | 20.5 | -1.4% | -4.9% |
| Male; Age 80 | 8.7 | +1.7% | -2.1% |
| Female; Age 65 | 23.3 | -5.3% | -6.7% |
| Female; Age 80 | 10.2 | -2.8% | -4.9% |

in the Netherlands since 2010, which has been low, especially for females.

Meanwhile, the CMI_2023 model calibration assumes that the lacklustre improvements in mortality seen in the Netherlands since 2010 will continue in the near term, trending only slowly up to a higher long-term rate of improvement. This is specified by the user of the CMI model and again varies by age. For this analysis the long-term rate has been chosen so as to be appropriate for the Netherlands. It is similar to the rate in the AG model and is not driving difference between the model forecasts.

Part of the explanation for the different forecasts is that the CMI model identifies that the birth cohort who have recently reached retirement age have historically experienced lower mortality improvements, and projects that this pattern will continue in the future.

*Figure 3* shows the heatmap of historical and projected mortality improvements for the Netherlands from the CMI_2023 model calibration. A positive number shows improving mortality.
The equivalent charts for the AG model show much less variation in projected mortality improvement by age and calendar year, and include no variation by year of birth.

## ALTERNATIVES TO EXTRAPOLATION

While there are strengths and limitations to both the AG and CMI models, they are both extrapolative models (at least over the short to medium term).

Extrapolative models can work well during periods when patterns are relatively stable but perform less well when there are sustained periods of higher and lower mortality improvement (for example the Netherlands saw strong mortality improvements in the 2000s and much weaker improvements in the 2010s). They also do not cope well with recent extreme outliers, as produced by the Covid-19 pandemic.

This is seen in the very different forecasts produced by the two models analysed here.

An alternative approach to forecasting short to medium term mortality improvement is to seek to understand what is driving mortality rates, in aggregate and for major causes of death. Actuarial forecasts can be improved with multi-disciplinary expert input from health professionals, epidemiologists and public health experts, which should include representation from the country in question.

One way to do this in practice is a Structed Delphi process – an iterative forecasting method that relies on a panel of experts, surveyed individually, with results discussed as a group. The results of such a process for the Netherlands have been invaluable for understanding recent mortality patterns and can help us to assess which of the actuarial forecasts is likely to be 'least wrong'. <

FIGURE 3: HEAT MAP OF CMI_2023 MORTALITY IMPROVEMENTS