MALTA FINANCIAL SERVICES AUTHORITY

Annex I – Statistical Model Background Information on the Drawdown Rates

ANNEX I

Scope and definitions

1. This document provides an overview of the statistical analysis carried out (using R) by the MFSA for the purpose of deriving the maximum pension drawdown rates for personal or occupational retirement products offered by life Insurance companies authorised under the Insurance Business Act hereinafter ''the Act'' to carry on long term business of insurance and retirement provision business and hereinafter referred to as ''Authorised Insurance Undertakings'' in Malta, as listed in the document 'Instructions and Drawdown Rates MFSA'. Based on the details provided in this document a trained user should be able to (closely) replicate the listed rates.

Data provided and amended for model input purposes

2. Past mortality rates that serve as input for mortality rate projections have been based on data provided by the Malta National Statistics Office for the period 2001-2020:

Population_Mortality 2001_2020.xlsx

3. Deaths and (mid-year) exposure levels have been provided by NSO for each calendar year, split by age and gender. No exclusions have been applied for the non-native population. As drawdown rates are gender-uniform, no split has been made in the analysis by gender. Due to the small sample for Malta, the MFSA has grouped ages together for statistical analysis purposes (0 deaths for a particular cohort may distort results). The following data file with grouped data has been used as input for the statistical analysis:

Input Data used for Statistical Model Estin

Statistical Estimation Model

4. The MFSA has used the Lee Carter model to model mortality rates varying by age and over time, with the ultimate aim to forecast mortality rates and life expectancy for the Maltese population.

5. The Lee Carter model can be presented as follows:

$$ln(m_{xt}) = a_x + b_x * k_t + \varepsilon_t$$

(a) with restrictions such that the b_x's are normalized to sum to one and the k_t's sum to zero, so the a_x's are average log rates. m_{xt} represents the mortality rate, a_x and b_x are age-dependent parameters, k_t is the time dependent parameter and e_{xt} represent 'error terms'. The vector a_x can be interpreted as an average age profile of mortality, the vector k_t tracks mortality changes over time, and the vector b_x determines how much each age group changes when k_t changes. When k_t is linear on time each age group changes at its own exponential rate, but this is **not** strictly a requirement of the model. The error term reflects age-period effects not captured by the model.

(b) Key of the model is that the age and time parameter are 'decoupled' as part of the estimation process.

(c) The assumption of k_t being linear is often reasonable, implying that gains to life expectancy are fairly constant year after year in most populations. Because of the linearity of k_t, it is generally modelled as a random walk with trend. As will be demonstrated below, the linearity assumption of k_t does indeed appear to be reasonable for this particular case study, rendering this statistical model an appropriate choice in the MFSA's view to forecast future mortality rates.

Statistical analysis results

6. The MFSA has analysed the data both with and without any adjustments for the Covid-affected calendar year 2020.

Results without corrections

7. When the data is used without adjustments, the statistical model estimation results in the following estimations for the parameter k_t of the model (as stated above the k_t parameters sum to 1):

8. Due to the relatively small sample size for Malta (especially for lower ages), the value of k_t estimated for years 2001-2020 exhibits some 'jumpy' behaviour, but a linear model does overall not appear unreasonable. As expected, calendar year 2020 results in a higher value of k_t, which directly reflects the influence of Covid-19 on mortality during this calendar year.

9. The MFSA has calculated drawdown rates based on the above, however, it has ultimately not opted to use the final results from this analysis, in view of the results being dominated in two ways by the outlier year 2020:

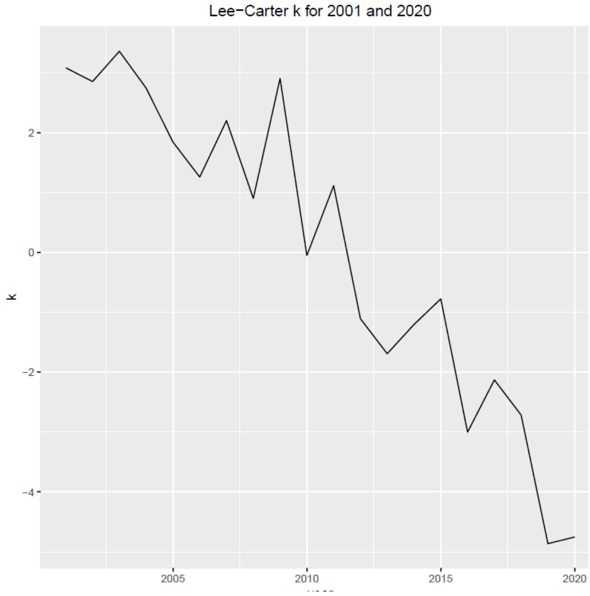
- Inclusion of this year obviously heavily influences the overall downward trend of the k-parameter.

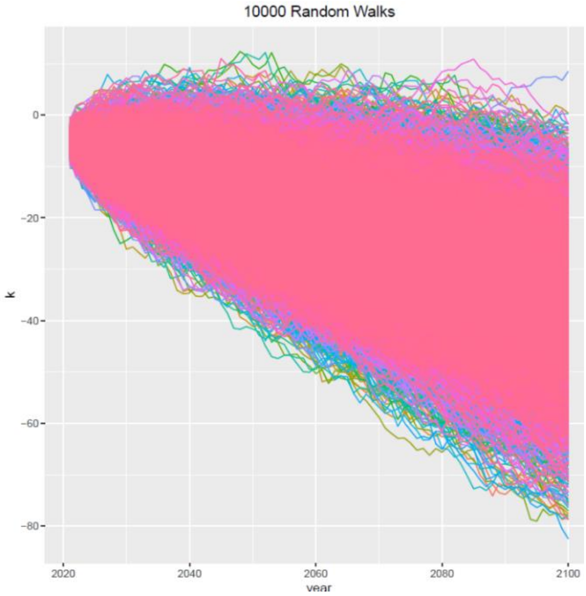
- As the random walk with trend takes as its starting point for the forecast the value for the final data year 2020, the *starting point* for the estimation process is *also* 'inflated' by the outlier element.

10. Obviously, it cannot be stated with certainty whether the year 2020 should be considered an outlier, or whether further pandemics (or other elements affecting mortality) may occur more frequently in the coming decades. In the MFSA's view, based on current evidence, disregarding the pandemic year 2020 will result in more realistic future mortality rates. It should be kept in mind that basing drawdown rates on a higher estimated level of mortality would increase the risks of depleting the retirement product early and not serving its purpose as a fund providing a retirement benefit during the final years of the policyholder, so there is also an element of prudence involved in this consideration.

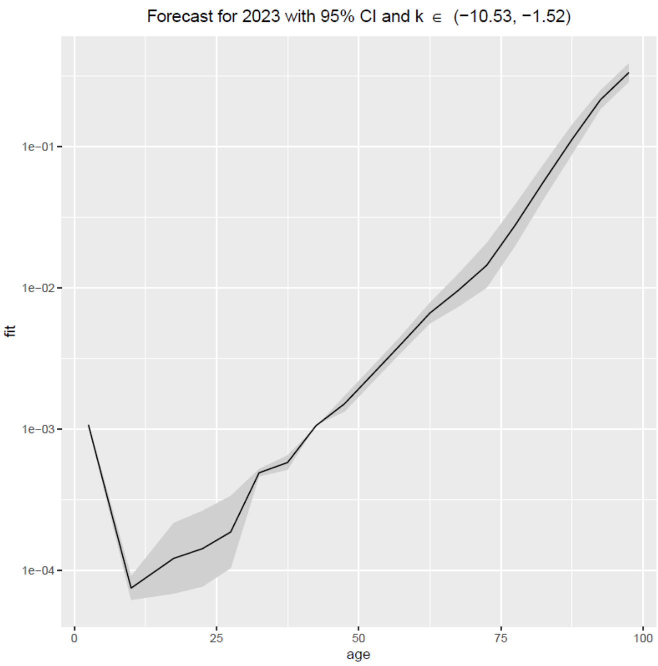
Results with 2020-correction

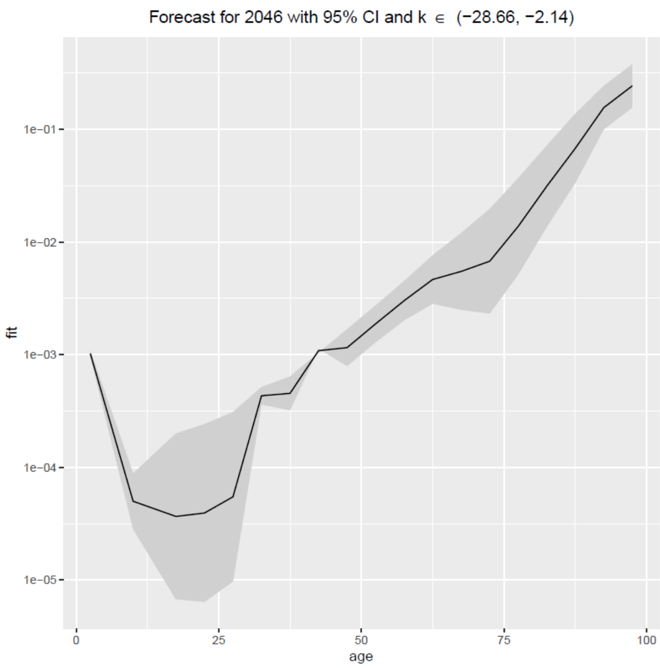
11. In the results used for the derivation of the listed drawdown rates, the MFSA has effectively removed the Covid-19 affected year (in practice the MFSA has replaced rates for 2020 by a linear interpolation of the rates of 2001-2019). This results in the graph for *k* below. When the k-factor is subsequently forecasted based on a random walk with trend, the following graph depicts results based on 10,000 random walks:





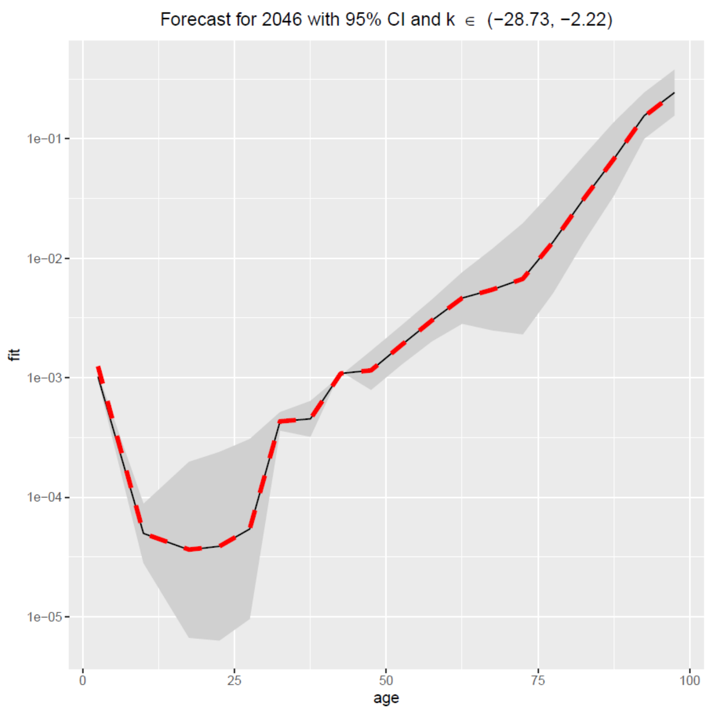
12. Based on the error-term of the random walk, the uncertainty will naturally increase for projections further into the future. The following graph shows the 95% confidence band around the projected mortality rates for 2023 and 2046:





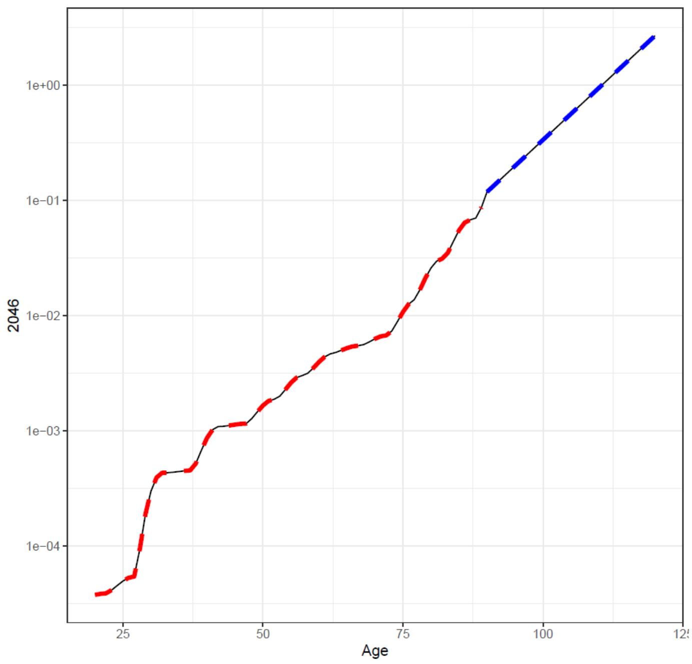
13. The MFSA has estimated bands based on the 60th percentile, 70th percentile and 95th percentile to obtain an idea regarding uncertainty of the forecasted rates but has ultimately opted not to use any margin in the mortality used for the drawdown rates and has based the rates on a best estimate assessment.

14. It should be noted above that the results do not take a smooth shape due to the 'age-grouping' that needed to be applied in the initial phase of the estimation process in order for the statistical model to work properly. In the final stage of the estimation process, this grouping step needs to be 'reversed', as for the derivation of the drawdown rates, single age mortality rates are required. The MFSA has applied the 'Loess' fitting method to obtain a smooth estimate of a curve going through a set of data points (model-free estimation method). The smoothness can be adjusted based on the 'span' parameter of the model. For span parameter 0.8 this results in the following 'curve for all ages for 2046 (red dotted line):



15. This shows that the fitted results for all ages fall well within the 95th percentile band and present a somewhat smoothed versions based on the grouped results.

16. For ages of 98 and higher, mortality rates have been exponentially extrapolated based on the pattern for ages 87-97 for all calendar years.



17. The resulting projected mortality data has finally been used to derive the applicable drawdown rates. For a person aged 61, the applicable drawdown rates are based on:

- the estimated mortality rate for a 61-year old in 2021
- the estimated mortality rate for a 62-year old in 2022 etc.