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On Basis Risk in Extreme Mortality CAT Bonds

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In this paper, we propose a method to measure basis risk of extreme mortality CAT bonds. We present this method through a fictitious extreme mortality CAT bond. This fictitious bond's final payoff is determined by comparing US population mortality index at maturity with the same index at issuance. However, the bond issuer's true mortality experience is reflected by England and Wales population mortality index.

To study the basis risk of this mortality CAT bond, we first calibrate the celebrated Lee-Carter model on US population mortality index and England and Wales population mortality index. For each population, by singular value decomposition we obtain a time series of kt, the mortality factor. We apply a heavy-tailed ARIMA(1,1,0) process with drift individually on each of the two series of kt. The innovations of our modeling are twofold:

The noises in the ARIMA(1,1,0) processes follow symmetric α-stable distribution with $\alpha \in (0,2)$. This assumption is based on findings on the extreme value index of the residual's distributions.

The dependence structure between the two series of kt is described via a copula of their bivariate noise vector. We follow the method proposed by Genest and Rivest (1993) to find an appropriate Archimedean copula, which well fits the data.

Finally, we generate Monte Carlo simulations for the marginals and copula of the noise vector, which will be used to predict mortality indices and calculate expected bond payoffs. Since default of the bond is a rare event, proper importance sampling method is used in the Monte Carlo simulation for the copula to reduce variance. We propose the relatively expected payoff given default (REPD) to measure the basis risk:

E (final payoff by EW index default occurs by EW index)
REPD = E (final payoff by US index default occurs by EW index).

We consider the case with REPD = 1 as neutral, i.e. there is no basis risk. For a bond with REPD larger than 1, there exists basis risk. The higher the REPD is, the larger basis risk the bond has.