# Mortality Models and Longevity Risk for Small Populations

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## Abstract

Prolonging life expectancy and improving mortality rates is a common trend of the 21st century. Lee-Carter model (Lee and Carter, 1992) and other stochastic models are a popular choice to deal with longevity risk. However, these mortality models often have unsatisfactory results for the case of small populations. Thus, quite a few modifications (such as approximation and maximal likelihood estimation) to the Lee-Carter can be used for the case of small populations or missing observations. In this study, we propose an alternative approach (graduation methods) to improve the performance of stochastic models.

The graduation methods considered are Whittaker method and partial standard mortality ratio (Lee, 2003), and they are applied to stabilize the model fit of mortality models. We first evaluate whether these methods can improve the parameter estimates of Lee-Carter model, following by comparing them to the coherent modification (Li and Lee, 2005). The comparisons are based on the computer simulations, as well as empirical data analysis (i.e., cross-validation or backcasting). Later, we apply the proposed approach, Lee-Carter model, and its coherent modification to annuity products. We found that the proposed approach has the smallest variance and best prediction accuracy.

Keywords: Longevity Risk, Small Area Estimation, Lee-Carter Model, Standard Mortality Ratio, Coherence

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