Calibrating the Lee-Carter and the Poisson Lee-Carter models via Neural Networks

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Abstract

In recent decades, the mortality of most developed countries was gradually declining as a result of improvements in public health, medical advances, lifestyle changes and government regulation. Although it is an obvious benefit for society, this longevity improvement could also represent a risk for governments and insurance companies. Indeed, if they do not properly consider these improvements in retirement planning and the life insurance products' pricing, they could get in financial trouble. The risk that future mortality and life expectancy outcomes turn out different than expected is typically called *longevity risk* and, as pointed out in [1], its management requires stochastic mortality projection models. In this vein, a number of stochastic mortality models were developed.
One of the first stochastic models describing the mortality of a single population was proposed by Lee and Carter (LC) [4]. Their model decomposes the age-time matrix of mortality rates into a bilinear combination of age and period parameters using the Principal Component Analysis (PCA), and forecasting is performed by projecting the time-index component into the future with time-series models. Numerous extensions of the LC model have been developed and proposed in the literature. For example, [2] embedded the LC model into a Poisson regression setting to overcome the homoskedastic error structure assumed into the original LC method.
This paper introduces a neural network approach for fitting the Lee-Carter and the Poisson Lee-Carter model on multiple populations. Although neural networks' application to mortality modelling is quite recent, the scientific contributions are increasing in number and intensity, see [3, 6, 5]. We propose a parsimonious neural network architecture specifically designed to calibrate each individual LC using all available information instead of using a population-specific subset of data as in the traditional estimation schemes. Some cross-population parameters encourage the information propagation among the individual model and produce estimates less sensitive to the random fluctuations often present in mortality rates' data. Furthermore, the neural network architectures developed present very few parameters to optimise and are easy to interpret. These features could encourage the use of neural networks in mortality modelling also by practitioners who are wary of the use of complex and hard-to-interpret models even if they have high predictive power. A large set of numerical experiments performed on all

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the countries of the Human Mortality Database (HMD) show that the forecasting performance results significantly improved as well.

Keywords: Mortality modelling, Multi-population mortality modelling, neural networks, Lee–Carter model, Human Mortality Database.

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