Dynamic modeling of the age-at-death distribution via mixtures of skewed distribution functions

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Abstract

There has been growing interest in modeling and predicting mortality for multiple countries. In this work, we focus on modeling and forecasting the age-at-death distribution for multiple European countries, relying on a novel Bayesian model encompassing multiple populations jointly. Although most methods focus on single-population modeling, we illustrate that this abundance of information can be appropriately included into the demographic model to improve the quality of the estimates for country-specific mortality and their evolution, allowing to share information across different nations and automatically leading to coherent predictions. We rely on a model based on a mixture density function of three components: a Dirac mass, a Gaussian distribution, and a Skew-Normal distribution. These components characterize the shape of infant, adult and old-age mortality, respectively, accounting for their relative weight in the overall shape of the age-at-death distribution. Following a Bayesian approach to inference, the proposed model allows to borrow information between populations and to shrink parameters toward a common mean, providing coherent estimates that do not diverge radically across countries. Dynamic modeling across multiple years is induced by an hierarchical dynamic prior distribution that simplifies the characterization of the temporal evolution of each component of mortality, allowing to predict the age-at-death distribution via recursive extrapolations, characterizing uncertainty. Empirical results across multiple European countries indicate that the proposed approach provides estimates and forecasts for the age-at-death distribution that outperform popular methods for predicting mortality (such as the milestone Lee-Carter and Lee-Li models), without increasing complexity in terms of interpretation of the results. In addition, post-processing the posterior distribution for the model parameters we provide estimates and predictions for any relevant functional characterizing mortality - such as the death rates at different ages or life expectancy at birth - accounting for the uncertainty in such estimates.