Climate change, mortality risk and machine learning

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Abstract

In their recent paper [1], Li and Tang investigate tail dependencies between temperature and mortality using multivariate extreme value theory. We are cooperating with the authors to apply their techniques in the context of life insurance risk modelling. Indeed, with typical life insurance projection models operating over horizons of at least 40 years, actuaries have no excuse to leave the impact of climate change out of scope of these models.

We begin by looking at historical climate and mortality data available from the UK Met Office and the UK Office for National Statistics and discuss which climate variables beyond temperature are relevant for our purposes. For example, we discuss the importance of humidity since the relevance of this variable has been demonstrated in [2]. Our next step is to determine the spatial and temporal resolution of our historical data?for example, do we use a country average temperature series, or do we require more granular climate data to factor in smaller scale climate features?

Perhaps not surprisingly, raw climate and mortality data mentioned above cannot be directly used for modelling purposes. For example, historical UK weather data are available for around 200 weather stations scattered around the country, the data format is not uniform, and some data points are missing. Raw data on death counts also presents us with a few challenges. For example, we need data split by age groups and regions, yet data protection legislation GDPR prevents the UK Office for National Statistics from sharing the data in the granularity ideal for our research purposes. Having highlighted data challenges, we proceed by discussing how machine learning techniques can help us enhance historical data, making it more amenable for our purposes. We start with simple imputation methods such as generalized linear models and k-nearest neighbors before moving on to more complex methods such as neural networks and kriging.

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After obtaining the historical climate series and mortality data, we proceed towards reviewing several approaches to mortality risk calibration, starting with the classical ones such as Lee-Carter and moving on to more advanced models.

Having established the relationship between climate variables and mortality risk, we set out to explore ways of estimating future mortality by leveraging climate models known from Earth science. Climate models help us understand future changes to our climate and are based on physical principles that are well understood. We briefly discuss different types of climate models following [3] and how their results can be used to project climate variables into the future. For example, we can obtain a daily average temperature series under the 'business as usual' emission scenario. This is where machine learning techniques are relevant again as these can help us reduce model bias.

Having established the relationship between climate variables and mortality risk and having projected climate variables into the future we are set to take the final step of the process, i.e., estimating future mortality risk. Bringing it all together in our 'traditional' actuarial cashflow models allows us to quantify the impact of climate change on life insurance businesses, e.g., annuities.

Keywords: Climate change; Mortality risk; Extreme value theory; Machine learning

References

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