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A Spatial Approach to Model Mortality Rates

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Abstract : Human longevity has been experiencing its largest increase since the end of World War II, and modeling the mortality rates is therefore often the focus of many studies. Among all mortality models, the Lee–Carter model is the most popular approach since it is fairly easy to use and has good accuracy in predicting mortality rates (e.g., for Japan and the USA). However, empirical studies from several countries have shown that the age parameters of the Lee–Carter model are not constant in time. Many modifications of the Lee–Carter model have been proposed to deal with this problem, including adding an extra cohort effect and adding another period effect. In this study, we propose a spatial modification and use clusters to explain why the age parameters of the Lee–Carter model are not constant. In spatial analysis, clusters are areas with unusually high or low mortality rates than their neighbors, where the "location" of mortality rates is measured by age and time, that is, a 2-dimensional coordinate. We use a popular cluster detection method—Spatial scan statistics, a local statistical test based on the likelihood ratio test to evaluate where there are locations with mortality rates that cannot be described well by the Lee–Carter model. We first use computer simulation to demonstrate that the cluster effect is a possible source causing the problem of the age parameters not being constant. Next, we show that adding the cluster effect can solve the non-constant problem. We also apply the proposed approach to mortality data from Japan, France, the USA, and Taiwan. The empirical results show that our approach has better-fitting results and smaller mean absolute percentage errors than the Lee–Carter model.

Keywords : mortality improvement, Lee–Carter model, spatial statistics, cluster detection
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