Improving Longevity and Mortality Risk Models using Common Stochastic Long Run Trends

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Abstract

Longevity and mortality improvement has been driven by many factors over the last century. There have been systematic changes in causes of death and these have been common across the developing economies. At the same time, the factors have impacted different ages resulting in dependence in improvements across age groups. As a result, longevity and mortality risk across countries and within a country across ages contains common stochastic trends. In order to improve models of longevity and mortality risk, it is important to incorporate these common trends in models used for risk management. Vector Error Correction Models (VECM) have been developed in econometrics to model multivariate dynamic systems including time dependency between economic variables. They incorporate common stochastic trends that exist between the variables, along with a long-run equilibrium relationship.

In this paper, VECM models are developed for causes of death and age based risk factors. Causes of death reflect underlying socio-economic factors and provide important insights into longevity and mortality modeling. Despite this, there is limited use of causes of death forecasting in mortality risk modeling. The assumption is usually made that causes of death are independent when they are considered. We analyze the five main causes of death across nine major countries. Our analysis shows that long-run equilibrium relationships exist between the five main causes of death, improving understanding of the dependence between these competing risks. Similarities between the countries under study are observed, with groups of countries having similar experience.

Projecting mortality within a country must take into account dependencies across age groups. Empirical evidence shows that multiple factors have driven changes in mortality rates and that these factors have impacted different ages to varying extents. In order to capture this age dependence of cause-specific mortality rates, a parameterized mortality function, the Heligman-Pollard function, is used in place of the highly parameterized Lee-Carter model. This is estimated using data over a period of 50 years. The parameters have interpretation as factors impacting specific age ranges. The parameters are modeled as stochastic factors using a VECM, taking into account time dependency and long run trends between the parameters not allowed for using more traditional ARIMA processes. The VECM approach is a significant improvement over ARIMA models allowing a more realistic quantification of risk including parameter risk.