Grouped Multivariate and Functional Time Series Forecasting: An Application to Annuity Pricing

Han Lin Shang

Research School of Finance, Actuarial Studies and Statistics, Australian National University

Steven Haberman

Cass Business School, City, University of London

GROUPED MULTIVARIATE AND FUNCTIONAL TIME SERIES FORECASTING:
AN APPLICATION TO ANNUITY PRICING

Han Lin Shang* and Steven Haberman

Abstract

Age-specific mortality rates are often disaggregated by different attributes, such as sex, state, ethnic group and socioeconomic status. In making social policies and pricing annuities at national and sub-national levels, not only is it important to forecast mortality accurately, but also, forecasts at sub-national levels should add up to the forecasts at the national level. This motivates recent developments of grouped functional time series methods (Shang, Han and Rob Hyndman., 2017) to reconcile age-specific mortality forecasts. We extend these grouped functional time series forecasting methods to multivariate time series and apply them to produce point forecasts of mortality rates at older ages, from which fixed-term annuities for different ages and maturities can be priced. Using the regional age-specific mortality rates in Japan obtained from the Japanese Mortality Database, we investigate the one-step-ahead to 15-step-ahead point forecast accuracy between the independent and grouped forecasting methods. The grouped forecasting methods are shown not only to be useful for reconciling forecasts of age-specific mortality rates at national and sub-national levels, but also to enjoy improved forecast accuracy. The improved forecast accuracy of mortality rates would be of great interest to the insurance and pension industries for estimating annuity prices, in particular at the level of population subgroups defined by key factors such as gender, region and socioeconomic grouping.

Keywords: forecast reconciliation; hierarchical time series; bottom-up method; optimal combination method; Lee-Carter method; Japanese Mortality Database.

*Corresponding author. Address: Research School of Finance, Actuarial Studies and Statistics, Level 4, Building 26C, Australian National University, Kingsley Street, Canberra, ACT 2601, Australia; Telephone: +61(2) 612 50535; Fax: +61(2) 612 50087; Email: hanlin.shang@anu.edu.au.