Mavros, George; **Cairns, Andrew J. G.**; **Streftaris, George**; **Kleinow, Torsten**
Stochastic mortality modeling: key drivers and dependent residuals. (English) Zbl 1414.91219
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Summary: This article proposes an alternative framework for modeling the stochastic dynamics of mortality rates. A simple age basis combined with two stochastic period factors is used to explain the key mortality drivers, while the remaining structure is modeled via a multivariate autoregressive residuals model. The latter captures the stationary mortality dynamics and introduces dependencies between adjacent age-period cells of the mortality matrix that, among other things, can be structured to capture cohort effects in a transparent manner and incorporate across ages correlations in a natural way. Our approach is compared with models with and without a univariate cohort process. The age- and period-related latent states of the mortality basis are more robust when the residuals surface is modeled via the multivariate time-series model, implying that the process indeed acts independently of the assumed mortality basis. Under the Bayesian paradigm, the posterior distribution of the models is considered to explore coherently the extent of parameter uncertainty. Samples from the posterior predictive distribution are used to project mortality, and an in-depth sensitivity analysis is conducted. The methodology is easily extendable in multiple ways that give a different form and degree of significance to the different components of mortality dynamics.

MSC:

91B30 Risk theory, insurance (MSC2010)
62P05 Applications of statistics to actuarial sciences and financial mathematics

Keywords:

stochastic mortality rates; multivariate autoregressive residuals model

Software:

WinBUGS; BayesDA

Full Text: DOI

References:

[1] Booth, H.; Maindonald, J.; Smith, L., Applying Lee–Carter under Conditions of Variable Mortality Decline, Population Studies, 56, 325-336, (2002)

[2] Brouhns, N.; Denuit, M.; Van Keilegom, I., Bootstrapping the Poisson Log-Bilinear Model for Mortality Forecasting, Scandinavian Actuarial Journal, 2005, 212-224, (2005) · Zbl 1092.91038

[3] Brouhns, N.; Denuit, M.; Vermunt, J. K., A Poisson Log–Bilinear Regression Approach to the Construction of Projected Life–Tables, Insurance: Mathematics and Economics, 31, 373-393, (2002) · Zbl 1074.62524

[4] Cairns, A. J. G.; Blake, D.; Dowd, K., A Two–Factor Model for Stochastic Mortality with Parameter Uncertainty: Theory and Calibration, Journal of Risk and Insurance, 73, 687-718, (2006)

[5] Cairns, A. J. G.; Blake, D.; Dowd, K.; Coughlan, G. D.; Epstein, D.; Khalaf-Allah, M., Mortality Density Forecasts: An Analysis of Six Stochastic Mortality Models, Insurance: Mathematics and Economics, 48, 355-367, (2011)

[6] Cairns, A. J. G.; Blake, D.; Dowd, K.; Coughlan, G. D.; Epstein, D.; Ong, A.; Balevich, I., A Quantitative Comparison of Stochastic Mortality Models using Data from England and Wales and the United States, North American Actuarial Journal, 13, 1-35, (2009)

[7] Czado, C.; Delwarde, A.; Denuit, M., Bayesian Poisson Log–Bilinear Mortality Projections, Insurance: Mathematics and Economics, 36, 260-284, (2005) · Zbl 1110.62142

[8] D'Amato, V.; Haberman, S.; Piscopo, G.; Russolillo, M., Modelling Dependent Data for Longevity Projections, Insurance: Mathematics and Economics, 51, 694-701, (2012) · Zbl 1285.91054

[9] Debón, A.; Martínez-Ruiz, F.; Montes, F., A Geostatistical Approach for Dynamic Life Tables: The Effect of Mortality on Remaining Lifetime and Annuities, Insurance: Mathematics and Economics, 47, 327-336, (2010) · Zbl 1231.91173

[10] Debón, A.; Montes, F.; Mateu, J.; Porcu, E.; Bevilacqua, M., Modelling Residuals Dependence in Dynamic Life Tables: A Geostatistical Approach, Computational Statistics & Data Analysis, 52, 3128-3147, (2008) · Zbl 1452.62760

[11] Gamerman, D.; Lopes, H. F., Markov chain Monte Carlo: Stochastic Simulation for Bayesian Inference", (2006), Boca Raton, FL: CRC Press, Boca Raton, FL · Zbl 1137.62011

[12] Gelfand, A. E.; Sahu, S. K., Identifiability, Improper Priors, and Gibbs Sampling for Generalized Linear Models, Journal of the American Statistical Association, 94, 247-253, (1999) · Zbl 1072.62611

[13] Gelman, A.; Carlin, J. B.; Stern, H. S.; Rubin, D. B., Bayesian Data Analysis, (2003), Boca Raton, FL: CRC press, Boca Raton, FL

[14] Haberman, S.; Renshaw, A., A Comparative Study of Parametric Mortality Projection Models, Insurance: Mathematics and Economics, 48, 35-55, (2011)

[15] Lee, R. D.; Carter, L. R., Modeling and Forecasting US Mortality, Journal of the American statistical association, 87, 659-671, (1992) · Zbl 1351.62186

[16] Lütkepohl, H., New Introduction to Multiple Time Series Analysis, (2005), Cambridge: Cambridge University Press, Cambridge · Zbl 1072.62075

[17] Ntzoufras, I., Bayesian Modeling Using WinBUGS, (2009), Hoboken, NJ: Wiley, Hoboken, NJ · Zbl 1218.62015

[18] Pedroza, C., A Bayesian Forecasting Model: Predicting US Male Mortality, Biostatistics, 7, 530-550, (2006) · Zbl 1170.62397

[19] Plat, R., On stochastic mortality modeling, Insurance: Mathematics and Economics, 45, 393-404, (2009) · Zbl 1231.91227

[20] Renshaw, A. E.; Haberman, S., Lee–Carter Mortality Forecasting with Age–Specific Enhancement, Insurance: Mathematics and Economics, 33, 255-272, (2003) · Zbl 1103.91371

[21] Renshaw, A. E.; Haberman, S., A Cohort–Based Extension to the Lee–Carter Model for Mortality Reduction Factors, Insurance: Mathematics and Economics, 38, 556-570, (2006) · Zbl 1168.91418