Measuring and Hedging the Basis Risk by Functional Data Models

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Abstract

Actually the longevity phenomenon is a relevant aspect for insurance companies which are obliged to quantify the impact of uncertainty of mortality trend on products issued, in order to manage the risk derived from it. In fact, the problem of ex post possible systematic deviations of observed death rates and survival hypothesis from ex ante projections made by insurance companies - longevity risk - can seriously damages the safe and careful management.

Recently, significant tools have been developed for transferring longevity risk to the capital markets, bringing additional capacity, flexibility and transparency to complement existing insurance solutions (Coughlan et al. 2011).

In particular, hedging longevity risk with index-based longevity hedges can have several advantages, as widely shown in literature (for instance in Blake et al. 2006, Coughlan et al 2009b).

Nevertheless, the difference between the insurer’s mortality experience based on annuitant mortality, and the hedged standardized index based on reference population mortality gives rise to the so-called basis risk (Ngai and Sherris 2011). It exists due to, e.g., differing profiles of socioeconomic groups, lifestyle and geography.

The presence of basis risk means that hedge effectiveness will not be perfect and that, post implementation, the hedged position will still have some residual risk. Several authors have explored the basis risk between populations associated with annuity portfolios and life insurance portfolios. Cox and Lin (2007) found empirical evidence of a (partial) natural hedge operating between such portfolios, implying that the basis risk between them is relatively small. Coughlan et al. (2007a) provided a calculation of the risk reduction between hypothetical annuity and life insurance portfolios using historical mortality experience data: the results suggest significant benefits in terms of reduction in risk and economic capital. Sweeting (2007) explored the basis risk associated with longevity swaps in a more qualitative fashion but draws similar conclusions.

The present paper seeks to contribute to that literature by setting out a framework for quantifying the basis risk. In particular we propose a model that measure the population basis risk involved in a longevity hedge, in the functional demographic model (FDM) setting. The literature (Hyndman and Ullah 2007) suggests that the FDM forecast accuracy is arguably connected to the model structure, combining functional data analysis, nonparametric smoothing and robust statistics. In particular, the decomposition of the fitted curve via basis functions represents the advantage, since they capture the variability of the mortality trend, by separating out the effects of several orthogonal components.

In particular, while most existing models are designed for a single population the research objective is to model mortality of two populations, (Li and Hardy 2011) in order to align with the hedging purpose. Finally, longevity hedging strategies are developed by involving mortality-linked securities.