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Swiss coherent mortality model as a basis for developing longevity de-risking solutions for Swiss pension funds: A practical approach

Cheng Wan [a,*], Ljudmila Bertschi [b,c]

[a] Towers Watson Research and Innovation Center, Youkeyuan Road 88, 430074, Wuhan, China

[b] SAV, Swiss certified pension actuary, Switzerland

[c] Towers Watson AG, Talstrasse 62, 8021 Zurich, Switzerland

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ABSTRACT

Pension funds in Switzerland are exposed to longevity risk possibly to a greater extent than in many other developed economies. The ground for this is a dearth of financial products to combat longevity risk, with a lack of buy-in and very limited variety of buy-out solutions available. The solutions that do exist frequently come at a very high price and many pension funds are in deficit on a buy-out basis. From our point of view creating an approach for evaluating the longevity risk faced by each pension fund and integrating it into dynamic risk budgeting strategies will help Swiss pension funds better understand the mechanism behind different longevity de-risking solutions and decide on the most suitable as well as affordable solution for them. To develop capital market solutions for longevity hedging strategies it is crucial that both hedgers (pension funds) as well as solution providers are able to quantify the longevity risk in the framework of a holistic risk management and to develop an adequate pricing approach.

In this publication we present our stochastic coherent mortality model developed for Swiss pension funds based on the reference population of fifteen countries and discuss the robustness of the forecasts relative to the sample period used to fit the model, biological reasonableness of the forecasts and other modelling parameters as well as possible impact on results. The model has taken into account past single population modelling techniques and allows flexible age effect to capture the spread behaviour introduced by the target population. The augmented terms for the spread function are chosen based on their forecast accuracy and a coherent behaviour is expected in the long term. The idea behind is fairly simple and yields a design with both transparency and robustness. The model usage is not limited to Switzerland.

1. Introduction

In recent years, longevity risk has become an important topic in developed countries. Many studies have shown that human beings are living substantially longer than anticipated. The life expectancy increases at a rate ranging from 1 to 5 months every year according to different estimates during the last century (Longevity Risk, edited by McWilliam, 2011). There is no sign that the improvements in longevity are going to stop. Consider enormous financial impacts of increasing life expectancy on the first and second pillars, it is no surprise that mortality modelling has attracted an increased attention.

As regards mortality modelling, one is referred to the Pension Institute working paper by Hunt and Blake (2013) and the book by Pitacco et al. (2009) for a comprehensive understanding. Cairns et al. (2009, 2011a) gave a quantitative comparison and discussion of commonly used mortality models such as the Lee and Carter model (1992), the Age–Period–Cohort (APC) model (Currie, 2006) and the Cairns–Blake–Dowd (CBD) models.

One of the current model interests rests at problems of multi-population modelling; Li and Lee (2005) applied the Lee–Carter model to a group population and tested if common factors can be employed to facilitate single population modelling. Dowd et al. (2011) proposed a gravity model for two populations with coherency degree tuned by a so-called gravity parameter. Cairns et al. (2011b) introduced joint mortality modelling for two populations under a Bayesian framework. Jarner and Kryger (2011) developed the SAINT model with application to Danish data with reference to a large international population, and this technique has already

* Corresponding author.
E-mail addresses: cheng.wan@towerswatson.com (C. Wan), ljudmila.bertschi@towerswatson.com (L. Bertschi).

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been used by ATP pension funds for reserving purposes and dynamic risk budgeting.

In this paper, we present a coherent stochastic model to forecast mortality and compare the forecast performances from our model, Li and Lee (2005), Plat (2009), Lee and Carter (1992) and CBD M7 (Cairns et al., 2009). Further in Section 1 we introduce the model background: the relevance of the longevity risk in Switzerland and the choice of reference population. In Section 2 we briefly set out the model specification, describe the estimation procedure as well as the procedures for testing of robustness. In Section 3, our methodology is applied to forecast Swiss mortality, robustness tests are conducted and the comparison of our results with mortality forecasting with the other four mortality models is given. In Section 4, we briefly summarize results and highlight the impact on pensioner liability.

1.1. Swiss social security system and the structure of swiss labour force

Retirement and risk benefits in Switzerland are provided through a well-established system that incorporates state provision, employer provision and personal savings, known as the "three pillars" system. Retirement and spouse pensions in the second pillar are guaranteed for life.

Switzerland has one of the highest immigration rates on the continent. Immigrants now make up 23% of the Swiss population (ca. 8 Mio in 2013) as the country traditionally used to be a destination for employment-seeking French, Germans, Italians, Spanish and other European countries as well as a highly skilled labour force from other distant countries (Efionayi et al., 2005). Like the rest of Europe, Switzerland knows that further immigration will be needed to compensate for the ageing population and to ensure economic growth in the future.

1.2. Swiss mortality tables and longevity risk in Switzerland

Switzerland is a small country. There is only one actuarial mortality table: LPP/BVG, available for private pension funds.[1] Another table, VZ, is used for Swiss public pension funds. Both tables are generational and deterministic and are not substantially different in relation to the level of future life expectancies. Insurance companies use their own mortality tables which are not disclosed and seem to be much more conservative than ones available for pension funds.

It is widely recognized in Switzerland that the longevity risk accompanied by the historically lowest level of interest rates in Switzerland is a major threat to pension funds and their sponsors as it cannot be simply hedged like in case of interest rate and other investment risks. Compared to the situation in the UK there is a dearth of financial products in Switzerland to combat longevity risk, with a lack of buy-in and a very limited variety of buy-out solutions. The solutions that do exist frequently come at a very high price and are unaffordable for pension funds and their sponsors. Taking into account that at the moment Swiss insurance companies practically do not conduct any pure pensioner buy-outs other solutions should be created to facilitate the longevity risk transfer from pension funds to other market players. There were no officially announced transactions with longevity swaps for Swiss pension funds but some companies and pension funds have started looking for solutions alternative to a "plain buy-out" approach. To promote products for longevity hedging on capital market as well as to reserve prudently for Swiss pension funds stochastic mortality models are indispensable as there is no other way to estimate the risk intrinsic to longevity nature.

The first publication on Swiss stochastic mortality modelling was prepared by Gaille (2012). She indicated that life expectancies in LPP/BVG generational table appeared to be underestimated especially for women.

1.3. The reference population

Following the approach by Li and Lee (2005), 15 low-mortality populations[2] are selected and pooled as the reference population. All data are downloaded from the Human Mortality Database (HMD).

Noticing that for ages beyond 90 death rates are often too variable and are impacted by country dataset quality issues, we restrict ourselves to the age range 20–89 over the period 1956–2009. We add death numbers (or exposures) across 15 countries at each age–period cell. Fig. 1 shows both pooled international and Switzerland mortality data at age 85 as an example to illustrate that in spite of the large variation observed in the Swiss data, their general trends are closely related.

In the following text, we use $m(x,t) = d(x,t)/e(x,t)$ as the crude centre death rate for age x in calendar year t, calculated by death number $d(x,t)$ divided by exposure to risk $e(x,t)$ from HMD data source. Another mortality measure used is the initial mortality rate $q(x,t)$, which is the probability that an individual with age x in calendar year t will die between year t and $t+1$. We have adopted a common approximation to convert between them: $q(x,t) \approx m(x,t)/(1+0.5m(x,t))$.

2. Stochastic mortality model

2.1. Model

After Lee and Carter (1992) a big variety of stochastic models to forecast mortality has been developed (see Cairns et al., 2011a). However, most of them are appropriate only for large single country populations. This is because large variability observed in small populations could reduce the forecast reliability. In addition, forecasting for single population mortality could give divergent trends for two closely related populations. To manage such problems, methodologies have been developed which can facilitate multi-population modelling and small population modelling. Li and Lee (2005) first investigate a group of populations to determine a common factor as a reference, and then estimate the single population based on the estimated reference. The SAINT model (Jarner and Kryger, 2011) is based on a similar idea, except that a frailty model is employed to estimate the mortality force $\mu(x,t)$ for the reference and multivariate time series are used for Danish spread modelling (see Table 1).

For our case, we believe that all populations in the reference group follow the same "reference" trend while a specific spread is allowed for each chosen population. Inspired by the models listed above, we follow the common procedure used by Li and Lee (2005) and the SAINT (Jarner and Kryger, 2011) which is to estimate a reference trend first, then to model the spread or the difference between the individual population and the reference population.

[1] LPP/BVG tables have been published every 5 years starting from 2000 and are based on mortality statistics of 14 biggest pension funds in Switzerland which belong to the leading Swiss firms from different industry sectors (equity index SMI/SLI).

[2] The reference population consists of national datasets of following fifteen countries: Austria, Denmark, England and Wales, Finland, France, West Germany, Japan, The Netherlands, Norway, Spain, Sweden, Switzerland, Canada, Italy and USA.