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AUTHORS	Mariarosaria Coppola Valeria D’Amato
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Mariarosaria Coppola (Italy), Valeria D'Amato (Italy)

Basis risk in Solvency Capital Requirements for longevity risk

Abstract

The international guidelines of Solvency II prescribe a regulation which should help insurance industry mitigating undesired outcomes arising from the exposure to the systemic risks. In particular, the rules on Solvency Capital Requirements recommend to separately compute them for each risk factor, where for the longevity risk sub-module the Solvency Capital Requirement results by the change in net asset value (NAV) due to a longevity shock which actually assumes a permanent reduction of the mortality rates for all ages by 20%. Nevertheless, the data based on statistics coming from various national longevity indices differ from those deriving from the regulatory assessment of solvency, determining significant underestimations or overestimations: a basis risk comes from a questionable adequacy of the longevity shock.

This paper contributes to the discussion on Solvency Capital Requirements by focusing on the main features of the potential basis risk which determines the inappropriate capitalization of insurance companies. Furthermore we analyze the sensitivities of the basis risk to different ages for better assessing the actual risk of insurance portfolios.

Keywords: basis risk, Solvency Capital Requirement, longevity risk, net asset value.
JEL Classification: G22, J11.

Introduction and motivation

The insurance industry faces with different systemic risks which threaten its stability. Longevity risk, i.e. the risk that the trend of longevity improvements significantly changes in the future, strongly affects the insurance portfolios.

Solvency II regulation promotes a correct assessment of the Solvency Capital Requirements (from herein SCRs), in order to mitigate the exposure to these risks. In particular in the regulatory model, longevity risk is explicitly accounted for as part of the life underwriting risk module. The Solvency II regime demands that the amount of SCR for longevity risk is calculated as the variation of net asset value (NAV). According to the Scenario Stress Testing, the change in NAV comes from the difference between the values in the best estimate framework and in a stressed condition (the so-called longevity shock) which influences the quantity of the capital that the insurer needs to meet its future obligations year by year till the contract will be in force. Nevertheless, the stressed conditions imposed by the standard model can be inconsistent, in light of the actual experience of the longevity phenomenon. We propose to analyze the dynamics of longevity improvements throughout opportune longevity benchmark as the longevity indices. We consider country-specific longevity indices produced by the Life & Longevity Markets Association – LLMA, as in LLMA (2012). We interpret the difference between the regulatory SCRs and the longevity index ones as a kind of basis risk which substantially affects the risk management, by involving managerial overreactions and improper solutions.

The remainder of this paper is structured as follows. In Section 1, the longevity indices are presented. Section 2 investigates the standard model for solvency capital requirements in Solvency II framework. The basis risk is then evaluated in Section 3 where the main outcomes of the empirical application are illustrated. The final section concludes the remarks.

1. Country-specific longevity indices in the life metrics framework

Before introducing the longevity index we will refer to, it is useful to point out the difference between a rate index and a price index. A rate index is an index of observed rates and a price index is an index of observed prices of securities or derivatives. Most indices in the financial world are of the latter kind. In this paper we consider a longevity index as opportune longevity benchmark for analyzing the impact of the longevity shock dynamics on the Solvency Capital Requirement calculations. In particular, we refer to the longevity index defined according to the J.P. Morgan LifeMetrics implemented by LLMA, which is a rate index rate. In the future when greater liquidity and transparency will develop in the longevity market, it may be possible to develop longevity price indices that reflect the prices of longevity bonds or swaps (LLMA, 2012). As well known LifeMetrics is an index model aimed to improve the level of longevity and mortality risk management, allowing these risks to be measured in a standardized manner, aggregated across different risk sources and transferred to other parties. In that framework the longevity index is defined as a body of data relating to the mortality, survivorship and life expectancy of a specified group of individuals, calculated according to robust and well-defined algorithms and processes. The three crucial elements that determine the nature of any longevity index are

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the underlying population, the body of mortality data associated with that population and the index methodology (LLMA 2012). For obtaining a suitable level of standardization the index methodology should be general enough that it can be applied, except in exceptional cases, to different populations. LifeMetrics Index at the moment furnishes current and historical longevity indices for England & Wales, Germany, the Netherlands and the USA. These longevity indices contain separate data in respect of males and females, and provide the following three types of mortality metrics for different ages in specified years:

- crude central rates of mortality;
- graduated initial rates of mortality;
- period curtate life expectancies.

Index values are published annually, and are calculated by an independent calculation agent. The calculation agent will calculate index values from raw death and population data released by government agencies. We consider this set of data as the benchmark we refer to for analyzing the adequacy of the solvency capital requirement standard formula.

2. The solvency capital requirement standard model in Solvency II framework

In recent decades, industrialized countries have been affected by remarkable improvements in human life expectancy, anyhow the future demographic patterns are uncertain and difficult to predict. The risk deriving from that uncertainty represents the longevity risk. In this context mortality forecasting represents an attractive tool in different areas being the basis for correct government policy and planning (Denuit, 2009). In the actuarial field the persistent decrease observed in mortality rates in the industrialized countries becomes the main concern to annuity and pension providers. In fact, the increase in the trend of life expectancy may lead to important consequences in the management of such institutions as the realization of payout levels higher than what the annuity or pension providers account for. The relevance of longevity risk is widely recognized in the Solvency II regulation. In this framework the insurance companies have to set aside reserves including Solvency capital Requirement, which represents the excess of capital to cover the difference between the best estimate and the actual cash flow of liabilities. According to this regulation, the SCR calculation could rely on a standard formula or an internal model. The basic principle is that the SCR is set at a level ensuring that the insurer and reinsurers can meet their obligations to policy holders and beneficiaries over the following one year with a 99.5% probability. The standard model furnished by the European Commission for approximating the capital requirements is based on a modular approach.

In this context, the overall risk is split into several risks (modules) and each of them is split again into risk sub-modules. For each module and sub-module the corresponding SCRs are calculated separately and then they are aggregated according to a pre-specified correlation matrix. The longevity risk represents a sub-module of the life underwriting risk module, this reflects the fact that it is one of the main risks that insurance companies or pension funds providers have to front. It covers the risk of losses or adverse changes in value of insurance liabilities resulting from changes in level, in the trend or in the volatility of mortality rates. The 5th Quantitative Impact Study-QIS5 (CEIOPS, 2010) stated that the capital charge for longevity risk (from herein SCR_{long}) results by the net change in NAV due to a longevity shock under a specific survival scenario at time $t = 0$:

$$SCR_{long} = \Delta NAV | longevity\ shock.$$

It is worth pointing out that CEIOPS (2010) defined the NAV as the difference between the market value of assets and liabilities. As well known, the market value of liabilities is difficult to determine, therefore it stated that it can be approximated by the so-called technical provisions which consist of the best estimate of liabilities BEL_t and risk margin (RM). The *BEL* is represented by "the expected or mean value (probability weighted average) of the present value of future cash flows for current obligations, projected over the contract's run-off period, taking into account all up-to-date financial market and actuarial information" (CEIOPS, 2010).

The RM can be interpreted as loading for facing all residual risk in respect of those met by the SCR. It is calculated via a cost of capital approach and in the case under consideration, taking into account only the longevity risk, it results:

$$RM_t = \sum_{h \geq 0} \frac{CoC \cdot SCR_{long,t+h}}{(1 + r_f)^{-h}},$$

where *CoC* is the cost of capital rate; r_f is the risk free interest rate.

In order to solve the evident situation of circularity, CEIOPS (2010) specifies that for SCR calculation liabilities, should not include the risk margin. Therefore, we have:

$$NAV_t = A_t - BEL_t,$$

where A_t represents the market value of assets at time *t* and BEL_t is the best estimate of liabilities at time *t*.

The longevity shock is actually represented by a 20% permanent reduction of the mortality rates for each age and contract linked to longevity risk.

In this paper to correctly calculate the solvency capital requirements we evaluate at the beginning of each year the amount of capital that the insurer needs to meet its future obligations year by year till the contract will be in force. We examine the impact of the shock's structure suggested by the standard formula on the SCR_{long} and liabilities at different ages by referring to the benchmark represented by the longevity index described in section 2.

3. Basis risk in Solvency Capital Requirements: empirical results

Depending on the true portfolio composition of the insurer, the SCRs set aside according to Solvency II might substantially deviate from the actual one and thus basis risk becomes visible. We undertake a simulation study to better understand the surplus or deficit caused by the standard regulatory model.

The data we consider are the US population divided by gender, ranging from 1950 to 2006, compiled by the Centers for Disease Control and Prevention ('CDC') and National Center for Health Statistics ('NCHS'), published by the US Census Bureau.

To observe the pattern of mortality phenomenon, the figure 1 shows the central mortality rate calculated on LifeMetrics Index, in case of male population for all ages and years selected for an example: 2004, 2005, 2006. The panel of figure 2 gives an idea about the differences with the female population.

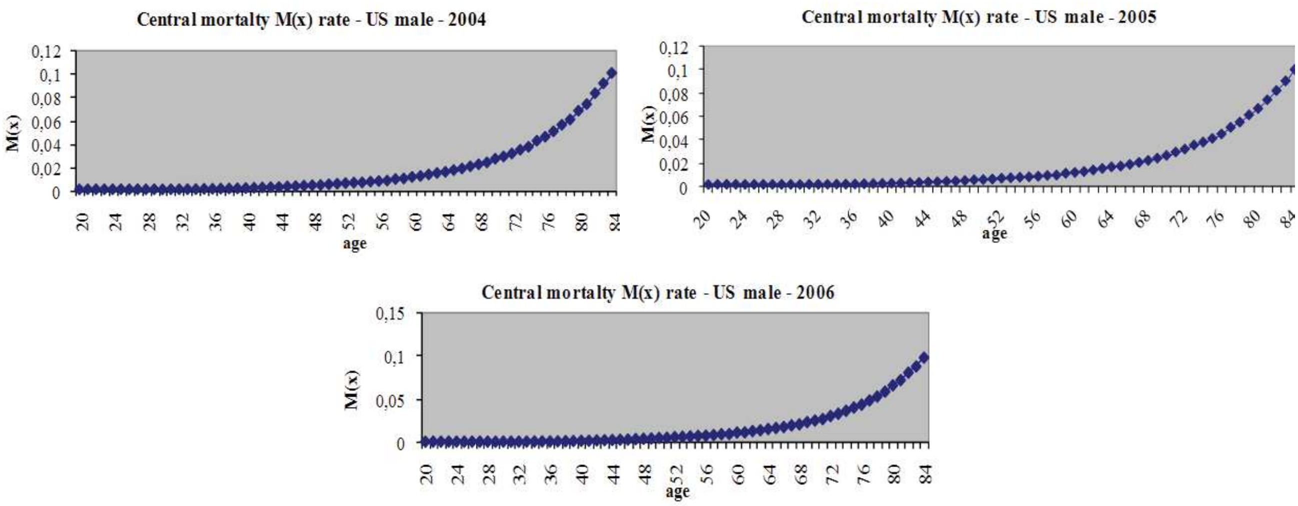

Fig. 1. Longevity LifeMetrics Index for US male (2004, 2005, 2006) from left hand side to right one

For instance it may be interesting to compare the mortality in a specific calendar year as 2004 for all ages. We can observe that the maximum peak in the female case is 0.025 in respect of 0.1 for male. In general for all years, the male population shows a bigger increase of mortality.

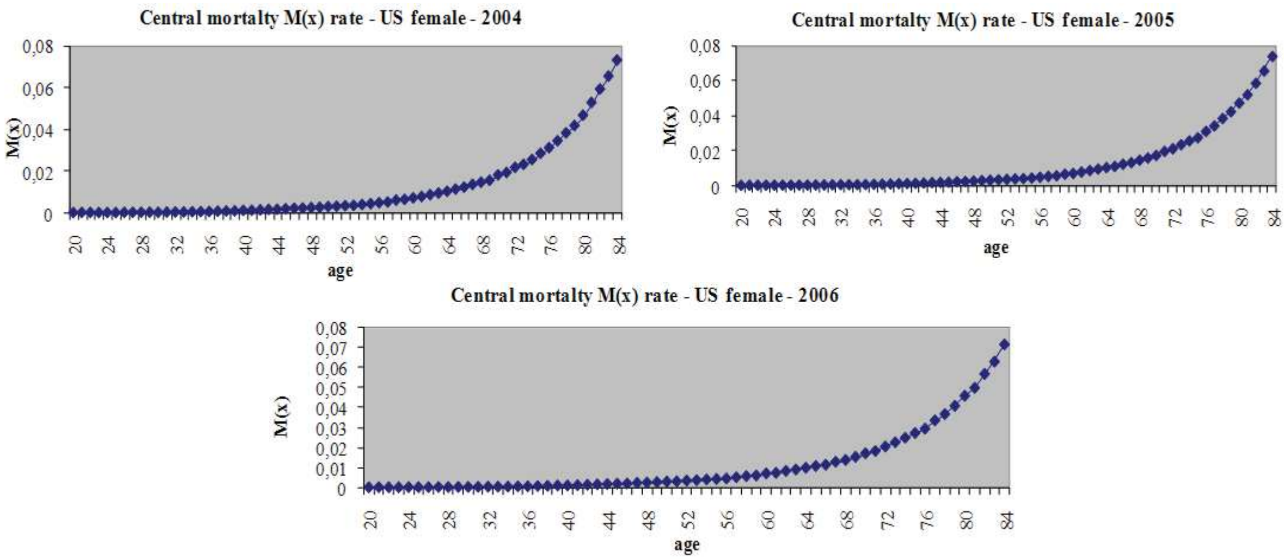

Fig. 2. Longevity LifeMetrics Index for US female (2004, 2005, 2006) from left hand side to right one

Furthermore, as the time increases, we report a shift of the age where the mortality starts to exponentially raise.

For the sake of simplicity, Table 1 is composed by a panel of results for different ages and segmented for genders. First of all the SCR is one-off shock according to the Solvency II rules. Let us compare the SCRs in the Solvency II context according to the standard formula and in case of the calculation indexed to the country Longevity Index specific for gender. The ideal adequacy condition is pursued when the regulatory SCR is equal to the indexed one. Otherwise a surplus or deficit of capitalization comes true. In particular, if the indexed SCR overcomes the regulatory requirement, it reveals an underestimation of the capital allocated for a correct risk management. In opposite event, an overestimation of the SCR causes an excess of immobilized assets, so that the insurer is not able to invest all of his resources and his capabilities to better match client needs.

Table 1. Solvency Capital Requirements in standard model vs indexed SCR, for male and female

	BASIS RISK IN SCR	
	Male	Female
Age 40		
Regulatory SCR	538821.4	473251.2
Indexed SCR	-184575.4	-229479.7
Age 45		
Regulatory SCR	566425.3	504899.7
Indexed SCR	-191644.3	-237032.4
Age 50		
Regulatory SCR	589982.7	533107.6
Indexed SCR	973136	902515.4
Age 55		
Regulatory SCR	607593.8	555588.4
Indexed SCR	-138527.8	-255853.0
Age 60		
Regulatory SCR	614796.8	568206.5
Indexed SCR	-115909.0	-297110.1

We can observe an increasing SCR, as the age raises in case of standard model proposed by regulatory framework. The higher uncertainty lays on the actual experience of longevity underlying the indexed SCR. Essentially the male SCR are higher than the requirements needed in case of an insurance portfolio composed by females. Finally the substantial differences between the regulatory SCR and the calculations based on country-specific longevity indexes reveal an emerging basis risk which determines actual costs or opportunity cost of capital.

Concluding remarks

A simple model has been chosen to illustrate the phenomenon of basis risk arising comparing the SCR calculated by the standard formula and the benchmark represented by the SCR calculated by the longevity index and set aside by the insurance company.

The basis risk is a concept typically introduced in actuarial literature about the longevity dynamics between the demographic trend of the reference population and that one of the actual insurance portfolio, in a hedging setting.

In this paper, we tested the existence of a basis risk in SCR which can be interpreted as a risk of surplus or deficit in the calculation of the capital saved for a correct risk management. It emerges comparing the actual portfolio SCR based on the experienced mortality by the country specific longevity indexes and that one calculated on the regulatory standards in Solvency II context.

We try to give another perspective of the discussion on Solvency Capital Requirements by focusing on the main features of the potential basis risk which reflect the inappropriate capitalization of insurance companies. Further research will focus on internal models including a stochastic framework for volatility of longevity which determines a strong uncertainty in estimation of reserves, prices and SCRs.

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