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ECONOMIC CAPITAL MODELS IN LIFE INSURANCE

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Economic capital (EC) as a measure of the company's risk capital depends on a number of company-specific and external (both macroeconomic and industry-specific) risk variables and formulaic model constructs. The authors use a copula approach to build a predictive model estimating the amount of economic capital a life insurance company needs to protect itself against an adverse movement in interest rates, mortality, and other risk drivers. Predictive modeling requires a study of statistical dependence between diverse risks whose dependence can be expressed in terms of a joint distribution of risk variables using a copula function. Risk capital can then be estimated by value-at-risk (VaR) and expected shortfall (ES).

Economic capital modeling allows insurance companies to obtain better control of their risks and manage their business. A research paper sponsored by the SOA and Towers Perrin outlines the general EC framework for a life insurance company and the major types of risk facing an insurance company. Mortality risk (including catastrophic, volatility, estimation, and trend risks) and interest rate risk are specified as key liability and asset related risks. Due to the nature of insurance products underwritten by a life insurance company, implementing EC for interest rate risk requires develop- ing an advanced way of calculating capital needs for a mixture of mostly fixed-income securities with various maturities and credit qualities.

Many large insurers and subsidiaries of European insurers are using EC and stress testing models for solvency and high-level capital planning considerations. However, there are many companies unfamiliar with implementing a model framework. One of the hurdles for new players is representing key independent variables by their distributions, since industry and company experience is usually stated as a deterministic best estimate value. Another major challenge is combining all modeled drivers of loss risk into a joint distribution. This is where the proper choice and use of a particular type of copula comes in. Morone et al. considered t-copulas for the analysis of a commercial bank portfolio of credit, market, and operational risks. Nguyen and Molinari used Archimedean copulas to represent life, non-life, and health underwriting risks, while Shim et al. discuss grouped t-copulas in the property and casualty insurance setting. Clearly, the choice of copula model is related to the nature of risks and particular choice of data.

Since the financial crisis of 2007–2009, the U.S. regulators adhere to the policy of maintaining interest rates at a very low level by historical standards. While this policy seems to produce a positive effect on overall economic development, it has created a challenging environment for the insurance industry. This effect is especially pronounced for life insurance companies struggling to gain investment returns that are sufficient for meeting their long-term

liabilities. Therefore, our asset analysis is based on post-crisis years addressing the unique challenges of low interest markets.

In the period of December 2015 through December 2018, the Federal Reserve had raised interest rates nine times and signaled that it will continue raising rates in the nearest future. Higher interest rates would provide much needed relief to the life insurers that experienced a serious asset-liability mismatch during the last ten years. However, in August of 2019 the FED reversed its course and lowered the target rate three times bringing it back to the levels that were not seen since 2008.

There are several factors that might lead to "preserving" the low interest rate environment for the years to come. Among them is the sheer size of funds the Federal Reserve induced into the financial markets during its large-scale purchases of long-term government bonds and other securities (quantitative easing program) in 2008, 2010 and 2012. This has created a market where too many dollars are chasing too few investment opportunities. The other factor is rather "modest" long-term economic growth expectations coming from the Federal Reserve and shared by the market participants.

Overall, there is a clearly observed long term down slope trend for the interest rates in the most developed countries. The historical data demonstrate that since the 1980-s, both long-term and short-term rates have been steadily declining, dropping from 20 percent in the 1980-s to close to zero in U.S. and even negative in Europe. Recently, some U.S. economists argued that negative rates are coming to the U.S. in the nearest future.

Keeping this in mind, our research develops a practical approach to EC that would help a life insurance company to calculate its capital needs in the low interest rate environment. In order to do so, we create an asset-liability framework modeling an insurance company portfolio. Then we use it to demonstrate how a copula-based approach can be applied to establish economic capital that would assist the company in sustaining an extended period of low interest rates. While such factors of life insurance risk as mortality and morbidity may not vary when the asset and/or interest rate market changes, other underwriting risks, such as the number of lapses in policies, may be interest rate market dependent.

In Section 2 we describe a one-year Economic Capital model with an emphasis on statistical aspects of model selection: choice of copula type (elliptic or Archimedean) and marginal distributions of the asset and liability variables. The study employs the time series structure of the asset variables allowing one to reflect monthly changes in the market and simultaneous changes in such underwriting risks as lapses. Our model also allows for the utilization of expert estimates or annual summaries of liability variables in absence of more frequent time series data.

The main model assumptions and limitations are summarized in Section 3 along with the variable selection for a practical illustration. Section 4 describes an application of our model to

a set of nine asset and six liability variables. Time series parameters and correlation structure of the asset variables are estimated from the 15-year period 2003-2018 chosen to represent the low interest rate market environment. Development of the model framework employed for the project uses traditional life products to illustrate copula utility. For products with interest sensitivity, equity market or other asset/liability linkages, use of the model will require additional expertise from the end user that may include further correlation factor study, marginal distribution development, use of R programming, etc. The severity of losses driving the ultimate economic capital levels is intended to be realistic in magnitude. As noted above, use of a low interest environment may also impact the severity of results.

When the model reflecting a company's investment portfolio and product mix is constructed, a Monte Carlo simulation introduced in Section 5 generates multiple future scenarios of one-year portfolio gains/losses, based on which value-at-risk and expected shortfall values are calculated. An interactive software tool allows for the adjustment of model inputs and parameters for the simulation in an Excel workbook format. Sample results of the simulation are provided in Section 6 along with the discussion of possible modifications of model inputs.

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