Stochastic Solvency Testing in Life Insurance

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Statement of Originality

This thesis contains no material that has been accepted for the award of any other degree or diploma in any University, and to the best of my knowledge and belief, contains no material published or written by another person, except where due reference is made in the thesis.

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Abstract

Stochastic solvency testing methods have existed for more than 20 years, yet there has been little research conducted in this area, particularly in Australia. This is for a number of reasons, the most pertinent of which being the lack of computing capabilities available in the past to implement more sophisticated techniques. However, recent advances in computing have made stochastic solvency testing possible in practice and have resulted in a trend towards this being done in advanced studies.

The purpose of this thesis is to develop a realistic solvency testing model in a form that can be implemented by Australian Life Insurers, in anticipation that the Australian insurance regulator, APRA, will ultimately follow the world trend and require stochastic solvency testing to be carried out in Australia. The model is constructed from three interconnected stochastic sub-models used to describe the economic environment and the mortality and lapsation experience of the portfolio of policies under consideration. Australian economic and Life Insurance data is used to fit a number of possible sub-models, such as generalised linear models, over-dispersion models and asset models, and the "best" model is selected in each case. The selected models are a modified CAS/SOA economic sub-model; either a Poisson or negative binomial (NB1) distribution (depending on the policy type considered) as the mortality sub-model; and a normal-Poisson lapsation sub-model.

Based on tests carried out using this model, it is demonstrated that, for portfolios of level and yearly-renewable term insurance business, the current deterministic solvency capital requirements provide little protection against insolvency. In fact, for the test portfolios of term insurance policies considered, the deterministic capital requirements have levels of sufficiency of less than 2% (on a Value at Risk basis) when compared to the change in capital distribution over a three year time horizon. This is of concern, as yearly-renewable term insurance comprises a significant volume of Life Insurance business in Australia, with there being over 426,000 yearly-renewable

term insurance policies on the books of Australian Life Insurers in 1999 and more business expected since then.

A sensitivity analysis shows that the results of the stochastic asset requirement calculations are sensitive to the choice of sub-model used to forecast economic variables and to the choice of formulae used to describe the mean mortality and lapsation rates. The implication of this is that, if APRA were to require Life Insurers to calculate their solvency capital requirements on a stochastic basis, some guidance would need to be provided regarding the components of the solvency testing model used. The model is not, however, sensitive to whether an allowance is made for mortality or lapsation rate over-dispersion, nor to whether dependency relationships between mortality rates, lapsation rates and the economy are allowed for. Thus, over-dispersion and dependency relationships between the sub-models can be ignored in a stochastic solvency testing model without significantly impacting the calculated solvency requirements.

Contents

List of Tables

List of Figures

CHAPTER 1

Introduction

The most important goal of any business is to remain solvent, as it can no longer continue its operations if it becomes insolvent, except in special circumstances where the government bails out the company by injecting capital. In the case of financial services institutions, such as banks and insurance companies, continued solvency is of importance, not just to the institution, but also to account/policyholders who could potentially face economic hardship if such an institution were to collapse. The 2001 collapse of Australian General Insurer HIH Insurance illustrates the adverse consequences to the public of such an event. As a result, the financial services industry is one of the most highly regulated industries, and all advanced economies have in place legislation designed to minimise the risk of a financial services institution going bankrupt. The legislation generally requires such institutions to hold capital greater than a specified minimum amount, often referred to as the *solvency capital requirement*, at all points in time. This thesis focuses on the calculation of this quantity in the context of the Australian Life Insurance industry.

Currently, Australian Life Insurers are required to calculate their solvency capital requirements on a deterministic basis using formulae set out in Life Insurance Prudential Standards LPS2.04 and LPS3.04[1]. However, recently there has been a trend in advanced economies, such as Switzerland, through the Swiss Solvency Test, and the European Union countries, through Solvency II, towards calculating insurer

[1]LPS2.04 and LPS3.04 specify methodologies the insurer must follow in order to determine its solvency and capital adequacy requirements, respectively. The insurer must hold assets greater than both of these requirements at all times. If the insurer's assets fall below the solvency requirement, the insurer is considered to be insolvent for statutory purposes, while if its assets fall below the capital adequacy requirement, the Australian insurance regulator, the Australian Prudential Regulatory Authority (APRA), will intervene in the hope of preventing the insurer from becoming insolvent.

solvency capital requirements using stochastic techniques, thereby requiring insurers to hold a capital amount that satisfies a probability-based criterion. For example, insurers might be required to hold an amount of capital sufficiently large so that there is a 99.5% chance that, in one year's time, the insurer's assets will exceed its liabilities. In order to satisfy such a criterion, the insurer must attempt to determine the probability distributions of the values of its assets and liabilities, or sometimes just of its capital holdings, at future points in time. These distributions usually need to be determined using computer-intensive simulation techniques. It was due to the unavailability of inexpensive, high-speed computers in the past that deterministic solvency testing techniques were used almost exclusively in all countries, and it is because of the easier access to such computers in recent years that stochastic solvency testing techniques have suddenly come to prominence.

It is anticipated that the Australian insurance regulator, the Australian Prudential Regulatory Authority (APRA), will ultimately require Australian Life Insurers to calculate their solvency capital requirements using stochastic methods. Such being the case, there is a need to develop a realistic asset-liability model that can be used for this purpose. In this thesis, such a model is constructed and the model is then used to assess whether the current Australian deterministic solvency capital criteria are appropriate, based on four commonly used stochastic solvency criteria: the 99.5% Value at Risk (VaR) and Tail Value at Risk (TVaR) of the change in capital distribution over a one year time horizon, and the 95% VaR and TVaR of the change in capital distribution over a three year time horizon. The developed model is a simulation model comprising three interconnected stochastic sub-models used to describe the economic environment and the mortality and lapsation experience. It is demonstrated, using Australian economic and Life Insurance data, that the "best" sub-model in each case (out of the range of models under consideration) is a modified CAS/SOA[2] economic sub-model, a Poisson or negative binomial (depending on the policy type considered) mortality sub-model, and a normal-Poisson lapsation sub-model.

Tests conducted in this thesis demonstrate that, although the current deterministic requirements are sufficiently high for portfolios of investment-linked or "traditional" (endowment insurance) policies, they provide very little protection against insolvency for portfolios of "traditional" term insurance or for portfolios of "modern" yearly-renewable term insurance under some of the solvency criteria. Sensitivity tests conducted in association with these investigations show that the (stochastic) total asset requirements calculated using the solvency testing model are virtually unaffected by ignoring the over-dispersion that was found to be present in the mortality and lapsation data used in this thesis, or dependency relationships that were found

[2]Casualty Actuarial Society/Society of Actuaries.

to exist between the economy and mortality rates, and the economy and lapsation rates. However, for some policy types, the requirements are significantly affected by changing the sub-model used to forecast the economic variables, or simplifying the formulae used to determine the mean mortality and lapsation rates in the sub-models used to forecast future mortality and lapsation experience. The implication of this latter result is that, if APRA is to require Life Insurers to calculate their solvency capital requirements using stochastic methods, then, in order to ensure consistency between insurers, some guidance should be provided with regard to the nature of the solvency testing model used.

The structure of this thesis is as follows: Chapter 2 provides a review of the existing stochastic valuation and solvency testing literature, as well as providing an overview of the current solvency legislation in place in Australia and in several other countries throughout the world. In Chapter 3, a framework for the stochastic solvency testing model built in this thesis is developed and a number of research questions are posed. Chapter 4 gives background details on many of the statistical models (including generalised linear models and time series models) and tests used in this thesis. The main data sets used in this thesis are described in Chapter 5, and in Chapters 6 to 8, a realistic stochastic solvency testing model, intended for use by Australian Life Insurers, is developed based on this data, and the method of implementation of the model is set out. Chapter 9 summarises the results of comparing the solvency capital requirements calculated using the stochastic solvency model developed in the previous chapters with those calculated under LPS2.04 and LPS3.04, and provides a sensitivity analysis of these results; and Chapter 10 concludes this thesis by discussing its limitations and suggesting possibilities for future research.