Available online at www.sciencedirect.com
ScienceDirect
Insurance: Mathematics and Economics 42 (2008) 839–849
INSURANCE MATHEMATICS & ECONOMICS
www.elsevier.com/locate/ime

Asset management and surplus distribution strategies in life insurance: An examination with respect to risk pricing and risk measurement

Nadine Gatzert*

University of St. Gallen, Institute of Insurance Economics, Kirchlistrasse 2, 9010 St. Gallen, Switzerland

Received October 2006; received in revised form September 2007; accepted 15 September 2007

Abstract

In this paper, we investigate the impact of different asset management and surplus distribution strategies in life insurance on risk-neutral pricing and shortfall risk. In general, these feedback mechanisms affect the contract's payoff and hence directly influence pricing and risk measurement. To isolate the effect of such strategies on shortfall risk, we calibrate contract parameters so that the compared contracts have the same market value and same default-value-to-liability ratio. This way, the fair valuation method is extended since, in addition to the contract's market value, the default put option value is fixed. We then compare shortfall probability and expected shortfall and show the substantial impact of different management mechanisms acting on the asset and liability side.

JEL classification: G13; G22; G29

Subject and Insurance Branch Code: IM30; IE43; IE50; IB10

Keywords: Life insurance; Asset management; Surplus distribution; Fair valuation; Lower partial moments

1. Introduction

Implicit options in life insurance contracts are of increasing concern in both academia and practitioners' world, especially since Equitable Life had to close to new business in 2000 due to improper hedging of provided options. One way of financial pricing of insurance liabilities is using risk-neutral valuation. Asset management and surplus distribution strategies are often omitted from this process, even though the assumption of unchanged asset allocation or constant annual surplus participation rates is rather restrictive. The volatility of the asset portfolio can also be affected by market conditions. The aim of this paper is to fill this gap and examine the impact of various management mechanisms on risk-neutral pricing and risk measurement for fair contracts with the same market value and the same default-value-to-liability ratio. The strategies considered are based on the insurer's degree of solvency, in the sense that the investment's volatility or the annual surplus participation rate are reduced when solvency is threatened.

There has been much research on fair valuation of embedded options in life insurance contracts, including Bacinello (2001, 2003a,b), Ballotta et al. (2006b), Briys and de Varenne (1997), Grosen and Jørgensen (2000, 2002), Hansen and Miltersen (2002) and Tanskanen and Lukkarinen (2003). A comprehensive review of this literature can be found in Jørgensen (2004). These authors use the appropriate concept of risk-neutral valuation of insurance contracts to price insurance liability risk; however, they do not consider risk measurement or management decisions concerning asset allocation or surplus distribution within this process.

Among the literature that accounts for actuarial aspects as well, Barbarin and Devolder (2005) present a model that combines financial and actuarial approaches for maturity guarantees with terminal surplus participation, similar to the model used by Briys and de Varenne (1997). Boyle and Hardy (1997) compare an actuarial simulation-based approach with a financial option pricing approach for the pricing and reserving of maturity guarantees. Gatzert and Kling (2007) propose a

* Tel.: +41 71 2434012; fax: +41 71 2434040.
E-mail address: nadine.gatzert@unisg.ch.

0167-6687/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.insmatheco.2007.09.001

procedure that considers both pricing and risk measurement, which is also feasible for cliquet-style contracts. They compare the objective real-world risk implied by fair contracts with the same market value for different models and thus identify key risk drivers for fair contracts. Kling et al. (2007) use an actuarial approach to analyse the interaction of contract parameters, regulatory parameters, and management decisions, comparing shortfall probabilities for guarantees with annual surplus participation common in the German market.

The implementation of management decisions regarding asset allocation or surplus participation is another aspect related to fair valuation and generally leads to modified payoffs. General managerial behaviour and financial risk management is discussed and presented, for example, in Babbel and Merrill (2005), Cummins et al. (2001) and Santomero and Babbel (1997). In the literature on participating life insurance contracts, Berketi (1999) and Berketi and Macdonald (1999) discuss the effect of risk management on payoff structure and insolvency risk by employing a mean-variance framework, and without following a fair valuation approach. Chadburn (1998) conducts the analysis under an objective real-world measure for different scenarios, comparing long-term and short-term management strategies, and studies the influence of management strategies on the policyholders' returns and the insurer's solvency. Hence, the articles mentioned so far contrast return and controlling solvency, thus evaluating the relative benefit of the policyholders' returns. Based on the surplus distribution mechanism and decision rules as introduced in Kling et al. (2007), Bauer et al. (2006) conduct fair valuation of participating life insurance contracts. The decision rules considered are implied by the insurer's reserve quota. Kleinow and Willder (2007) study hedging strategies and calculate fair values for maturity guarantees, where policyholders participate in the insurer's investment portfolio that is subject to the insurer's management decisions.

The purpose of this paper is to extend previous literature by investigating the impact of asset management and surplus distribution strategies on risk-neutral pricing and risk measurement. Considering both approaches allows increased insight into the impact of these management decisions. The valuation of insurance liabilities is involved in premium calculation and is thus of interest to insurers and policyholders. Risk measurement of the actual real-world risk using, e.g. lower partial moments under the physical measure in addition to the (risk-neutral) pricing of these contracts provides important information for rating agencies, regulatory purposes (e.g. Solvency II in the European Union), investors, and other stakeholders, among others.

The analysis is based on participating life insurance contracts common in the United Kingdom and other European countries, as described by Ballotta et al. (2006b). These contracts feature a guaranteed interest rate and annual and terminal surplus participation. Three types of management strategies are considered that are based on the insurer's degree of solvency, in the sense that the investment's volatility or the annual surplus participation rate are reduced when solvency is threatened. Two of the considered management strategies regulate the asset side through adjusting the investment's volatility; one strategy controls the annual surplus participation rate, thus acting on the liability side of the balance sheet. These feedback mechanisms affect payoffs as well as pricing and risk measurement quantities. To isolate the effect on shortfall risk, we calibrate contract parameters that lead to the same market value and the same safety level for the insurer. By fixing these two pricing figures, the fair valuation method is extended. We use the default-value-to-liability ratio as a measure of safety level. We then compare shortfall probability and expected shortfall for the three different management strategies.

The remainder of the paper is organized as follows: In Section 2, the model and valuation framework is introduced. In Section 3, we present a procedure to take simultaneously the insurer's safety level and fair contracts into consideration and then measuring shortfall risk associated with the contracts. The integration and effect of asset management and surplus distribution strategies on risk for fair contracts is described in Section 4. Section 5 examines the influence of the considered management strategies on risk for fair contracts when fixing market value and safety level. The results are then compared to the results based on the standard fair valuation approach. Section 6 concludes.

2. Model framework and fair valuation of insurance company's liabilities

This section describes the model framework for a life insurance company. The liability structure described is implied by participating life insurance contracts based on the framework suggested by Ballotta et al. (2006b). In particular, the liability structure is described by a guaranteed interest rate, annual surplus participation, and participation in the terminal surplus.

At inception of the contract, the policyholders pay an exogenously given up-front premium $P_0 = k \cdot A_0$, where k is a positive real number. The company's initial equity is denoted by $E_0 = (1-k) \cdot A_0$. Hence, the coefficient k can be considered the leverage of the company. The sum of the initial contributions $A_0 = E_0 + P_0$ is then invested in assets, the so-called reference portfolio. Under the objective measure $\mathbb{P}$, the total market value of assets A evolves according to a geometrical Brownian motion,[1]

$$\mathrm{d}A(t) = \mu A(t)\mathrm{d}t + \sigma A(t)\mathrm{d}W^{\mathbb{P}}(t), \tag{1}$$

with asset drift μ, volatility σ, and a $\mathbb{P}$-Brownian motion $W^{\mathbb{P}}$, where we assume a complete, perfect and frictionless market. In this setting, solution of the stochastic differential equation in (1) (using Ito interpretation) is given by

$$A(t) = A(t-1)\exp(\mu - \sigma^2/2 + \sigma(W^{\mathbb{P}}(t) - W^{\mathbb{P}}(t-1))) \tag{2}$$

for $t = 1, 2, \ldots$ given $A(0) = A_0$ (see, e.g. Björk (2004)). By changing the measure to the risk-neutral unique equivalent

[1] Thus $(W_t), 0 \le t \le T$ stands for a standard Brownian motion on a probability space $(\Omega, \mathcal{F}, \mathbb{P})$ and $(\mathcal{F}_t), 0 \le t \le T$ is the filtration generated by the Brownian motion.