



Analyzing surplus appropriation schemes in participating life insurance from the insurer's and the policyholder's perspective

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ABSTRACT

This paper examines the impact of three surplus appropriation schemes often inherent in participating life insurance contracts on the insurer's shortfall risk and the net present value from an insured's viewpoint. (1) In case of the *bonus system*, surplus is used to increase the guaranteed death and survival benefit, leading to higher reserves; (2) the *interest-bearing accumulation* increases only the survival benefit by accumulating the surplus on a separate account; and (3) surplus can also be used to *shorten the contract term*, which results in an earlier payment of the survival benefit and a reduced sum of premium payments. The pool of participating life insurance contracts with death and survival benefit is modeled actuarially with annual premium payments; mortality rates are generated based on an extension of the Lee-Carter (1992) model, and the asset process follows a geometric Brownian motion. In a simulation analysis, we then compare the influence of different asset portfolios and shocks to mortality on the insurer's risk situation and the policyholder's net present value for the three surplus schemes. Our findings demonstrate that, even though the surplus distribution and thus the amount of surplus is calculated the same way, the type of surplus appropriation scheme has a substantial impact on the insurer's risk exposure and the policyholder's net present value.

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1. Introduction

Participating life insurance contracts are an important product design in the German insurance market and comprise various mechanisms of how surplus is distributed to the policyholders. Previous work has shown that different surplus distribution schemes can significantly impact the insurer's risk exposure. In this context, an important issue has not been comprehensively analyzed to date, which is the concrete appropriation of distributed surplus. In particular, in Germany, policies may feature different appropriation schemes.¹ Surplus appropriation refers to the way earned surplus, determined via a given surplus distribution mechanism, is actually credited to the individual policyholder. In the case of the bonus system, surplus is used to increase the guaranteed death and survival benefit. In contrast to this, the interest-bearing accumulation emphasizes the survival benefit, which is increased by the surplus, while the death benefit is kept constant. The third alternative uses the surplus to shorten the contract term, which results in an earlier payment of the survival benefit and a reduced sum of premium payments. These three

schemes have not been comparatively examined, even though their impact on the insurer's risk situation and the policyholders' expected payoff can differ considerably. The aim of this paper is to fill this gap and to analyze this issue in depth.

In the literature, participating life insurance, along with its surplus distribution mechanisms and interest rate guarantees, have attracted widespread attention. Research on the risk-neutral valuation of participating life insurance contracts includes, for example, Briys and de Varenne (1997), who study the fair value of a point-to-point guarantee, where the company guarantees only a maturity payment and an optional participation in the terminal surplus at maturity, and determine a closed-form solution based on contingent claims theory. Grosen and Jørgensen (2002) extend this framework by including a regulatory intervention rule, which reduces the insolvency probability and can be priced similar to barrier options. In Grosen and Jørgensen (2000), a cliquet-style interest rate guarantee is modeled, where surplus is annually credited to the policy reserves based on a reserve-dependent surplus distribution mechanism to smooth market returns. Once the surplus is credited to the reserves, it becomes part of the guarantee and is then annually at least compounded with the guaranteed interest rate, thus implying cliquet-style effects. Besides the bonus option and the minimum interest rate guarantee, the authors also include and evaluate a surrender option by means of American-style derivatives pricing. Based on the model by Grosen and Jørgensen (2000), Jensen et al. (2001)

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¹ See, e.g., Schradin et al. (2006, p. 17).

develop and apply a finite difference algorithm in order to numerically evaluate the contracts and further integrate mortality risk. Different annual surplus smoothing schemes are also examined in Hansen and Milthersen (2002) for the Danish case and in Ballotta et al. (2006), where specific focus is laid on a comparison and trade-off of fair contract parameters. A comparison of different surplus distribution models of participating life insurance with respect to model risk can also be found in Zemp (2011).

Other work that focuses on the surrender option embedded in participating life insurance contracts includes Albizzati and Geman (1994), who also account for stochastic interest rates, as well as Bacinello (2003) for an Italian-style contract. Siu (2005) treats the surrender option by means of a regime-switching model for economic states, including interest rates, expected growth rates and volatility of risky assets, and also presents approximation methods for participating American-style contracts. Schmeiser and Wagner (2011) compute fair values of options to early exercise, including the paid-up option, the resumption option, and the classical surrender option.

Furthermore, several papers have focused on combining risk pricing and risk measurement. Barbarin and Devolder (2005) propose a model to first assess the risk of a point-to-point guarantee and, second, calibrate the terminal bonus participation parameter to obtain fair contracts. Graf et al. (2011) extend the approach used by Barbarin and Devolder (2005) and generalize previous results by proving that the combination of actuarial and financial approaches can always be conducted as long as the insurance contracts do not introduce arbitrage opportunities. Gatzert and Kling (2007) determine the real-world risk implied by fair contracts with the same market value, and Gatzert (2008) further integrates different asset management and surplus distribution strategies in the analysis of participating life insurance contracts with the aim to assess their impact on the contracts' fair value, while keeping the default put option value constant. Kleinow and Willder (2007) study hedging strategies and calculate fair values for maturity guarantees, where the surplus participation depends on the insurer's management decisions regarding the investment portfolio.

With respect to surplus distribution schemes and risk measurement, Gerstner et al. (2008) provide a general asset-liability management framework for life insurance, which incorporates, *inter alia*, a reserve-dependent bonus distribution mechanism based on Grosen and Jørgensen (2000). As an application of their model, they study the impact of different parameter settings and exemplary products on the insurer's shortfall risk. Based on a single premium term-fix insurance and thus focusing purely on financial risks, Kling et al. (2007a) analyze the risk exposure of an insurer offering cliquet-style interest rate guarantees for different contract characteristics, including the initial reserve situation, asset allocation, and the actual surplus distribution. Kling et al. (2007b) extend this framework and consider the financial risk inherent in three surplus distribution systems, including surplus appropriation. The first system incorporates a cliquet-style interest rate guarantee, where the guaranteed rate also has to be paid on surplus, the second mechanism represents an interest-bearing accumulation, where surplus cannot be reduced once it has been credited to the policyholder's account (but without cliquet-effects), and third, a surplus model, where the insurer can reduce surplus to keep the insurance company in business and to avoid insolvencies. As in Kling et al. (2007a), mortality effects are not included.

Hence, what remains open is a holistic analysis of the financial and mortality risk of surplus appropriation schemes on the basis of a typical life insurance product, which is modeled actuarially by considering death and survival benefits. The explicit combination of actuarial pricing and reserving, as well as financial approaches, with respect to shortfall risk and valuation in the analysis of surplus

appropriation schemes has not been done to date and is intended to offer insight into the impact of the type and characteristics of surplus schemes on an insurance company's risk exposure and the policyholder's net present value. Furthermore, the system of shortening the contract term has not yet been examined.

The aim of this paper thus is to fill this gap by analyzing the impact of surplus appropriation schemes on a life insurer's risk exposure. In addition and apart from this perspective on risk, we further study the policyholders' net present value, i.e., the difference between the expected discounted death or survival benefit and the sum of premium payments. The model of the life insurance company is based on a participating life insurance contract² with annual premiums, where mortality rates are modeled using an extension of the Lee-Carter (1992) model proposed by Brouhns et al. (2002), and the asset base follows a geometric Brownian motion. In contrast to previous literature, insurance liabilities for a pool of policies with death and survival benefits are calculated using actuarial reserving rules, which depend on the surplus mechanism. In particular, based on the smoothing surplus distribution scheme of Grosen and Jørgensen (2000), we analyze and compare three companies with different appropriation schemes, including the bonus system,³ the interest-bearing accumulation,⁴ and shortening the contract term. In a numerical simulation analysis, we study the influence of different asset portfolios and shocks to mortality on the insurer's risk situation and the policyholder's net present value. Our findings demonstrate that, even though the surplus distribution and thus the amount of surplus is calculated the same way, the type of surplus appropriation scheme substantially impacts the insurer's risk exposure and the policyholder's net present value. In addition, the effect of the choice of the asset portfolio as well as shocks to mortality differ considerably with respect to the insurer's risk level depending on the respective surplus appropriation scheme, which should be taken into account in the context of underwriting activities and in asset management.

The paper is structured as follows. Section 2 introduces the model framework of the insurance company and the three surplus appropriation schemes under consideration as well as the asset and mortality model. Numerical results are presented in Section 3, and Section 4 concludes.

2. Model framework

2.1. Overview of the insurance companies

We consider three life insurance companies that differ only in their surplus appropriation scheme, i.e., the way the surplus distributed to the policyholders is actually appropriated to their accounts. The schemes are present in the German insurance market, but may as well be extended to similar schemes in other countries. In the case of the bonus system, surplus is used to increase the guaranteed death benefit as well as the survival benefit and thus increases the policy reserves. In contrast to this, the interest-bearing accumulation emphasizes the survival benefit, which is increased by the surplus (and guaranteed until maturity), while the death benefit is kept constant. The third alternative uses the surplus to shorten the contract term, which results in an earlier payment of the survival benefit and a reduced sum of premium payments. The corresponding balance sheet for all three types of companies is exhibited in Table 1.

² In this paper, we use the expression "participating life insurance" analogously to an endowment contract.

³ The bonus system accounts for cliquet-style effects, and, by including mortality, surplus leads to higher payments to the policyholders during the contract term due to the increased death benefits.

⁴ The interest-bearing accumulation has been studied in a similar form in Kling et al. (2007b) but without death benefits or explicit actuarial reserving rules.

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