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Risk comparison of different bonus distribution approaches in participating life insurance

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ABSTRACT

The fair pricing of explicit and implicit options in life insurance products has received broad attention in the academic literature over the past years. Participating life insurance (PLI) contracts have been the focus especially. These policies are typically characterized by a term life insurance, a minimum interest rate guarantee, and bonus participation rules with regard to the insurer's asset returns or reserve situation. Researchers replicate these bonus policies quite differently. We categorize and formally present the most common PLI bonus distribution mechanisms. These bonus models closely mirror the Danish, German, British, and Italian regulatory framework. Subsequently, we perform a comparative analysis of the different bonus models with regard to risk valuation. We calibrate contract parameters so that the compared contracts have a net present value of zero and the same safety level as the initial position, using risk-neutral valuation. Subsequently, we analyze the effect of changes in the asset volatility and in the initial reserve amount (per contract) on the value of the default put option (DPO), while keeping all other parameters constant. Our results show that DPO values obtained with the PLI bonus distribution model of Bacinello (2001), which replicates the Italian regulatory framework, are most sensitive to changes in volatility and initial reserves.

1. Introduction

In recent years, pricing and fair valuation of explicit and implicit options in life insurance products have received broad attention in the academic literature and by practitioners. In particular, participating life insurance (PLI hereafter) contracts have been the focus. Besides embedding a term life insurance and a minimum interest rate guarantee, these policies comprise bonus participation rules regarding the insurer's profit. Researchers replicate these bonus policies differently, depending on the regulatory framework that the model is applied to and on the research objective. A comparative analysis of these bonus models with respect to risk appears to be difficult, since designs differ greatly. Thus, earlier literature mainly focuses on risk analysis with regard to one bonus distribution model while avoiding a direct comparison across different schemes. However, changing market conditions, for instance a change in asset volatility, may affect these models quite differently. Similarly, inaccurate parameter estimations (parameter uncertainty) could have a stronger impact on one model than on the others. Thus, a direct comparison of bonus distribution models can provide important insight, in particular for regulators. Regulators can identify model risks that they impose on insurance companies, which could be less pronounced with bonus distribution models found in other countries. As a consequence, regulators may reconsider the bonus distribution approach chosen and adopt one that appears to be less sensitive to parameter estimations.

In this paper, we categorize and present the most common PLI bonus distribution mechanisms. Subsequently, we perform a comparative analysis of the different bonus models with regard to risk. We calibrate contract parameters so that the compared contracts have a net present value of zero and the same safety level under the risk-neutral probability measure $\mathbb{Q}$ as initial position. The safety level is defined as the expected present value of the default put option (DPO hereafter), which corresponds to the situation in which a regulatory authority prescribes a certain safety level (e.g., Solvency II or the Swiss Solvency Test). Based on this parameterization, we derive sensitivities of the DPO value regarding the underlying asset volatility, as well as the company's reserve situation.

Our results provide new insight for insurance companies as well as regulators on the risk involved in different bonus distribution models. Using the results of our analysis and/or applying our method of comparison will support regulatory authorities (as well as insurance companies) in selecting a bonus distribution model whose default risk is less sensitive to parameter estimations, i.e., to identify a bonus model on which parameter uncertainty has less impact. In particular, our analysis evaluates model risks associated with the misspecification of the underlying asset volatility for the

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different PLI bonus modeling approaches. Similarly, we compare to what extent a growing pool size – which will naturally reduce the amount of reserves per contract if no increase in equity capital takes place – influences the default risk in these bonus modeling approaches.

The field of fair valuation of PLI contracts has been researched extensively. In their basic setting, most PLI models work with single-premium contracts, whereas the policyholder is assumed to continue until maturity (i.e., does not die or surrender). As a common factor in European countries (e.g., Germany, Denmark, Switzerland) we focus on bonus models which embed a cliquet style interest rate guarantee and some kind of bonus distribution mechanism. The most fundamental and frequently applied models in this area are the ones introduced by Bacinello (2001), Haberman et al. (2003), Grosen and Jørgensen (2000), Hansen and Miltersen (2002) and Kling et al. (2007). We do not analyze the bonus models of Barbarin and Devolder (2005) and of Briys and de Varenne (1997), since they involve a point-to-point guarantee, not a cliquet style one. Furthermore, we do not focus on Albizzati and Geman (1994), Tanskanen and Lukkarinen (2003) and Kleinow (2009). Albizzati and Geman (1994) do not incorporate any bonus distribution mechanism while Tanskanen and Lukkarinen (2003) and Kleinow (2009) derive general PLI models for fair valuation which allow for implementing different bonus policies.

Bacinello (2001) introduces a model of PLI based on the Italian regulatory framework. Her basic model features a bonus distribution scheme based on the annual return on a reference portfolio. The bonus model does not incorporate any reserve building/profit stabilization mechanism and is therefore relatively elementary. Bacinello (2003) additionally embeds a surrender option.

On the other hand, Haberman et al. (2003) include a return stabilization mechanism—their bonus distribution is based on the arithmetic average return over the past years and is built upon the British regulatory framework.[1] Additionally, Ballotta et al. (2006) incorporate the DPO. This bonus distribution model is applied by Ballotta (2005), who changed the underlying asset process to a jump-diffusion and was adapted by Kleinow and Willder (2007).

On the contrary, Grosen and Jørgensen (2000) do not distribute bonuses based on returns, but rather based on the company's reserve situation. Their bonus model is based on the Danish regulatory environment. It has been applied by Jensen et al. (2001), Prieul et al. (2001), Siu (2005) and Gerstner et al. (2008). An important extension of the model of Grosen and Jørgensen (2000) can be found in Hansen and Miltersen (2002). They include terminal bonus payments and annual fees to the insurance company. Similar bonus models can be found in Miltersen and Persson (2000) and Miltersen and Persson (2003).

Finally, Kling et al. (2007) developed a framework which strives to closely replicate the German insurance market. They work with a target interest rate, which leads to stable profits for policyholders as long as the reserve situation remains relatively stable. This bonus model was applied by Bauer et al. (2006) and Zaglauer and Bauer (2008).

The purpose of this paper is to present and analyze the five basic PLI bonus distribution models under the risk-neutral measure $\mathbb{Q}$, namely Bacinello (2001), Haberman et al. (2003), Grosen and Jørgensen (2000), Hansen and Miltersen (2002) and Kling et al. (2007). In particular, we calculate and compare the value of the DPO given by these different models. First, we introduce and categorize the five basic bonus models and apply an integrative notation. To the best of our knowledge, only Cummins et al. (2007) compare different PLI models. However, Cummins et al. (2007) do not perform a risk comparison, but rather an analysis of the discounted payoff distribution.

Second, we calibrate contract parameters so that the compared bonus distribution mechanisms have the same (fair) contract value and the same safety level (defined as the present value of the DPO), under the risk-neutral measure. Third, we derive sensitivities of the DPO value to changes in the underlying asset volatility, as well as the company's initial reserve situation (per contract), while keeping all other contract parameters fixed. By doing so, we are able to compare the DPO value across the introduced bonus distribution models. Only Gatzert and Kling (2007) provide a framework that allows a comparison of PLI contracts which embed a cliquet style option with regard to risk. They analyze shortfall probability measures (e.g., lower partial moments) with regard to the bonus models of Grosen and Jørgensen (2000), Hansen and Miltersen (2002) and Briys and de Varenne (1997). However, although they identify key risk drivers, they avoid a direct comparison across the different models. By contrast, we introduce a new method for calibrating PLI contracts that allows us to directly compare the risk involved in the different bonus distribution models. In addition, by keeping our initial calibration fixed, we can isolate effects caused by changes in the underlying asset volatility and the initial reserve situation (i.e., we can directly assess model risks).

The remainder of this paper is organized as follows. Section 2 introduces the basic model properties. In Section 3, the five different PLI bonus distribution models are presented. Section 4 provides the comparative analysis. We present our conclusions in Section 5.

Table 1
The insurance company's balance sheet at time t. The left column shows the insurance company's assets $A(t)$ and the right column shows the corresponding liabilities $(P(t), B(t), C(t))$.

Assets	Liabilities
$A(t)$: assets	$P(t)$: policyholder's savings account $B(t)$: bonus account $C(t)$: company's account
$A(t)$: total assets	$A(t)$: total assets

2. Basic model framework

2.1. Model overview

We assume an insurance company with various homogeneous insurance contracts (or one single large contract). The policyholder pays a single upfront premium P_0 and is assumed to continue the contract until maturity T (i.e., we exclude death or surrender). Table 1 shows the company's balance sheet at time t. $P(t)$ denotes the value of the policyholder's account at time t. $C(t)$ is the company's account and $B(t)$ is the so-called bonus reserve which consists of asset valuation reserves as well as equity capital. The sum of all three accounts gives the company's asset base $A(t)$. The policyholder's initial proportion of assets is denoted by

$$\theta = \frac{P_0}{P_0 + B_0 + C_0} = \frac{P_0}{A_0}, \quad (1)$$

where $P_0 = P(0), B_0 = B(0), C_0 = C(0)$, and $A_0 = A(0)$. In the following, we describe in detail how these different balance sheet accounts develop over time.

[1] In fact, Haberman et al. (2003) introduce three different bonus distribution schemes. We apply this scheme as it is commonly used by British insurance companies (see Ballotta et al., 2006). Thus, if we mention the bonus model of Haberman et al. (2003) throughout this paper, we always refer to the model whose smoothing mechanism is based on the arithmetic mean return over past periods.