Insurance: Mathematics and Economics 49 (2011) 580–596

Contents lists available at SciVerse ScienceDirect

Insurance: Mathematics and Economics

journal homepage: www.elsevier.com/locate/ime

A joint valuation of premium payment and surrender options in participating life insurance contracts

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ARTICLE INFO

Article history:
Received September 2010
Received in revised form
December 2010
Accepted 19 August 2011

JEL classification:
G22
G23
G13

MSC:
IM10
IB10
IE10
IE50

Keywords:
Participating life insurance contracts
Embedded options
Paid-up and resumption
Surrender
Monte Carlo method
Optimal stopping problem

ABSTRACT

In addition to an interest rate guarantee and annual surplus participation, life insurance contracts typically embed the right to stop premium payments during the term of the contract (paid-up option), to resume payments later (resumption option), or to terminate the contract early (surrender option). Terminal guarantees are on benefits payable upon death, survival and surrender. The latter are adapted after exercising the options. A model framework including these features and an algorithm to jointly value the premium payment and surrender options is presented. In a first step, the standard principles of risk-neutral evaluation are applied and the policyholder is assumed to use an economically rational exercise strategy. In a second step, option value sensitivity on different contract parameters, benefit adaptation mechanisms, and exercise behavior is analyzed numerically. The two latter are the main drivers for the option value.

1. Introduction

Flexible premium payment options are offered in most life insurance contracts in the US and European market. In this work we consider a *paid-up option*, the right to stop premium payments annually until maturity of the contract, a *resumption option*, the right to resume payments after exercising the paid-up option, and, a *surrender option*, the right to terminate the contract early. Exercising these options implies that the benefits – on death, survival and surrender (if applicable) – are adapted, namely, decreased or increased, depending on the option and the underlying contract policy. The paid-up option differs from the surrender option in that the contract is not terminated but continues with adapted (reduced) benefits. The resumption option allows to resume premium payments, after exercise of the paid-up option, and thus to increase the previously adapted benefits. The aim of this article is to study the value of these options and combinations thereof within participating life insurance contracts that include two standard options, namely, an *interest rate guarantee*, and, a *guaranteed annual surplus participation*.

Life insurance contracts often embed various types of implicit options. In Summer 2000 when the British life insurer Equitable Life had to stop taking new business due to an improper hedging of provided options, concern over these kind of options was intensified. This example shows how false estimation of policyholders' option exercise behavior can induce considerable problems to an insurer. In light of the financial crisis and the new variable annuity products with embedded options, the importance of the valuation and the risk management of options in insurance contracts has become even more evident. Recent examples are the stop for new business for variable annuity products, e.g., from the US insurer The Hartford (May 2009 in the UK), and similarly from French insurer AXA (TwinStar Invest product, May 2009 in Germany). Hence, it is basically not enough to consider a product as "sufficiently" priced, without analyzing specific option-like elements embedded in the

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doi:10.1016/j.insmatheco.2011.08.004

contract. Additionally, the sole assumption that policyholders do not exercise options rationally from an economic point of view is generally not adequate, even if this could be shown with an *ex post* analysis; in fact policyholders could possibly be advised to exercise in principle close to the right moment, with accordingly potential drawbacks for the insurance company.

Furthermore, in a competitive market, the separate inspection of embedded options with regard to pricing and risk management is crucial. Knowledge over the option's value and its drivers are important for product design. For a given product with its conversion mechanism of the guaranteed benefits after exercise of the options, and assumptions on the policyholder's exercise behavior, the value of embedded options can be calculated. Furthermore, zero-valued options could be offered through arranging a re-configuration of the product, for example, through adaptation of the benefit conversion mechanism. Adequate pricing of embedded options is a competitive advantage and hence option pricing has to be taken into account since policy inception. With regard to stress-testing of products, it is relevant to know the fair price to be able to answer practical questions, like how much more value a policyholder could get by exercising differently than what has been observed.

Finally, current and planned regulation rules and reporting standards (Solvency II, SST,[1] NAIC RBC,[2] IFRS) prescribe risk-adequate capital deposits for embedded options. For evaluation of the necessary capital, detailed risk models are required and hypotheses, e.g., on the policyholder's exercise behavior needs, should be used. In many cases, internal models for the risk assessment need to be refined to comply with the rules, and the options offered have to be analyzed with care.

In recent scientific literature, option valuation has also been of growing interest. Fair pricing of contracts with a guaranteed interest rate and different annual surplus participations are studied, e.g., by Bacinello (2001), Hansen and Miltersen (2002), Tanskanen and Lukkarinen (2003), Ballotta et al. (2006) and Branger et al. (2010). Grosen and Jorgensen (2000) and Jensen et al. (2001) take into account the surrender option, on top of the analysis of guaranteed interest rate and surplus participation. The works by Bacinello (2003a,b, 2005); Bacinello et al. (2009) focus on the analysis of the surrender option in Italian life insurance contracts with single and periodic premiums, including mortality risk; the surrender option in French life insurance contracts is analyzed by Albizzati and Geman (1994). Note that most studies consider paid-up and surrender options which are studied separately. Herr and Kreer (1999) model a life insurance contract with surrender and paid-up options with underlying stochastic interest rates; here the surplus participation is considered to be deterministic. Further works including the analysis of surrender and paid-up options are provided in the general framework provided by Steffensen (2002), or the actuarial approach comparison done in Linnemann (2003, 2004).

Numerical analysis of risk-neutral valuation of embedded options has been recently done in Bauer et al. (2006). Bauer et al. (2010) give a broad overview on numerical techniques while other works synthesize and analyze the performance (e.g., Brennan and Schwartz, 1978 and Bakshi et al., 1997), assess option pricing functions (Scott, 1987), or correctly identify risk premia (Branger and Schlag, 2008). Kling et al. (2006) perform an analysis of paid-up options for government-subsidized pension products in Germany based on different assumptions about the policyholder's exercise behavior. Option valuation has been executed in several different ways, including the calculation through an optimal feasible exercise strategy in the case of one Bermudan-style embedded option, see for example the works by Barraquand and Martineau (1995) and Andersen (1999), applied in Douady (2002) and Kling et al. (2006).

The present methodology and framework is closest to the work done by Gatzert and Schmeiser (2008). In the latter, paid-up and resumption options in life insurance contracts are studied with the focus on the assessment of the risk arising from theses options. When pricing the embedded options in the framework of this paper, which is not done in Gatzert and Schmeiser (2008), nor in their focus, the option values are zero, and this holds independently of the benefit conversion mechanism and the timing of option exercise. Since conversion mechanisms are crucial for insurers, and in order to most transparently analyze them from a customer point of view, we switch from a reserve-linked modeling (as, e.g., in Gatzert and Schmeiser (2008)) to a perspective concentrating on policy assets in this paper. Furthermore, the present work also includes the surrender option and focus lies on joined option pricing with respect to the policyholder's exercise behavior and the benefit conversion offered by the insurer.

A joint valuation of the combination of the above introduced premium payment options, namely, the paid-up, resumption and surrender options, in a same model framework using an optimal economically rational exercise strategy has not been studied to date. In a first step, we provide a framework that includes a basic participating life insurance contract with annual premium payments including two standard options, interest rate guarantee and guaranteed annual surplus participation. In a second step, we include the above mentioned premium payment options: We consider contracts embedding only one of these options, and contracts embedding the combination of the paid-up and resumption, or the paid-up and surrender option respectively. Combining two options leads to a complex path-dependent structure relying on the policyholder's exercise strategy as well as the conversion of the guaranteed benefits after exercise of an option. The interaction between financial and mortality factors, periodic premium payments, and the options leads to a complex payoff distribution for the contract.

Three valuation techniques relying on different assumptions to evaluate the derived framework are proposed. The core valuation is the assessment of the *option value* through an optimal exercise strategy. For valuation, we apply the standard principles of risk-neutral evaluation and assume that the policyholder makes the optimal decision (timing of exercise) based only on available information. In this paper, building on the valuation technique presented in Andersen (1999) and Douady (2002), written out in Kling et al. (2006) for the case of only one option, the method is used and extended to allow for the joint valuation of two options. Other interesting valuations include the maximum of the option payoff giving rather the behavioral-independent risk potential, or, evaluating and maximizing the expected payoff for different exercise times. At different stages, the sensitivity of the reported values to a variation of the contract parameters is assessed.

Key results include the contract valuation and payoff values for different contract parameters. A detailed analysis of the fair pricing, through adaptation of the annual surplus participation, of the basic contract with regard to the contract length, the guaranteed interest rate respectively risk-free interest rate, and investment volatility is given. The presented algorithm for finding and applying an optimal exercise strategy in the case of the valuation of combined options is tested in different configurations. We compare the resulting option value with the maximal risk potential of the option offering. The option value yields values of the order of 1%–3% of the expected premium payments,[3]

[1] Swiss Solvency Test.

[2] Risk based capital (RBC) according to the National Association of Insurance Commissioners (NAIC).

[3] Expected premium payments denote the value of all payments made into the contract, discounted at time $t = 0$, conditional upon average mortality probability and average probability of option exercise.