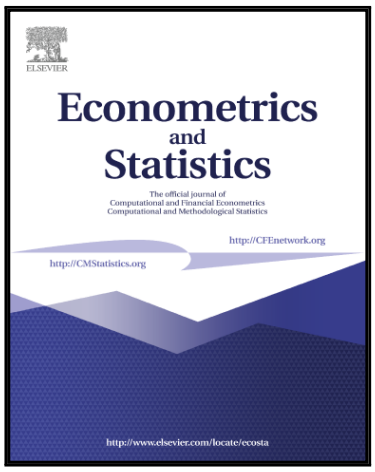

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Yixing Zhao, Rogemar Mamon, Huan Gao

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A two-decrement model for the valuation and risk measurement of a guaranteed annuity option

Yixing Zhao[a], Rogemar Mamon[a,b,*], Huan Gao[c]

[a]Department of Statistical and Actuarial Sciences, University of Western Ontario, London, Ontario, Canada
[b]Division of Physical Sciences and Mathematics, University of the Philippines Visayas, Miag-ao, Iloilo, Philippines
[c]Model Validation, Bank of Montreal Financial Group, Toronto, Ontario, Canada

Abstract

The lapse risk arising from the termination of policies, due to a variety of causes, has significant influence on the prices of contracts, liquidity of an insurer, and the reserves necessary to meet regulatory capital. The aim is to address in an integrated manner the problem of pricing and determining the capital requirements for a guaranteed annuity option when lapse risk is embedded in the modelling framework. In particular, two decrements are considered in which death and policy lapse occurrences with their correlations to the financial risk are explicitly modelled. A series of probability measure changes is employed and the corresponding forward, survival, and risk-endowment measures are constructed. This approach superbly circumvents the rather slow "simulation-within-simulation" pricing procedure under a stochastic setting. Implementation results illustrate that the proposed approach cuts down the Monte-Carlo simulation technique's average computing time by 99%. Risk measures are computed using the moment-based density method and benchmarked against the Monte-Carlo-based numerical findings. Depending on the risk metric used (e.g., VaR, CVaR, various forms of distortion risk measures) and the correlation between the interest and lapse rates, the capital requirement may substantially change, which could be either an increase or decrease of up to 50%.

Keywords: stochastic model, lapse rate, change of probability measure, risk measure, moment-based density approximation

1. Introduction

Financial innovations, created to respond to the needs of clients amidst increased longevity and an ageing population, have made the insurance market an investment hub. A wider range of products that both act as income security and investment protection is now available. This kind of products typically has option-embedded features and requires the accurate modelling of the uncertainty akin to various risk factors along with the correlation amongst them. Interest and mortality risks are deemed to be the two most important factors in the valuation and risk management of longevity products; they have been extensively examined altogether for several decades. Nonetheless, lapse risk is another essential factor in pricing insurance products; such a risk refers to the possibility that policyholders terminate their policies early for various reasons. Policy's lapse risk could then lead to huge losses and liquidity problem for insurance companies, and therefore, is an important consideration given economic and financial uncertainties.

Some theoretical and empirical studies were carried out in an attempt to explain the lapses' determinants and eventually incorporate them in actuarial pricing and risk management. For instance, Kim [20] and Zians et al. [38] developed lapse-rate models with explanatory variables dependent mainly on (i) unemployment rate and (ii) the difference between market interest and credit rates, whilst Albizzati and Geman [1] and Bacinello [2] considered the surrender option embedded in a life insurance. For a comprehensive review of lapse-rate modelling in life insurance, one may refer to Eling and Kochanski [8].

In current practice, lapse rate is assumed constant in actuarial valuation as research advances on its modelling are rather slow and not sustaining as those of interest and mortality dynamics. Such a lack of research progress is attributed primarily to the absence of reliable data and inability to access copyrighted data owned by a company or professional organisation. One may use, however, insights on certain longevity product (e.g., variable annuity (VA)) in probing the very nature of lapse risk. Recall that a VA is a tax-deferred investment that allows the holder to choose from a suite of investments paying retirement income at a level dependent on the over all performance of the selected investments. A penalty is levied when a VA contract is terminated, and this mechanism somehow mitigates policy surrender, thereby lowering the lapse rate. Nonetheless, the surrender of a VA is most likely if there are investment alternatives that have better returns outweighing surrender losses.

Also, we note that policyholder's decision to surrender is directly affected by economic circumstances. For instance, when interest rate falls, which in turn stimulates borrowing, a low lapse rate is expected because the policy holder can obtain a loan at a lower interest rate instead of incurring a heavy surrender penalty. Although there are papers that deal with the dynamic behaviour of lapse rates (e.g., Xue [35]; De Giovanni [6]; and Loisel and Milhaud [24]), their aims are not aligned to actuarial applications. Furthermore, their frameworks do not take into consideration the interaction amongst lapse risk, interest rate and mortality risk. In Barsotti et al. [3], the correlation and contagion effects covering policyholders behaviors are embedded into a

*Corresponding author. Department of Statistical and Actuarial Sciences, University of Western Ontario, 1151 Richmond Street, London, Ontario, Canada, N6A 5B7. Email: *rmamon@stats.uwo.ca*