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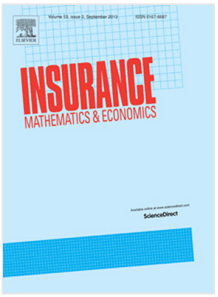

Analytical valuation and hedging of variable annuity guaranteed lifetime withdrawal benefits

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Analytical Valuation and Hedging of Variable Annuity Guaranteed Lifetime Withdrawal Benefits

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Abstract

Variable annuity is a retirement planning product that allows policyholders to invest their premiums in equity funds. In addition to the participation in equity investments, the majority of variable annuity products in today's market offer various types of investment guarantees, protecting policyholders from the downside risk of their investments. One of the most popular investment guarantees is known as the guaranteed lifetime withdrawal benefit (GLWB). In current market practice, the development of hedging portfolios for such a product relies heavily on Monte Carlo simulations, as there were no known closed-form formulas available in the existing actuarial literature. In this paper, we show that such analytical solutions can in fact be determined for the risk-neutral valuation and delta-hedging of the plain-vanilla GLWB. As we demonstrate by numerical examples, this approach drastically reduces run time as compared to Monte Carlo simulations. The paper also presents a novel technique of fitting exponential sums to a mortality density function, which is numerically more efficient and accurate than the existing methods in the literature.

Key Words. Variable annuity guaranteed benefit, guaranteed lifetime withdrawal benefit, risk-neutral valuation, delta-hedging, fitting probability density function, exponential sums.

1 Introduction

Variable annuities(VAs) are life insurance contracts that offer policyholders participation in equity investments. They provide life contingent benefits like traditional life insurance or annuities, while allowing policyholders to reap benefits of financial returns on their premiums. Variable annuities were introduced in the United States in 1950s with the earliest products made available by the Teachers Insurance and Annuity Association of America (TIAA) - College Retirement Equities Fund (CREF). They were created to provide incomes with investment returns to retired professors. Nowadays variable annuities have become popular products available through direct purchase or through tax-sheltered retirement savings plans such as IRAs, 401(k)s, 403(b)s, etc. Various forms

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