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Random Willow Tree with Application in Risk Management

Derivatives underlying a portfolio is popular on the market to diversify the market risk. However, existing method, the nested simulation, is quite time-consuming for pricing and managing the risk. In this article, we propose an efficient approach, randomized willow tree method. There are three main stages for our approach, portfolio distribution approximation, randomized willow tree construction and managing the risk of derivatives. We first generate some simulated paths to describe the evolution of dynamic portfolio values. Then, the minimal relative entropy (MRE) method is applied to approximate the distribution of portfolio values at each time based on the simulated data. After the approximated distributions are determined, a randomized willow tree can be constructed for pricing and managing the risk of derivatives underlying the portfolio. Finally, we apply the proposed approach to calculate annual dollar delta, 99% VaR and CVaR of a particular derivative, i.e., a 19-year variable annuity with guarantee riders. This application demonstrates the efficiency and accuracy of the proposed approach compared with the common nested simulation technique, especially for a large pool of derivatives underlying the same portfolio.