The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Exact Simulation and Rare Event Simulation Methods in Derivative Pricing and Risk Management

By

Mr. Ziqing XU

ABSTRACT

In this thesis, we discuss two types of Monte Carlo simulation methods and their applications in quantitative finance. In the first project, we investigate analytical solvability of models with affine stochastic volatility (SV) and L´evy jumps by deriving a unified formula for the conditional moment generating function of the log-asset price and providing the condition under which this new formula is explicit. We then combine our theoretical results, the Hilbert transform method, various interpolation techniques, with the dimension reduction technique to propose unified simulation schemes for solvable models with affine SV and L´evy jumps. Our approach is applicable to a broad class of models, maintains good accuracy, and enables efficient pricing of discretely monitored path-dependent derivatives. We analyze various sources of errors arising from the simulation approach and present error bounds. Extensive numerical results demonstrate that our method is highly accurate, efficient, simple to implement, and widely applicable. In the second project, we explore various enhancements in rare event simulation algorithms to achieve better computational efficiency and accuracy for computing marginal risk contributions of the popular Gaussian copula model and t-copula model. The Glasserman-Li exponential twisting method is seen to have a close link with the saddlepoint approximation method. We develop the hybrid saddlepoint approximation method that inherits the merit of the nice analytical tractability exhibited by the saddlepoint approximation framework. We enhance the efficiency of calculating the saddlepoint via an interpolation procedure. We also propose new formulas to enhance the cross entropy method for the estimation of the optimal parameters in the t-copula model. Extensive numerical tests on computing risk contributions were performed on various copula models with multiple risk factors. Our enhanced exponential twisting method, cross entropy method, and hybrid saddlepoint approximation method are seen to exhibit a high level of efficiency, accuracy, and reliability when compared with existing importance sampling algorithms in computing risk measures and marginal risk contributions in copula credit models.

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Time : 11:00 am

Venue : Room 4475 (Lifts 25/26)

***Thesis Examination Committee*:**

Chairman	**:**	**Prof. Andrew Wing On POON, ECE/HKUST**
Thesis Supervisor	**:**	**Prof. Yue Kuen KWOK, MATH/HKUST**
Thesis Supervisor	**:**	**Prof. Ping-Ping ZENG, Department of Mathematics/ Southern University of Science and Technology**
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Member	**:**	**Prof. Wei JIANG, IEDA/HKUST**
External Examiner	**:**	**Prof. Nan CHEN, Department of Systems Engineering and Engineering Management/ The Chinese University of Hong Kong**

(Open to all faculty and students)

The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).