

CAI WU

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EDUCATION

University of California, Santa Barbara
PhD in Statistics and Applied Probability

Sep 2025 - Now

Fudan University
Bachelor of Science in Economics, minor in Financial Mathematics

Sep 2020 - June 2025

University of California, Berkeley
Visiting student in BGA program

Jan 2023 - May 2023

RESEARCH INTEREST

Domain Quantitative Finance, Decentralized Finance, Financial Technology; E-sports Analytics; Operations Research

PUBLICATIONS, PREPRINTS, AND WORKING PAPERS

1. VIX options valuation via continuous-time Markov chain approximation and Itô-Taylor expansion, with Zhenyu Cui, Chihoon Lee, and Mingzhe Liu. *The Journal of Derivatives* 32.1 (2024): 11-31.
2. Explicit solution to the economic index of riskiness, with Zhenyu Cui and Lingjiong Zhu. *Economics Letters* 232 (2023): 111343.
3. Adding and subtracting Merton: a new approach for optimal portfolio and consumption problem, with Zhenyu Cui, Kailin Ding, and Yanchu Liu. *Working paper*.
4. Variance optimality of empirical martingale simulation estimators, with Zhenyu Cui, Yanchu Liu, Ruodu Wang, and Lingjiong Zhu. *Working paper*.
5. An exact explicit solution to the adjustment coefficient in risk theory, with Zhenyu Cui. *Permanent working paper*.

RESEARCH EXPERIENCE AND ONGOING PROJECTS

Adding and subtracting Merton: A new approach for the optimal portfolio problem

Undergraduate researcher advised by Prof. Zhenyu Cui

Oct 2023 - Present

- Proposed a diffusion-operator-integral-expansion-based method to solve optimal investment and consumption problems, particularly analytically intractable ones, which is flexible enough to incorporate multi-dimensional underlying stochastic processes and non-concave utility functions.
- Designed and programmed for numerical experiments for the application of the proposed method to the optimal investment problem under the CEV, Heston, and $4/2$ models, optimal investment-consumption problem under the setting of mean-reverting returns, optimal bond allocation with consumption under affine term structure, and optimal investment problem with S-shaped utility function.

Variance optimality of empirical martingale simulation estimators

Undergraduate researcher advised by Prof. Zhenyu Cui

June 2023 - Present

- Provided theoretical foundations of the variance optimality of empirical martingale simulation (EMS) estimator introduced in Duan and Simonato (1998), which is an improvement of Monte Carlo estimator.
- Helped establish the conditions under which the asymptotic variance of the EMS estimator is smaller than that of the standard Monte Carlo estimator, with specific cases where the EMS estimator is not effective in reducing the variance discussed.
- Designed and programmed for the numerical tests of the application of EMS to European option pricing under the Variance gamma process and Heston model, in addition to two extreme cases under Black-Scholes model showing both the dramatic efficiency and possible inefficiency of EMS.

VIX options valuation via continuous-time Markov chain approximation and Itô-Taylor expansion

Undergraduate researcher advised by Prof. Zhenyu Cui

May 2023 - Feb 2024

- Proposed an analytical method to price VIX derivatives under stochastic volatility models based on a closed-form approximation of VIX index through Itô-Taylor expansion and the subsequent continuous-time Markov chain approximation.

- Programmed for the numerical tests implementing the Itô-Taylor expansion to obtain an approximate VIX value under the Heston, CEV, $3/2$, $4/2$ and α -hypergeometric models and compared with benchmark values obtained from closed-form expressions or Monte Carlo simulations.
- Programmed for the numerical tests implementing the CTMC approximation to obtain an approximate VIX option prices under the aforementioned models and compared with benchmark values obtained from Monte Carlo simulations.
- Carried out the sensitivity analysis of convergence for the Itô-Taylor expansion of VIX in terms of the order of expansion and the CTMC approximation under the aforementioned models with regard to the initial stock price and strike.
- Designed the calibration scheme for both affine and non-affine stochastic volatility models and calibrated the Heston, $3/2$ and α -hypergeometric model utilizing VIX options quotes data of 2016 on a weekly scale.

Explicit solution to the economic index of riskiness and the adjustment coefficient in risk theory

Undergraduate researcher advised by Prof. Zhenyu Cui

May 2023 - Oct 2023

- Proposed an exact series expansion formula for the economic index of riskiness and the adjustment coefficient in risk theory utilizing Lagrange inversion theorem.
- Derived the explicit expression for three specific riskiness indices, Cramér-Lundberg model (both with and without reinsurance), Sparre-Anderson model, discrete time risk model and a few more types of Lundberg equation.
- Programmed for all the numerical experiments, including Aumann-Serrano index under Gamma distributed gambles, Foster-Hart riskiness index under uniformly and Beta distributed gambles, BCCY riskiness under uniformly distributed gambles and exponential and Erlang(2) claims in the classical Cramér-Lundberg model to verify the accuracy and convergence efficiency of the proposed series expansion.

Offline simulation of portfolio default risk under stochastic volatility models

Fudan University

"Chun-Tsung Scholar" advised by Prof. Yanxi Hou, funded by Hui-Chun Chin and Tsung-Dao Lee Chinese Undergraduate Research Endowment (CURE)

Nov 2022 - Nov 2023

- Replicated numerical tests implemented in Jiang et al. (2019) to verify their proposed method to measure the portfolio default risk.
- Combined variance reduction techniques like EMS to the simulation as a modification to the perturbation method.
- Designed and programmed for additional experiments for underlying assets modeled by the $3/2$ model, α -hypergeometric model and portfolio including path-dependent products like arithmetic Asian options with floating strike and lookback options to illustrate the accuracy and efficiency of the proposed method.

SKILLS

Coding Languages

Python, MATLAB, Mathematica

Natural Languages

Chinese Mandarin (native), Japanese (native), English (fluent)