The Cambodia Journal of Basic and Applied Research

Journal homepage: http://www.rupp.edu.kh/CJBAR/

Print ISSN: 2790-3508 Online ISSN: 2790-3516

# News

## A Multiscale Heston's Stochastic Volatility Model with a Stochastic Interest Rate Principal Investigator (PI) and Co-PIs: Dr. Sotheara Veng (PI, RUPP), Dr. Sony Chan (Co-PI, RUPP), and Dr. Ji-Hun Yoon (Member, Pusan National University, Korea)

Dr Veng and his team completed their 3-year Higher Education Improvement Project (HEIP) successfully between 01 January 2020 and 31 December 2022. The project cost 20,978.645 US dollars. The Heston stochastic volatility model has been considered to be one of the most popular models in option pricing problems. It is known that the Heston model is able to describe a number of well-known empirical features of asset price, and provides an analytical formula for standard European options. Still, it has a number of drawbacks. To address these, the Heston model is brought into a multiscale stochastic volatility model by incorporating an additional fast mean-reverting factor on top of the square root process. This model brings significant improvement over the Heston model. However, in this multiscale stochastic model, the interest rate is assumed to be constant, which does not fully take into account its real stochastic nature.

In this research proposal, they incorporate a stochastic interest rate into the multiscale stochastic volatility model to study a European option pricing problem and a portfolio optimization problem, which are two main problems in financial mathematics. Most of the planned objectives of the sub-project were achieved and the outcomes can be considered to be above average. We have published a paper in a peer-reviewed international journal and have submitted another. Moreover, the number of graduated students involved in the sub-project was higher than expected. Most importantly, the Cambodia Securities Exchange (CSX), the targeted collaborating industry, showed willingness to continue collaboration. When it introduces more financial products in the near future, the need for recruiting students that have graduated in the field of financial mathematic will increase.

Sustainability plan/future plan. This sub-project is a part of RUPP's ongoing activities to increase research capacity on topics relevant to the wellbeing of Cambodia. Recently, RUPP has drafted a research management manual and laboratory management manual. As planned, these documents will be passed to the university's board for approval. The university has committed staff for the project, all of whom are expected to continue research activities and to train graduate students to do research through the graduate programs in Mathematics at the Graduate School of Science. Besides funding from the World Bank, the university also has strong financial support from SIDA, which has recently been approved to continue for the 2$^{nd}$ round, up to 2026. With the completion of this sub-project, the PI can apply for a research grant from RUPP when the above-mentioned manuals are approved.

**Table 1.** Achievements of research objectives.

| Research objectives* | Status (please ✓) | | | Evidence/explanation |
|---|---|---|---|---|
| | Achieved | Potentially achieved | Not achieved | |
| Formulating a multiscale Heston's stochastic volatility model with a stochastic interest rate in which analytic tractability is retained for European option pricing and portfolio optimization problems. | ✓ | | | Can be seen in the submitted paper (the second paper) |
| Seeking approximate solutions of partial differential equations for options under the proposed model by using asymptotic analysis. | ✓ | | | Can be seen in the submitted paper (the second paper) |
| Applying a Monte-Carlo simulation to obtain an actual option price, which will be used as a benchmark for comparison purposes. | | | ✓ (0%) | It turned out that we did not need a Monte-Carlo simulation as the actual option price could be derived explicitly. |
| Analyzing the error between the approximate solution and the actual option price resulting from the Monte-Carlo method. | | | ✓ (0%) | Since we did not need a Monte-Carlo simulation, there was no error analysis. |
| Calibrating the theoretical price to the real market data through implied volatility fitting to see whether the formulated model really outperforms the existing one. | ✓ | | | Can be seen in the submitted paper (the second paper) |
| Seeking approximate solutions of value function for portfolio optimization under the proposed model by using asymptotic analysis. | ✓ | | | Can be seen in the published paper (the first paper): (https://doi.org/10.1007/s10614-021-10121-w ) |
| Obtaining explicit optimal control for the value function. | ✓ | | | Can be seen in the published paper (the first paper): (https://doi.org/10.1007/s10614-021-10121-w ) |