MScFE 620 DERIVATIVE PRICING

Group Work Project # 2

See grading rubric here.

Scenario

As you have upgraded your option pricing skill set, you can demonstrate those skills by pricing the same options as before. The group is now asked to assess the causes of volatility by 2 properties: 1) stochastic volatility and 2) jumps in the underlying stock price. Specifically, you will use the Heston Model and Merton Model instead of the Black-Scholes Model.

Tasks

This assignment is based on the same questions as in GWP1. To maintain the same numbering, questions begin from #5.

Remember to use the following general parameters:

- S0 = 80
- r = 5.5%
- sigma = 35%
- Time to maturity = 3 months

Also, remember that you will be employing Monte-Carlo method, so make sure you run a sufficiently high number of simulations and consider enough time steps (for you to determine).

Step 1: In 2-person groups, **omit Team Member C's** questions.

Team Member A: Stochastic Volatility Modeler

For the Heston model, you can use the following parameters:

- $\nu_0 = 3.2\%$
- $\kappa_\nu = 1.85$
- $\theta_\nu = 0.045$

5. Using the Heston Model and Monte-Carlo simulation, price an ATM European call and an ATM European put, using a correlation value of -0.30.
6. Using the Heston Model, price an ATM European call and an ATM European put, using a correlation value of -0.70.
7. Calculate delta and gamma for each of the options in Questions 5 and 6. (*Hint: You can numerically approximate this by forcing a change in the variable of interest –i.e., underlying stock price and delta change—and recalculating the option price).*

Team Member B: Jump Modeler

For the Merton model, you can use the following parameters:

- $\mu = -0.5$
- $\delta = 0.22$

8. Using the Merton Model, price an ATM European call and an ATM European put with jump intensity parameter equal to 0.75.
9. Using the Merton Model, price an ATM European call and an ATM European put with jump intensity parameter equal to 0.25.
10. Calculate delta and gamma for each of the options in Questions 8 and 9. (*Hint: You can use the same trick as in Question 7).*

Team Member C: Model Validator

11. For Questions 5, 6, 8, and 9, determine if the prices of the put and call from the Heston Model and Merton Model satisfy put-call parity.
12. Run the Heston Model and Merton Model for 7 different strikes: 3 OTM calls; 1 ATM call; and 3 ITM calls. The strikes should be equally spaced. Try to use the following APPROXIMATE moneyness values: 0.85, 0.90, 0.95, 1, 1.05, 1.10, and 1.15. Recall that moneyness = stock/strike.

Step 2

All team members:

13. Repeat Questions 5 and 7 for the case of an American call option (no need to price the put). Comment on the differences you observe from original Questions 5 and 7.
14. Using Heston model data from Question 6, price a European up-and-in call option (CUI) with a barrier level of $95 and a strike price of $95 as well. This CUI option becomes alive only if the stock price reaches (at some point before maturity) the

barrier level (even if it ends below it). Compare the price obtained to the one from the simple European call.

15. Using Merton model data from Question 8, price a European down-and-in put option (PDI) with a barrier level of $65 and a strike price of $65 as well. This PDI option becomes alive only if the stock price reaches (at some point before maturity) the barrier level (even if it ends above it). Compare the price obtained to the one from the simple European put.

Submission Requirements and Format

One team member submits the following on behalf of the entire group:

1. A **zipped folder** including:
    a. An executable Jupyter notebook* that includes the question number, the code, its output, and the answer to each question along with the solution
        i. Option prices MUST be rounded to the nearest cent: for example, 39.51, not 39.50941851234124151
        ii. Option prices should be neatly organized in a table and NOT presented individually
    b. A duplicate version of the Jupyter notebook above in PDF or HTML format. In order to include the output of the code, you must RUN the code before downloading the PDF.
2. **1 PDF document** with the question number and the written answers to the questions only (the document will have the same content as the ones above but without the code)
    a. Use the available Report Template and fill out the required information in the first page.

****Use Google Colab or GitHub to collaborate** in completing the executable Python program.*

*The PDF file with the answers to the questions must be uploaded **separately** from the zipped folder that includes any other types of files. This allows Turnitin to generate a similarity report.*

Rubric

Your instructor will evaluate your group submission for GWP3 using the following rubric:

Quantitative Analysis (Open-Ended Questions) 40 Points	Technical and Non-Technical Reports 30 Points	Writing and Formatting 20 Points
The group is able to apply results, formulas, and their knowledge of theory to real-life finance scenarios by doing the following: ● Providing all the necessary information to support their arguments. ● Presenting arguments that reflect group discussion and research. ● Using authoritative references to support a position and provide updated information. ● Concluding with practical takeaways for more insightful financial decision-making.	Technical Reports contain 3 parts: 1) **code** for each question (be sure to explicitly state the question number), 2) the corresponding output of that **code**, and 3) **interpretations** and/or **recommended courses of action** that reasonably follow from those results. **Note**: Technical reports will include the technicalities of models, such as names, methods of estimation, parameter values, etc., and exclude generalities about the work done. It should NOT include names of Python code that were used.	A submission that looks professional should: ● Include the axes, labels, and scales in graphs. ● Be free of significant grammar errors or typos. ● Be organized, well structured, and easy to read. ● Contain proper citations and a bibliography in MLA format.
	Non-Technical Reports contain 3 parts: 1) clear explanation of results; 2) the recommended course of action that follows; and 3) the identification of factors that impact each portfolio. **Note**: AVOID all references to model names, algorithms, and unnecessary details. Instead, focus on the investment decision.	

Revised: April 21, 2025