Advanced Derivatives Coursework

M.Sc. in International Finance
Master Level M2 - Academic Year 2025-26
Professor: Dr. Jeroen Kerkhof

Deadline:

Sat 6 December 2025

Read the following instructions carefully

- This coursework forms 30% of your overall course grade.
- Groups must be of 3 persons.
- Upload a ZIP file DSP_COURSEWORK_GROUP_X where the X is the group number. Also indicate the names and the student ID's of the students in the group on the title page.
- The ZIP file should contain a pdf report and ONE notebook, If you want to work on separate notebooks and then merge them at the end then here is an example of how to do this in Python `https://stackoverflow.com/questions/33957418/merging-two-notebooooks-into-one-in-jupyter-ipython`.
- The notebook should contains all of the answers to questions 1-6 in this coursework. Make sure it is clearly divided into each question. Make it very clear to understand and ensure that you comment on what you did and why. Explain your results in plain English (See plain_english.mp4 if you are unsure).

1. This question is about Black-Scholes-Merton Hedging.

(a) Install FinancePy and for speed issues, in the following, call directly into the model library rather than go via the EquityOptions class. Here is some example code:

```
v = bs_value(S, T, K, r, q, sigma,
                OptionTypes.EUROPEAN_CALL.value)
delta = bs_delta(S, T, K, r, q, sigma,
                    OptionTypes.EUROPEAN_CALL.value)
```

This will be about 60 times faster than going via pure Python code.

(b) Write a Python function called **DeltaHedge** that simulates the delta hedging of a European put option from trade date until expiry using a self-financing portfolio. It should use the function in (a) for calculating the option price and delta. The function inputs must include the option strike K, spot price of the stock S, risk-free rate r, the stock price drift μ (we do not necessarily assume that the stock grows at r), volatility σ and years to expiry T. The other input must be the hedging frequency per year N.

The dynamics of the stock price should be assumed to be lognormal with a drift μ (hedging does not have to set equal $\mu = r$ as the true stock price evolution is not risk-neutral) and a volatility σ. The output of your function should be a tuple that has 4 elements:

- The terminal stock price $S(T)$ in the simulation path;
- The option payoff;
- The realized variance of returns during the hedging period;
- The replicating error which is the difference between the total value of the hedging portfolio and the option payoff.

Make sure your code is clear and well-commented with good variable names.

(c) Write another function that calls the previous DeltaHedge function and which can then be used to calculate the hedging error over $10,000$ different paths. You must provide a clear and easy-to-understand listing of your code in the answer.

(d) Consider a put option with $S(0) = 100$, $K = 100$, $r = 4\%$, $T = 1.0$ and $\sigma = 20\%$. Assume here that $\mu = 5\%$. For this option, make a scatterplot of the hedging error (y-axis) versus the terminal stock price (x-axis) for $N = 12$ (monthly), $N = 52$ (weekly) and $N = 252$ (daily). Use different symbols or colours to distinguish the points. Discuss your results.

(e) For each value of N also calculate the mean and variance of this option hedging error over 10,000 different paths. You can use this to generate the answers to the remaining parts of this question. Present this in a simple table format.

(f) Create a scatterplot of the realized volatilities vs the replication error. Explain the pattern.

(g) For the same put option, calculate the mean absolute error value and the variance of the hedging error for $\mu = 2.5\%, 5.0\%, 7.5\%, 10\%$ by sampling $10,000$ hedging paths using $N = 52$. Show the results in a table. What does this tell you? Does the value of the drift change the hedging by a little or a lot?

2. This question is about the impact of the moneyness.

(a) We start with the code of Question 1. However, we make an adjustment. The option is 20% in-the-money using log forward moneyness.

$$m = \log(F(0)/K)$$

Repeat the delta hedge for the monthly, weekly, daily time periods (multiple paths). Calculate the descriptive statistics (mean, variance, etc). Alsp perform a scatterplot versus the terminal stock price. Discuss the differences (if any) with Question 1.

(b) Now perform the same analysis when the option is 20% out-of-the-money.

(c) Discuss the differences between the ITM, ATM and OTM option hedge results. How might this impact the volatility smile?

Table 1: **ZC swap quotes**

maturity	quote
1Y	6.05%
2Y	4.30%
3Y	3.50%
4Y	3.15%
5Y	2.95%
6Y	2.90%
7Y	2.70%
8Y	2.65%
9Y	2.60%
10Y	2.55%
11Y	2.50%
12Y	2.48%
15Y	2.46%
20Y	2.44%
25Y	2.42%
30Y	2.40%

Table 2: quotes for annual zero-coupon inflation swaps. Base month equals August-2025.

Table 3: **Inflation History**

Aug-25	120.70
Sep-25	120.24

3. This question is about Inflation Markets

(a) calibrate the inflation curve $I(0,T)$ for all necessary T using the zero-coupon inflation swap quotes in Table 1. The latest inflation numbers are given in Table 3. Nominal interest rates are flat at 3%.

(b) Determine the forward CPI numbers for Aug-26, Aug-27, ..., Aug-37, Aug-40, Aug-55. Interpolate the curve using log-linear interpolation.

(c) Compute the inflation PV01 for all quoted inflation swaps.

(d) Now consider the liabilities of a pension fund given in Table 3. Determine the nominal and real value of these liabilities.

(e) Explain how you could hedge the interest-rate and inflation risk of these liabilities.

maturity	liability
1Y	1m
2Y	2m
3Y	4m
4Y	5m
5Y	8m
6Y	10m
7Y	12m
8Y	15m
9Y	18m
10Y	25m
11Y	23m
12Y	20m
15Y	15m
20Y	9m
25Y	6m
30Y	2m

Table 4: Real liability profile of a small pension fund (in mln).

Maturity	Quote (bp)
1Y	75
2Y	78
3Y	80
4Y	85
5Y	90

Table 5: CDS quotes

4. This question is about CDS Valuation and Risk.

(a) Today you move to the CDS desk. The first thing they ask you to do is build the curve based on the quotes for today for Company DoOrDie. Use FinancePy's CDS functions (CDS and CDSCurve) to build a cds curve for this company. Use a recovery rate of 40%. For the remainder use 1-Nov-2025 as the trading date. If you need interest rates, you may assume a flat curve at 3% for the whole exercise.

(b) Determine the market spread of a 4-year CDS that matures on the 20 March 2029. Explain how the value is determined.

(c) Calculate the value of an existing long protection CDS contract traded with a contractual spread of 120bp with a maturity date 20 March 2029 and a notional of $20m.

(d) Recalculate the value of the contract for $R = 0\%, 10\%, 20\%, 30\%$. Are the changes significant or not? Can you explain why?

(e) Calculate the change in the CDS value to a 1bp increase in each of the 1Y, 2Y, 3Y, 4Y and 5Y CDS market rates. Show the results in a table. Explain what you find and how a dealer would hedge this 3.5 year CDS trade. Do not do any further calculations.