



University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

UNIVERSITY COLLEGE DUBLIN

DERIVATIVE SECURITIES (FIN42020)

Autumn 2022

STUDY GUIDE



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WELCOME MESSAGE

Hi All,

I would like to welcome you all to FIN42020!

As some background, I'm the academic director of the MSc in Financial Data Science. I use derivatives data in my own research, and in this course you will be using some of the same S&P500 option data from Option Metrics to test some of the pricing concepts you will learn in the course, to delta hedge and to structure volatility trades.

I hope that by taking this course you all improve your knowledge on the usefulness of Derivative Securities and learn about how they are priced and traded in live markets. I look forward to discussing these topics together in class!

Best Regards,

Richard

“You cannot get educated by this self-propagating system in which people study to pass exams, and teach others to pass exams, but nobody knows anything. You learn something by doing it yourself, by asking questions, by thinking, and by experimenting.”

- Prof. Richard Feynman

PART 1: MODULE DELIVERY

- I would like the lectures to be as interactive as possible, with some student led discussion and some in class exercises. To facilitate this, I ask that students read through the provided lecture slides in advance of the sessions. This is a masters level course with a significant reading and self-study component.
- I will not read verbatim all of the topic slides in the class - the focus will be on explaining and expanding on key concepts and giving real world examples.
- The course is completed over only six weeks - I recommend a continuous approach to the group project, completing as we go through the material so you don't fall behind. Meet your team and start communication and planning as soon as you can.
- The schedule for sessions is given in the **MODULE DELIVERY SCHEDULE** section below.
- Module delivery is face to face only – complete topic materials are provided via Brightspace, including a list of relevant chapters in the textbook, if you miss a lecture and you are welcome to ask questions in the next session.

PART 2: MODULE OUTLINE

Course Text: Hull, J. C., Options, Futures, and other Derivatives, 9th edition, (Pearson, 2014)

Themes and Topics

- **Topic 1: Introduction to Derivative Products**

- a. What are Derivatives?
- b. Why do we need Derivatives?
- c. Who uses Derivatives?
- d. Forward and Futures
- e. Options
- f. Swaps

Readings: Hull chapter 1, 2, 3, 5

- **Topic 2: Interest Rates and Asset Prices**

- a. Role of Interest Rates
- b. Pricing Bonds
- c. Projection and Discounting
- d. Arbitrage
- e. Fundamentals of Derivative Pricing

Readings: Hull chapter 4

- **Topic 3: Hedging using Linear Derivatives**

- a. Basis Risk
- b. Hedge Ratios
- c. Interest Rate Risk

Readings: Hull chapter 3, 6

- **Topic 4: Swaps**

- a. Types of Swap
- b. Interest Rate Swaps
- c. Comparative Advantage
- d. Using Currency Swaps
- e. Asset Swaps
- f. Credit Default Swaps

Readings: Hull chapter 7

- **Topic 5: Using Vanilla Options**

- a. European Style Options
- b. Synthetic Forward
- c. Basic Vanilla Option Strategies
- d. Early Exercise and American Options

Readings: Hull chapter 11, 12

- **Topic 6: Stochastic Processes and Binomial Trees**

- a. Choosing a Stock Price Process
- b. Markov Processes
- c. The Wiener Process
- d. Ito's Lemma
- e. No-Arbitrage vs Risk Neutral Approach

Readings: Hull chapter 13, 14

- **Topic 7: Black-Scholes Option Pricing**

- a. The Stock Price Assumption
- b. Estimating the Volatility
- c. Black-Scholes Derivation
- d. Implied Volatility
- e. Assets Providing a Known Yield
- f. The "Greeks"

Readings: Hull chapter 15

- **Topic 8: Risk Management and Measurement**

- a. Value at Risk
- b. Measuring Volatility
- c. Variance of Portfolio
- d. Model Validation



- **Topic 9: Credit Derivatives**

- a. Credit Risk
- b. Credit Indices
- c. Credit Products
- d. Counterparty Credit Risk

Readings: Hull chapter 24, 25

- **Topic 10: More Complex Options**

- a. More Complex Options
- b. Futures Options
- c. Black's Formula
- d. Path Dependency
- e. Exotic Options

Readings: Hull chapter 17, 18, 19, 20, 21

PART 3: MODULE DELIVERY SCHEDULE

The module delivery relies on students' ability to engage in prior preparation, to seek confirmation and clarification as appropriate and to be actively engaged during the sessions.

Session Arrangements

Each student is expected to attend and be prepared for all sessions. Table 1 below outlines the structure for the sessions.

Table 1: Module Delivery Schedule

Date	Topics	Readings
Thursday, October 27 th	Course Introduction Topic 1	<ul style="list-style-type: none">• Course Slides• Hull chapters 1, 2, 3, 5
Tuesday, November 1st	Topic 2	<ul style="list-style-type: none">• Course Slides• Hull chapter 4
Thursday, November 3rd	Topic 3 (Tutorials 1&2)	<ul style="list-style-type: none">• Course Slides• Hull chapters 3, 6
Tuesday, November 8th	Topic 4	<ul style="list-style-type: none">• Course Slides• Hull chapters 11, 12
Thursday, November 10th	Topic 5 (Tutorials 3&4)	<ul style="list-style-type: none">• Course Slides• Hull chapters 13,14
Tuesday, November 15th	Topic 6	<ul style="list-style-type: none">• Course Slides• Hull chapters 15
Thursday, November 18 th	Industry guest speaker	

Tuesday, November 22nd	Topic 7 (Tutorials 5&6)	<ul style="list-style-type: none"> • Course Slides Hull chapters 1, 2, 3, 5
Thursday, November 24 th	Topic 8	<ul style="list-style-type: none"> • Course Slides Hull chapters 20,21
Tuesday, November 29 th	Topic 9 (Tutorials 7&8)	<ul style="list-style-type: none"> • Course Slides Hull chapters 24,25
Thursday, December 1st	Project Topic Q & A (Last chance to ask any clarification on anything in the project!)	
Tuesday, December 6 th 10:00 AM	Topic 10	<ul style="list-style-type: none"> • Course Slides Hull chapters 17, 18, 19, 20, 21

Table 2: Module Delivery Schedule

Preparation Required in Advance of Sessions

You are requested to have read the assigned chapters and lecture slides in advance.

PART 4: TUTORIALS

Tutorials will be taught by Min Cao: min.cao@ucdconnect.ie

The topics and timings are given in Table 1 above.

PART 5: ASSESSMENT DETAILS

This module has **two** assessment components with specific weightings and marks awarded totalling 100. The purpose of each assessment is as follows:

Continuous Assessment

Continuous Assessment is worth 50% of the overall grade of module. The assessment comprises the group assignment (50%).

Table 2B – Assignment Deadline Summary

<u>Continuous Assessment</u> Deadlines	Date Assignment Due
Continuous Assessment: Group Assignment	5pm 9th December 2022

Assignment – Options Pricing

Report: There is no specific word count requirement or limit.

Keep the report brief and impactful with an executive summary style, but do not leave out any key information from your work. Presentation is very important, label figures and tables correctly, add informative captions.

Data: You will be assigned a trade date corresponding to options in a provided file containing real S&P 500 option data from Option Metrics. The file includes put and call option prices of varying strikes, traded on your date, with an expiry 30 days later. **Unless more than one option is needed in a question, you should select the closest to 'at the money' call option on your date** (the option with the strike price closest to the closing price of the S&P500 on that date).

Q1 (10 Marks)

- From the zero rate file provided, obtain an appropriate interest rate for your option.
- A dividend yield file is provided, find the relevant div yield for your option.
- Using the implied volatility value from the option metrics file for your option as the volatility input to the Black-Scholes model (including a dividend yield), price your option and compare to the mid-point of the option metrics bid/ask spread.
- Can you find an implied volatility (using e.g. excel solver/fmincon in Matlab) for which the B-S-M formula price matches the midpoint of the Option Metrics Bid/Ask spread exactly?
- Does this match the implied volatility in the Option Metrics data?

Q2 (10 Marks)

Use the at the money option and the data obtained in question 1 (interest rate, dividend yield, implied volatility, along with the option strike and time to expiry) to produce graphs to show:

- The sensitivity of the Black-Scholes option price to changes in volatility, σ (from $\sigma = 5\%$ to $\sigma = 80\%$ in steps of 5%).
- Using the first two derivatives w.r.t. price (delta, gamma) in a Taylor series expansion, superimpose a plot of the projected price around the price of your option using a grid of price changes in the range -30% to +30%.
- The sensitivity of the Black-Scholes option price to changes in the time to maturity T ($T = 1$ week, 1 month, 1 quarter, 6 months, 1 year, 5 years).
- The sensitivity of the Black-Scholes option price to changes in the interest rate r . (e.g. r in the range 0% to 14%, in steps of 0.25%)

Briefly discuss your results in relation to option theory and option hedging risk.

Note: To produce the graphs hold all other inputs to the option price formula constant - except for the parameter you are testing.

Q3 (10 Marks)

Using the option parameters from Q1, produce a graph comparing a call's intrinsic value [defined as $\max(S-X,0)$] and its Black-Scholes price at each point for a range of possible index values.

i.e. you are changing S in the formula above across a range of possible index values, X is the strike from your original option in Q1. For each S in your range, compute the B-S price using that S as the spot and all other inputs to B-S from your original option in Q1. You then plot the intrinsic value function above and the B-S price against S on the x axis. For example – e.g. vary S in the range -60% to + 60% of the index spot on your trade day in 5% steps.

Discuss your results in relation to option theory and whether you would ever exercise your option (or would you sell it to someone instead for the Black Scholes price).

Likewise, using an at the money put from your date in the options data file produce a graph comparing a put's intrinsic value [defined as $\max(X-S,0)$] and its Black-Scholes price. Again, discuss your results in relation to option theory and whether you would ever exercise your option (or sell it to someone instead for the Black Scholes price).

Q4 (10 Marks)

Using a large sample of S&P500 returns up to your option trade date to fit a volatility model and use this model to forecast volatility over the lifetime of the option (the one month from the trade date to the expiry date). Code is provided in Matlab to do this for a GARCH(1,1) model.

In a Table report:

- your *annualised forecast volatility*,
- the *annualised realised volatility* of the index over the time to expiry of your option (volatility of index returns from the trade date to expiry);.
- The VIX value on the trade date.
- The implied volatility of your option from Option Metrics.

Compare your volatility forecast to the option implied volatility, based on this comparison or any other rationale that a trader on that date may have applied (rationale to be included in the report):

- construct an option spread to trade volatility using any subset of all of the options from the full traded set on your date.
- Plot the payoff function of your option spread
- In a small Table: Report the cost of the portfolio, the value on expiry of the index and the resulting P&L (using your payoff function at that expiry value).
- Comment on your results.

Q5 (10 Marks)

Delta hedge an ATM call option that you assume you are selling on your trade date. You are a market maker and receive the Ask price:

- Calculate a delta value on each day to expiry from the Black Scholes formula (assuming all parameters including implied volatility stay the same while updating the spot price of the index based on the value at close each day & decrementing the time to expiry of the option by a day each time).
- Use these values to delta hedge your position (you sold the call option).
- Assuming transaction costs of 10bps, report the overall P&L from your delta hedged call position aggregated over the daily purchases/sales of the index and your final liability less the final offsetting index position that you sell/.
- Matlab code is provided for this step.
- Plot your daily delta value, and the p&I from the index holding.

Repeat the process using your volatility forecast from Q4 instead of the option implied volatility and comment on any differences.

- There is a project session on Tuesday, December 1st.
- This session is not arranged to do your project for you, it will be a last chance Q&A responding to any questions from project teams that need clarification or that the class is struggling with.
- 30% of the mark is a peer-assessed Team Work score.
- On submission each team member will be scored by all other team members on 3 headings:
 - Effort (/10)
 - Attitude (/10)
 - Contribution (/10)
 - The overall team member score is the average of your team members score and is to be input into the project submission sheet by the Project Leader.
 - The project leader can collate scores on e.g. a google spreadsheet.
- Each team must appoint a Project Leader, the person responsible for submitting a single combined work – if you can't agree on one by majority vote it defaults to member #1 in the project list.
- **Everyone is supposed to participate, contribute and learn from every section of the project, not just 'their section'.**
- A student failing the team work evaluation will not be awarded their team's mark (and will be evaluated after the fact on their own documented contribution only). Please email your team your contributions to keep a record of them, undocumented contributions will not be considered in this scenario.
- **To encourage students not to leave things to the last minute - After the project session, I will not respond to any further project related queries, all queries must be raised in advance or in the session – this requires you to be somewhat prepared.**
- All members of the team are expected to do all of the project – you can consider it an individual assignment in terms of workload, having teams should only improve your teamwork skills and the quality of the end report.

Examination (50%):

The examination will be in person written exam and will focus on learning outcomes from the module topics including the material covered in the textbook, class exercises, assigned readings, seminar questions and class discussions. For this, students are expected to demonstrate their understanding of theory and practice, addressed throughout the module to a level reflected by the UCD grade descriptors in Table 4.

The exam will consist of two sections, Section A 10 short questions with no choice Section B choose 3 from 4 longer questions.

PART 6: GRADING

TABLE 4: Grade Descriptors

Grade	Criteria more relevant to module levels 0, 1 and 2 in the categories of knowledge, understanding and application
A+	<p>Outstanding A comprehensive, very well-structured, highly focused and concise response to the assessment task, consistently demonstrating</p> <ul style="list-style-type: none"> • an exceptionally extensive and detailed knowledge of the subject matter • a highly-developed ability to apply this knowledge to the task set • evidence of extensive background reading and demonstration of synthesis of this material • clear, fluent, stimulating and original expression • excellent presentation (spelling, grammar, graphical) with essentially no presentation errors
A	<p>Excellent A comprehensive, highly-structured, focused and concise response to the assessment task, consistently demonstrating</p> <ul style="list-style-type: none"> • an extensive and detailed knowledge of the subject matter • a highly-developed ability to apply this knowledge to the task set • evidence of extensive background reading • clear, fluent, stimulating and original expression • excellent presentation (spelling, grammar, graphical) with minimal or no presentation errors
B	<p>Very Good A thorough and well-organised response to the assessment task, demonstrating</p> <ul style="list-style-type: none"> • a broad knowledge of the subject matter • considerable strength in applying that knowledge to the task set • evidence of substantial background reading • clear and fluent expression • quality presentation with few presentation errors
C	<p>Good An adequate and competent response to the assessment task, demonstrating</p> <ul style="list-style-type: none"> • adequate but not complete knowledge of the subject matter • omission of some important subject matter or the appearance of several minor errors • capacity to apply knowledge appropriately to the task albeit with some errors • evidence of some background reading • clear expression with few areas of confusion • writing of sufficient quality to convey meaning but some lack of fluency and command of suitable vocabulary • good presentation with some presentation errors

D	<p><u>Satisfactory</u> An acceptable response to the assess with</p> <ul style="list-style-type: none"> • basic grasp of subject matter, but somewhat lacking in focus and structure • main points covered but insufficient detail • some effort to apply knowledge to the task but only a basic capacity or understanding displayed • little or no evidence of background reading • several minor errors or one major error • satisfactory presentation with an acceptable level of presentation errors
D-	<p><u>Acceptable</u> The minimum acceptable standard of response to the assessment task which</p> <ul style="list-style-type: none"> • shows a basic grasp of subject matter but may be poorly focussed or badly structured or contain irrelevant material • has one major error and some minor errors • demonstrates the capacity to complete only moderately difficult tasks related to the subject material • no evidence of background reading • displays the minimum acceptable standard of presentation (spelling, grammar, graphical)
FM	<p><u>Unacceptable</u> A response to the assessment task which is unacceptable, with</p> <ul style="list-style-type: none"> • a failure to address the question resulting in a largely irrelevant answer or material of marginal relevance predominating • a display of some knowledge of material relative to the question posed, but with very serious omissions / errors and/or major inaccuracies included in answer • solutions offered to a very limited portion of the problem set • an answer unacceptably incomplete (e.g. for lack of time) • a random and undisciplined development, layout or presentation • unacceptable standards of presentation, such as grammar, spelling or graphical presentation • evidence of substantial plagiarism

The grading scheme used for parts of this module will follow the UCD 'Alternative Linear Conversion Grade Scale':

Alternative Linear Conversion Grade Scale

40% Pass (85% = A-)

Grades	Lower %	Upper %
A+	≥ 95	100
A	≥ 90	< 95
A-	≥ 85	< 90
B+	≥ 80	< 85
B	≥ 75	< 80
B-	≥ 70	< 75
C+	≥ 65	< 70
C	≥ 60	< 65
C-	≥ 55	< 60
D+	≥ 50	< 55
D	≥ 45	< 50
D-	≥ 40	< 45
E+	≥ 35	< 40
E	≥ 30	< 35
E-	≥ 25	< 30
F+	≥ 20	< 25
F	≥ 15	< 20
F-	≥ 10	< 15
G+	≥ 5	< 10
G	≥ 0.02	< 5
G-	≥ 0.01	< 0.02
NM	0	< 0.01
ABS	No work was submitted by the student or the student was absent from assessment	

For more information on understanding UCD grades please refer to:

<https://www.ucd.ie/students/exams/gradingandremediation/understandinggrades/>

