Student Coursework Instructions

**Course Title: Financial Derivatives**

Course Code: C39SN

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**INDEX OPTIONS**

**Group Project (in groups of four each)**

**Caution**

**Plagiarism is a serious offense that, in extreme cases, may lead to expulsion from the University. You should interact only within your group, and groups should work independently. You may not seek any help from anyone outside your group. Any evidence of accessing such help, copying from other peer groups or any other form of collusion or plagiarism will be raised to the Disciplinary Committee for investigation and your mark withheld until the issue is resolved.**

**Coursework Submission Instructions (please follow these carefully)**

Deadline for submission is provided by course instructor/tutor.

You need to submit a hard copy of your project that has:

* 1. A cover page that contains the following information:
     1. Title: ‘C39SN2 Coursework: Financial Derivatives Project’
     2. Names or IDs of all group participants;
     3. Group number (the number of your group on the Vision sign-up list)
     4. Word count
  2. A filled-in and signed ‘Coursework Group Self-Assessment Form’ (included with the course package and obtainable from Vision).
  3. A CD or USB that contains a copy of your Excel caclualtions (this can be put in an envelope and attached to the report by a sticky tape).

**Coursework**

**(You need to read Chapter 4 of Chance and Brooks (Option Pricing: The Binomial Model) prior to attempting the coursework. Links to all websites relevant to this coursework are given below and are posted under ‘Links’ in Vision).**

An index option is a financial derivative that gives the holder the right, but not the obligation, to buy or sell a basket of stocks (e.g., S&P 100 or FTSE 100) at an agreed-upon price (strike price) on a certain future date (European), or any time up to that date (American).

Index Options on US stock indices are traded at the Chicago Board Options Exchange (CBOE, see www.cboe.com). **This coursework is an investigation of the pricing of options on the S&P 100 index**. There are European-style options (CBOE symbol code: XEO) and American-style (CBOE symbol code: OEX) options on the S&P 100.

**Approach**

**This is a demanding coursework. You are advised to start as early as possible, and follow the following steps in order:** Read Chapter 4 of Chance and Brooks (Option Pricing: The Binomial Model).

1. Read the instructions below to understand the requirements.
2. Read the instructions again and extract a list of ALL the data that you need to download (from CBOE and Bloomberg, see below). This data will consist of prices, exercise prices and time to maturity on European and American call and put options on the S&P100 index; volatility and dividend yield of the S&P100 index; and interest rate data (Bloomberg). Note that you will need to *download all the data within the same 15-minute interval*, since CBOE's website provides data with a 15-minute delay, and if you download the data during different 15-minute intervals they will not match with each other.
3. Prior to downloading the data logon to the CBOE website and familiarise yourself with it, the option symbols (also explained below), and with the 'mouse clicks' that you need to perform in order to download the data. This will prepare you well to act fast enough to download the data within the same 15-minute interval window.
4. You will then need to do calculations based on this data and, therefore, will require the use of Excel. You will also need to repeat these calculations for different options, and, in order to automate the calculations, you are strongly advised to think carefully about the structure and organisation of your spreadsheet prior to implementation.
5. Assume a 365 day year throughout.

**Requirement:**

**A report of 1500 to 2000 words in length (excluding figures and appendix) that contains a response to the questions that feature under the two steps below. You are required to show detailed calculations by, for example, attaching your Excel sheet in a USB or a CD to the hardcopy submission, or by attaching snapshots to Excel sheets in an Appendix to your report (in this latter case, please highlight, reveal or type the equations used in each cell).**

**STEP 1**

*Downloading Option Data*

You will need to download prices for puts and calls as in the matrix in the table below (under *Choice of Options for Analysis*). First read the section below and when you are ready to download the data login to the CBOE website [www.cboe.com](http://www.cboe.com/). Choose the ‘delayed quotes’ tool under the ‘Quotes & Data’ tab. When the ‘Delayed Quotes’ window opens, enter on the left panel the symbol codes OEX or XEO while checking (clicking) the choice ‘All exchange option quotes.’ A table of information on options available will then display. It is best to just copy and paste in Excel the entire table that comes up from the website. You need to follow this procedure twice, once to extract a table of OEX options, and another for XEO options. Once you have all the data in Excel you can then pick and choose the options that you want to focus on in the analyses.

Beside prices, you will need to also note the time you downloaded the data, in order to calculate the time left to maturity for these options, and the level of the S&P 100 index (i.e., the spot price of the index) at the time of your downloading the options data. These last two pieces of information appear towards the top of the table anyway, so it is good practice to copy the entire table together with the information that appears at the top of it.

*Choice of Options for Analysis*

Consider pairs of put and call options with each pair having the same strike price and maturity. You need pairs of American-style (OEX) and pairs of European-style (XEO) options. For each exercise style choose a pair that are at-the-money, and another that are out-of-the-money, so that American and European pairs that are at-the-money have the same (or close) time to maturity and exercise price. Do the same for in-the-money and out-of-the-money options. You should end up with a choice of options that fit the description of the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **American (OEX)** | **European (XEO)** | **Same or close** |  |
| ATM call | ATM call | Exercise price and time to maturity | All options should be active (i.e., showing some volume and/or open interest, but preferably both) |
| OTM call | OTM call | Exercise price and time to maturity |
| ITM call | ITM call | Exercise price and time to maturity |
| ATM put | ATM put | Exercise price and time to maturity |
| OTM put | OTM put | Exercise price and time to maturity |
| ITM put | ITM put | Exercise price and time to maturity |

For ATM options choose options that are closest at-the-money (i.e., with a strike price closest to the level of the S&P100 index at the time of downloading the data). Then choose options with exercise price on either side of that of the ATM options such that a pair is ITM and a pair is OTM Choose a particular maturity between 1 week and 1 year for all options that you will use. In all your choices of strike price and maturity be guided by the table above (flexible) and by options that are most active (i.e., ones that are showing some volume of trade and/or open interest, but preferably both). If you do not see price, volume and open interest data next to an option it is either you are accessing the website when CBOE is not open or the options are not heavily traded. In this case choose other options and access the website during *Chicago* opening times. Avoid lunch time in Chicago. Take a note of the exact time and date of your data download, or simply copy the screen information. Trading Hours: 8:30 a.m. - 3:15 p.m. Central Time (Chicago time).

*Interest Rate Data*

You also need an annualised risk-free rate to calculate ‘theoretical’ fair prices for the options. Use the ‘interest rates’ market data provided by Bloomberg (<http://www.bloomberg.com/markets/rates/index.html>). Select an appropriate yield for the risk free interest rate. This usually is the yield of a Treasury Bill (or zero curve) that has a maturity closest to that of the option(s) you downloaded. Note that if you download options with different maturities you may need more than one interest rate to match. If the maturity of your options is in-between the maturities of two listed Treasury’s then you may need to ‘interpolate’ the yield to end up with one that matches the maturity of the options.

Alternative sources of interest rate data (the first is more official) are:

1. <http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/Historic-LongTerm-Rate-Data-Visualization.aspx>
2. If you have access to Datastream use the following mnemonics (instrument code): FRTB3M, FRTB6M. Datastream is available in the pc labs in Mary Burton Building only. It is found under icon names ‘Avance4’ or ‘Advance5’. But it takes a bit of getting used to.

*Proper calculations of option prices*

Note that in calculating theoretical option prices you will need a value for the annual dividend yield on the S&P100 index and an estimate of volatility of the index. Read the relevant sections below on how to obtain these.

*Estimating Volatility of the Index*

An estimate of sigma (volatility) for the index can be obtained by reading the value of the volatility index that has a symbol VXO. (Enter VXO on the right hand side box that appears when you click the 'Quotes&Data' tab and choose 'Delayed Quotes' in the CBOE website).

*Estimating Annualised Dividend Yield*

To calculate prices you also need an estimate of the annualised dividend yield of the S&P100 index at the time of downloading the price data. Search for a reasonable value, and although this can be difficult, try <http://etfdb.com/index/sp-100-index/dividends/> which gives the dividend yield on a fund that tracks the S&P100.

*Enriching Your Analysis?*

You can do the analysis using mid prices = (bid+ask)/2. Or you can enrich your analysis by performing calculations on bid and on ask prices separately. The difference between the results using the bid from those using the ask prices should be a reflection of the effect of ‘transaction costs,’ and hence you can discuss these effects.

***Step 1 Coursework Requirements***

The requirements are:

1. Investigate (calculating and checking) whether the *put-call parity* holds for the actual market prices of both the European and the American options. Interpret the results (more emphasis and marks will be given to interpretation).
2. Calculate the difference between the prices of the American and European options that have the same exercise price and maturity. Interpret the results (more emphasis and marks will be given to interpretation).

**STEP 2**

*Binomial Model Setup Features*

Using the 'binomial model', build a binomial tree for the index level with three time steps, so that the overall time horizon is equal to the maturity of the options selected (i.e., divide the maturity into three equal intervals).

With regard to calculations of the maturity dates of the options, bear in mind that the XEO and OEX option contracts at CBOE mature on the Saturday following the third Friday of the maturity month of each contract (full contract specifications are available under the 'Products' tab in the CBOE website, <http://www.cboe.com/products/indexopts/oex_spec.aspx> ).

With regard to the binomial calculations choose the upward and downward size of price movement as a function of the volatility of the index level (i.e., function of sigma of the index). You can use the equations provided by Chance and Brooks for up (u) and down (d) parameter movements as functions of sigma, also provided in the lecture material.

*Estimating Volatility of the Index*

An estimate of sigma (volatility) for the index can be obtained by reading the value of the volatility index that has a symbol VXO. (Enter VXO on the right hand side box that appears when you click the 'Quotes&Data' tab and choose 'Delayed Quotes' in the CBOE website).

*Estimating Annualised Dividend Yield*

To calculate prices you also need an estimate of the annualised dividend yield of the S&P100 index at the time of downloading the price data. Search for a reasonable value, and although this can be difficult, try <http://etfdb.com/index/sp-100-index/dividends/> which gives the dividend yield on a fund that tracks the S&P100.

If you can't find 15-minute dividend try:

<http://markets.on.nytimes.com/research/markets/mutualfunds/snapshot.asp?symbol=OEF>

*Binomial Pricing*

Using the VXO estimate of volatility evaluate the *call and put options* using the three-step binomial tree previously constructed for the index level (here you need to have your tree calculations automated so you can evaluate all options). Compare these values with the observed prices in the market and discuss the reasons why you may or may not observe differences. (More emphasis and marks will be given to discussion.)

*Black and Scholes versus Binomial*

Use the VXO estimate of volatility to calculate the Black-Scholes prices of the put and call options. Compare these values with market prices and with those obtained by the Binomial tree. Discuss possible reasons for any differences (Black-Scholes versus Binomial, American versus European, puts versus calls, ATM versus OTM). (More emphasis and marks will be given to discussion.)

*Implied volatility*

By trial and error, find the value of the volatility parameter at which the Black and Scholes price equals the observed actual market price for each option (here you need to have your tree calculations automated so that it will give you a price every time you vary the volatility value). The value of volatility at which the observed actual market price equals the model price is known as ‘implied volatility’. Compare these values of implied volatility with each other and with that obtained from the VXO index and discuss the reasons for any differences from each other and from the VXO value. (More emphasis and marks will be given to discussion.)

**Notes**

**CBOE symbol explanation**

In CBOE each option has a symbol, and here is an example of how to read these symbols.

Example: OEX1327A600 - E (2013 Jan 600.00 Call)

OEX is the CBOE symbol of the instrument (in this case S&P 100 American option).

The next two digits, 13, stand for the year 2013.

The next two digits and letter stand for the expiration date and expiration month

* For call options ‘A’ stands for January, ‘B’ for February, ‘C’ for March,..etc. to ‘L’.
* For put options ‘M’ stands for January, ‘N’ for February, ‘O’ for March,..etc. to ‘X’.

So ‘27A’ is 27th of January, and since the letter is used then it indicates a call option.

The following number, 600, stands for the strike price of the option.

The letter E after the hyphen indicates the market in which the option is traded, in this case CBOE.

Alternatively, if you click on the symbol the website will provide you with more detail.

Full description of the contract details, including the exact maturity day can be found by clicking the 'Products' tab in the CBOE website,

<http://www.cboe.com/products/indexopts/oex_spec.aspx>

**Marking Scheme**

In general the overall course requirements and the marking scheme are as follows:

1. Discussions of whether the put call parity holds for actual market prices of European and American options? (10 marks)
2. Interpret differences between American and European option prices (5)
3. Construct 3-step binomial (15)
4. Compare binomial and actual prices – interpret any differences (10)
5. Calculate B&S prices. (5)
6. Compare B&S with binomial prices – discuss differences,

B&S vs Binomial (6)

American vs European (6)

ATM vs OTM (8)

1. Calculate implied volatility (5)
2. Plot implied volatility against moneyness or X. – discuss any smile? (10)
3. Compare implied vol with each other and with VXO – interpret differences (10)

Spreadsheets (10)