UE 111
FINANCIAL MODELING AND APPLICATIONS
TD #4: OPTIONS

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Exercise 1

1. Write a VBA function `Bisection_No_Loop` that computes the implied volatility of an option using the bisection (dichotomy) algorithm. Yet, contrary to the program developed during class sessions, the program will not use any loop. Hint: use recursion, i.e. the fact that a function can call itself.

2. Using the data in the TD4.xls workbook, use your function to estimate the implied volatility of the Starbucks call options in cells `E8` to `E16`. Plot a graph of the estimated implied volatility against the strike price of the various options. What do you notice? Should we expect to get this sort of result? Why? How come we get this result?

Exercise 2

When using the Newton-Raphson method to calculate implied volatility, it is necessary to know the partial derivative of the option-pricing formula with respect to the volatility (vega). In some types of options (in particular exotic and American options), vega is not known analytically. The bisection method, which is a similar-in-spirit though more efficient method than the dichotomy method, can be used to estimate implied volatility when vega is unknown. The bisection method requires two initial volatility estimates (seed values):

1. A "low" estimate of the implied volatility, σ_L, corresponding to a Black-Scholes option value c_L;

2. A "high" volatility estimate, σ_H, corresponding to a Black-Scholes option value c_H.

If the two initial guesses σ_L and σ_H are well chosen, the option market price c_m lies between c_L and c_H. The first bisection estimate σ_1 of implied volatility is given as the linear interpolation between the two estimates, i.e.:

$$\sigma_1 = \sigma_L + (c_m - c_L) \times \frac{\sigma_H - \sigma_L}{c_H - c_L} \tag{1}$$

Based on the new guess σ_1, one can construct an another guess, σ_2, using relationship (1), etc. The process stops at the order p when σ_p is such that the absolute value of the difference between the option Black-Scholes price – valued at point σ_p – and the market price c_m is lower than some ε (e.g. $\varepsilon = 1.10^{-6}$).

Write a function named `Bisection(OptionType, S, K, r, sigma_L, sigma_H, T, c_m)` that allows to retrieve the implied volatility of a stock which serves as an underlying asset for an option whose characteristics are `(OptionType, S, K, r, T)` and whose market price is `c_m`. Use this function to compute in cells `F8` to `F16` the implied volatility of Starbucks call options and check whether you get the same results as with the function coded in exercice 1.

Exercise 3

The goal of this exercise is to compute the implied volatility of Starbucks call options using Excel solver tool.

1. Based on the organization of data in workbook TD4.xlsx, and assuming that you use a loop with a counter variable named `MyRow` that takes on values from 8 to 16 (the values of the rows that contain Starbucks call option strike prices and market values), what is the command line that writes in cell `F2` the formula that computes the pricing error?

2. Write a sub procedure named `Volat_Solver` that instructs the solver to find the value of the implied volatility.

3. Finish your code, i.e. write the program that will automatically report in cells `G8` to `G16` the value of the implied volatility for all Starbucks call options.