ESSCA - Quantitative finance on VBA

Session 2 – Black-Scholes model and its Greeks

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Part 1 – Black-Scholes model – Implementation and User form creation

1. Create a function that implements the Black-Scholes model. This function must take the type of the option as an input argument and must compute the price of the option according to its type.
2. Create a user form for the Black-Scholes model:

   Main steps of the algorithm

- Step 1: create the frame of the user form, add objects (i.e. textboxes, buttons etc.) to it and click on each object to activate it
- Step 2: name each object
- Step 3: within the created "price" button, add the code that:
  - upload data from the user form (spot price, risk free rate, volatility and strike price)
  - upload the option type (you can use an option button)
  - upload the residual maturity (you can create a function which computes the residual maturity)
  - Affect the result of these uploaded parameters of the Black-Scholes function to the "result" (a textbox) object.
- Step 4: create a sub that launches the user form

Part 2 – Black-Scholes model – computation and Greeks

1. Implement the Black-Scholes model for a dividend paying security (q is the continuously paid dividend rate) where:

$$C(S,T) = e^{-qT} S_0 \Phi(d1) - e^{-rT} K \Phi(d2)$$

$$P(S,T) = -e^{-qT} S_0 \Phi(-d1) + e^{-rT} K \Phi(-d2)$$

And:

$$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S_t}{K}\right) + (r - q + \frac{1}{2}\sigma^2)(T-t)\right]$$

$$d_2 = d_1 - \sigma\sqrt{T-t} = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S_t}{K}\right) + (r - q - \frac{1}{2}\sigma^2)(T-t)\right]$$

Φ is the standard normal cumulative distribution function.

2. Implement the Greeks of the Black-Scholes model, where ϕ is the density function of the standard normal distribution:

	Calls	Puts
value	$Se^{-q\tau}\Phi(d_1) - e^{-r\tau}K\Phi(d_2)$	$e^{-r\tau}K\Phi(-d_2) - Se^{-q\tau}\Phi(-d_1)$
delta	$e^{-q\tau}\Phi(d_1)$	$-e^{-q\tau}\Phi(-d_1)$
vega	$Se^{-q\tau}\phi(d_1)\sqrt{\tau} = Ke^{-r\tau}\phi(d_2)\sqrt{\tau}$	
theta	$-e^{-q\tau}\frac{S\phi(d_1)\sigma}{2\sqrt{\tau}} - rKe^{-r\tau}\Phi(d_2) + qSe^{-q\tau}\Phi(d_1)$	$-e^{-q\tau}\frac{S\phi(d_1)\sigma}{2\sqrt{\tau}} + rKe^{-r\tau}\Phi(-d_2) - qSe^{-q\tau}\Phi(-d_1)$
rho	$K\tau e^{-r\tau}\Phi(d_2)$	$-K\tau e^{-r\tau}\Phi(-d_2)$