University of Texas at Austin

# HW Assignment 8

## Hedging. Exchange options.

Please, provide your **complete solutions** to the following problems:

**Problem 8.1.** (15 points) There are two stocks present in our market: **S** and **Q**. Their current prices are $S(0) = 60$ and $Q(0) = 65$. Both stocks pay dividends continuously. The dividend yield for **S** is 0.02 while the dividend yield for **Q** equals 0.03.

You are given that for $t \geq 0$

$$\text{Var}[\ln(S(t)/Q(t))] = 0.04t.$$

What is the Black-Scholes price of a one-year **exchange call** with underlying **S** and the strike asset **Q**?

**Problem 8.2.** (15 points) Assume the Black-Scholes framework for the pair of stocks **S** and **Q**.

For the stock **S**, you are given that

- the current stock price is \$80 per share;
- the stock pays dividends in the amount $0.05S(t)\,dt$ during the time period $(t, t + dt)$;
- the stock's volatility is 0.2.

For the stock **Q**, you are given that

- the current stock price is \$50 per share;
- the stock pays no dividends;
- the stock's volatility is 0.4.

The correlation between the returns of **S** and **Q** is $-0.4$.

The continuously compounded, risk-free interest rate is 0.055.

What is the price of the maximum option on **S** and **Q** with exercise date at time$-4$?

**Problem 8.3.** (20 points) Assume the Black-Scholes framework. A market maker writes an option (call it option $I$) on a non-dividend-paying stock whose price is equal to $S(0)$ and receives $V_I(0)$ for its sale at time$-0$. Moreover, the market-maker delta-gamma hedges the commitment using another option (call it option $II$) on the same stock and the stock itself. Denote the time$-0$ price of option $II$ by $V_{II}(0)$.

(i) (2 points) Let the current gamma of the written option be equal to $\Gamma_I$ and let the gamma of the option used for hedging be equal to $\Gamma_{II}$. What is the number of units of option $II$ which the market-maker has in the total hedged portfolio?

(ii) (3 points) In addition to the above notation, let the delta of option $I$ be denoted by $\Delta_I$ and let the delta of option $II$ be denoted by $\Delta_{II}$. What is the number of shares of stock needed in the total hedged portfolio? Express this number in terms of deltas and gammas of the two stocks and nothing else.

(iii) (3 points) Using the above notation, what is the time$-0$ value of the total hedged portfolio?

(iv) (4 points) Denote the theta of option $I$ by $\Theta_I$ and the theta of option $II$ by $\Theta_{II}$. Using the delta-gamma-theta approximation, approximate the value after one day of option $I$ and option $II$ if the stock price changes by $ds$. Feel free to denote one day by $dt$.

(v) (8 points) What is the approximate value after one day, i.e., at time $dt$, of the entire delta-gamma-neutral portfolio acording the the delta-gamma-theta approximation?