UNIVERSITY OF TEXAS AT AUSTIN

HW Assignment 5

Hedging. Exchange options.

Please, provide your *final answer only* to the following problems:

Problem 5.1. (2 points) An investor wants to delta-hedge a bull spread she bought. Then, she should short-sell shares of the underlying asset. *True or false?*

Problem 5.2. (2 points) A market-maker writes a call option on a stock. To decrease the delta of this position, (s)he can **write** a call on the underlying stock. *True or false?*

Problem 5.3. (2 points) Market makers usually do not need to rebalance their portfolios after the initial hedge is established. *True or false?*

Problem 5.4. (2 points) In order to **both** delta hedge and gamma hedge a position in a certain option, the market-maker must trade in another type of option (i.e., not only in the money-market and the underlying risky asset). *True or false?*

Problem 5.5. (2 points) Consider an option whose payoff function is given by $v(s,T) = \min(s, 50)$. If a market-maker **writes** this option, they need to short sell shares of stock to create a delta-neutral portfolio. *True or false?*

Problem 5.6. (5 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 $t \geq 0$

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

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

(a) \$2.86
(b) \$3.01
(c) \$7.27
(d) \$7.86
(e) None of the above.

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

Problem 5.7. (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 5.8. (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 Γ_I and let the gamma of the option used for hedging be equal to Γ_{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 Δ_I and let the delta of option II be denoted by Δ_{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 Θ_I and the theta of option II by Θ_{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?