

Energy Derivatives
Professor Pirrong
Homework 4
2017

1. It is 5 April, 2017. July, 2016 Crude Oil futures are currently trading at \$51.90/bbl. The annualized volatility (sigma) for CL futures is .275. The continuously compounded, annualized risk free interest rate is .015. Options on June futures expire on 15 June, 2017.

- a) Use the Black formula to determine the value of a European put option on June CL futures struck at \$51. Use a binomial model with seven time steps to determine the value of the same option. How far off is the binomial model estimate?
- b) What is the delta of the put? What is the gamma of the put? What futures position would you use to hedge long puts on 10,000 barrels? What futures position would you use to replicate long puts on 10,000 barrels? (Indicate the size of the position in barrels and whether you are long or short the futures).
- c) Use the Black model to value a European call on July CL struck at \$51. Verify that put-call parity holds. What are the delta and gamma of the call? What futures position would you use to hedge short calls on 10,000 barrels? What futures position would you use to replicate short calls on 10,000 barrels?
- d) Value a European call on July CL struck at \$55. How would you delta hedge a long position in 100,000 barrels of calls?

2. On 5 April, 2017 July 2017 Crude Oil futures traded at \$51.91/bbl. July CL options expire on 15 June. A July call struck at \$52 is selling at \$2.56/bbl. What is the implied volatility of the \$52 call? Assume an interest rate of 1.5 percent.

3. You are making a market in nat gas options. On 5 April you sold put options on 100 June, 2017 Natural Gas futures contracts. The options are struck at \$3.32 MMBTU. The relevant volatility is 35 percent, and the relevant interest rate is 1.5 percent. The options expire on 25 May 2017. The current June 2017 NG futures price is \$3.335/MMBTU. Each contract is for 10000 MMBTU.

- a) What is the price of the options you sold?
- b) What are the Delta, Gamma, and Vega of the entire position in the options that you sold?
- c) What are the risks associated with this transaction?
- d) Devise a delta hedge for this transaction. How many futures contracts should you trade? For what delivery month? Should you buy or sell futures?
- e) What risks do you face when you merely delta hedge? How can you mitigate these risks?
- f) You have an opportunity to purchase calls on June 16 NG struck at \$3.37/mm BTU. Devise a transaction in the 3.37 strike Jun 17 calls and Jun 17 futures that offsets the delta and gamma risks of your original sale of puts. How many 3.37 calls should you trade? Should you buy or sell? How many Jun 17 futures should you trade? Should you buy or sell? What is the vega of your gamma and delta hedged position?