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Chapter 19. Energy Options Markets for Managing Risk

19.1. Give an energy example where you might want to lock in a maximum price? A minimum price?

19.2. Puts and calls effectively put a maximum or a minimum price on a commodity.

19.2a. Which puts a maximum price, and which puts a minimum price.

19.2b. If you owned a natural gas call option with strike price \$2.60, at what spot prices are you in the money.

19.2c. If you owned a natural gas put option with strike price \$2.60, at what spot prices are you in the money.

19.3. Is it quite easy to graph the values of puts and calls.

19.3a. Use Excel to graph a short call with strike price of \$5 and C_t = \$0.10 for S_T from 0 to 10. The following figure demonstrates formula's that will help you make the graph.

	A	B	C	D	E
1	S_T	K=	5	C_T=	0.1
2	0	=-MAX(A2-C1-E1,-E1)			
3	1	=-MAX(A3-C1-E1,-E1)			
4	=A3+(A3-A2)	=-MAX(A4-C1-E1,-E1)			
5	=A4+(A4-A3)	=-MAX(A5-C1-E1,-E1)			
6	=A5+(A5-A4)	=-MAX(A6-C1-E1,-E1)			
7	=A6+(A6-A5)	=-MAX(A7-C1-E1,-E1)			
8	=A7+(A7-A6)	=-MAX(A8-C1-E1,-E1)			
9	=A8+(A8-A7)	=-MAX(A9-C1-E1,-E1)			
10	=A9+(A9-A8)	=-MAX(A10-C1-E1,-E1)			
11	=A10+(A10-A9)	=-MAX(A11-C1-E1,-E1)			
12	=A11+(A11-A10)	=-MAX(A12-C1-E1,-E1)			

Note the Excel command for maximum is max. Notice how the increment for S_T is set up from A2 and A3 and C1 locks the absolute address of C1 into all the formulas.

The values from these formula's and the graph are shown on the right.

	A	B	C	D	E	F	G
1	S_T	K=		C_T=	0		
2	0	0.1					
3	1	0.1					
4	2	0.1					
5	3	0.1					
6	4	0.1					
7	5	0.1					
8	6	-0.9					
9	7	-1.9					
10	8	-2.9					
11	9	-3.9					
12	10	-4.9					

19.3b. Graph the net payoff of a long call with K = 7 and C_T = 0.3.

19.3c. Graph the net payoff of a long put with K = 3 and C_T = 0.2.

19.3d. Graph the net payoff of a short put with K = 6 and C_T = 0.4.

19.4. You have a call option for the underlying asset discussed in the text worth S_t=$100 this period. The price can either rise by n or fall by n. In the text, the price of the asset can go up 0.1 or 10% to equal (1+n)S_t=(1+.1)= $110 or fall to (1+n)$S_t$=(1-.1)100=$90 next period (T). The interest rate is 6%.

19.4a. Revalue the above call if n is 0.12 instead of 0.10.

19.4b. For the above example, what would p_u (value of the put when the stock prices goes up) and p_d (the value of the put when the stock prices goes down) be for a put option with strike price $100?

19.4c. What is the value of the put now?

19.5. Assume a stock price is $110 and next year it will either rise by 20% or fall by 10%. The risk free rate is 5%.

19.5a Find the value of a call option with an exercise price of $120, which expires in a year, by using a replicating portfolio?

19.5b. What are the equivalent risk free probabilities associated with these market price changes? What do they imply about the price of the portfolio?

19.5c. Find the value of a put option for this stock with the same exercise price using the same replicating formula?

19.5d. Value the same portfolio using the probabilities from part b.

19.6. Answer the following questions about options portfolios.

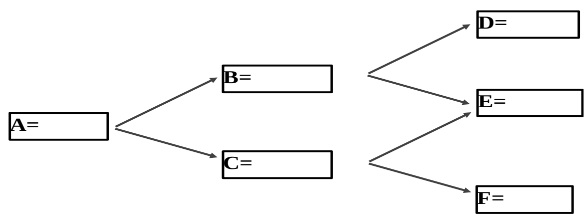
19.6a. Find the value of a call option with an exercise price of $120 which expires in a year by using a replicating portfolio?

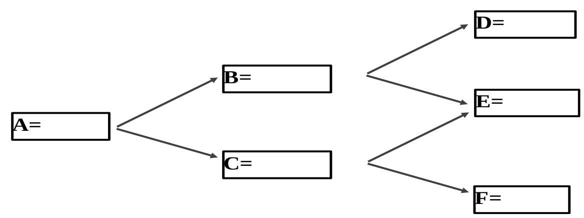
19.6b. What are the equivalent risk free probabilities associated with these market price changes? What do they imply about the price of the portfolio?

19.6c. Find the value of a put option for this stock with the same exercise price using the same replicating formula?

19.7 For the example in the text (shown below), let's value a European Put with strike price of 102.

19.7a. Let the spot price of the stock be 100. The price increases and decreases are 10% and the risk-free rate is 5%. On the left side graph below, value the underlying asset at nodes A,B,C,D, E, F. On the right, value the put at D, E, F.





19.7b. Compute the probability of a price increase and a price decrease and the probability of being at each node B, C, D, E, F.

19.7c What is the value of the option at each node A-F.

19.7d Value a European call option at each price for the above problem.

19.8. Now make the problem a little harder by making the option an American option.

19.8a. In the above problem, what is the probability that you get to D, E, and F?

19.8b. Value an American put for the above problem with strike price of 102.

19.8c. Value an American call for the above problem with strike price of 102.

19.9. Continuing from 19.8, we can make the problem harder still.

19.9a. Value the put in 19.8 if the expiration date were 3 periods out.

19.9b. Value the call in 19.8 if the expiration date were 3 periods out.

19.10. You have daily data for a week for oil prices. Monday = \$54, Tuesday = \$55, Wednesday = \$52, Thursday = \$53, Friday = \$55. Compute the daily rate of return using the discrete formula below.

$$rate\ of\ return = \frac{(S_{t+1} - S_t)}{S_t} = \frac{\Delta S_t}{S_t}$$

Remember, the rate of return on oil for a day is any capital gains or losses from one day to the next divided by the original value of the asset = $(S_{t+1} - S_t)/S_t = \Delta S_t/S_t$.

19.11. Compute S_t for the following.

19.11a. Let $S_t = e^{u_t}S_{t-1}$. $S_{t-1} = 10$, $\mu_t = 0.07$. Compute S_t?

19.11b. Let $S_t = e^{u_t}S_{t-1}$. $S_{t-1} = 10$, $\mu_t = -0.1$. Compute S_t?

19.11c. Let $S_t = e^{u_t}S_{t-1}$. $S_{t-1} = 10$, $\mu_t = 0$. Compute S_t?

19.12. Suppose daily data for oil prices is Monday = \$54, Tuesday = \$55, Wednesday = \$52, Thursday = \$53, Friday = \$55. Compute the daily rate of return, its mean, and its variance using the continuous formula for rate of return $\mu_t = \ln S_{t+1} - \ln S_t$..

19.13. Compute U, D, and p for the call option below . You have found the variance for the daily Brent crude oil rate of return to be 0.000227 and the annual risk free rate from 3 month T-bills to be = 0.073.

19.14. Compute U, D, R and p for a monthly lattice using the example in 19.13.

19.14a. First convert the variance to monthly data $\hat{\sigma}_m^2$ = 20*0.000227 = 0.00454. Next apply equations (19–2) and (19–3) to compute U and D.

19.14b. Next compute the risk-free probabilities from equation (19–1). Suppose the risk free annual rate taken from U. S. 3-month T-bills is 4.7%. To get a monthly interest rate, divide the annual rate by 12 to get r = 0.047/12 = 0.00392

19.15. If the bond you would purchase had continuous compounding, the risk free probability would be computed from the equation

$S_t*U*p + S_t*D*(1 - p) = B_t*e^r$

19.15a. What would the solution to p be in this case for the values from 19.14?

19.15b. Note you always convert continuous compounding to discrete and vice versa by changing the interest rate. For example, if the rate = 0.05 percent using annual compounding, the continuous rate would be solved from (1+0.05) = e^r.=> r = ln(1.05) = 0.049. If the continuous rate is 0.10, what is the equivalent rate for annual compounding.

19.16. If the monthly variance of an asset was 0.051, what would be its weekly variance? What would be its daily variance?

19.17. You can find one month, two month, three month and four month futures prices for light sweet crude at https://www.eia.gov/dnav/pet/pet_pri_fut_s1_a.htm. You can choose from the following periods: daily, weekly, monthly, and annual.

19.17a. Using ten years of daily data for 2009-2019, compute the variance of the rate of return of a one month futures contract for W. Texas Intermediate (WTI).

19.17b. Compute U, D and p from your answer to part a for a monthly lattice.

19.17c. Use U, D, and p to value an American call option purchased this month for 3 months from now at strike price 25.

19.18. The net value of long European puts and calls at expiration (*T*) are functions of their cost C_T, the spot price at expiration (S_T), and their strike price (*K*) and can be written as

$$\pi_T^C = max(-C_T, S_T - K - C_T)$$

$$\pi_T^P = max(-P_T, K - S_T - P_T)$$

Multiply the long values by -1 to get the value of the corresponding value of short European puts and calls at expiration. Trading strategies or spreads are buying or sell more than one type of option. To find net value of spreads at expiration, you add together the net values of each of the options you are holding. Graph the net value of the following spreads using the Excel worksheet at http://dahl.mines.edu/optionstrading.xls. Use the following costs for puts and calls. Note when you might want to use each spread. The spot price was approximately $26.15 at the time these options were valued. Note the =strike prices are in cents per barrel whereas the cost of the puts and calls are in dollars per barrel. To graph one option at a time change the values in red font in cells A5 to C5. In A5 enter whether you are graphing a put or a call. Be sure to use singular for the put or call (i.e put not puts, call not calls). Otherwise the program may not work correctly. In cell C5 enter the strike price. Use a positive strike price if you are buying the option, but a negative strike price if you are selling the option. In D5 enter the cost of the option as a negative number.

The model for two contracts at a time is in cells worksheet 1 option in file http://dahl.mines.edu/ch19n-m.xls. Fill in the cells A4-C6. In A20 enter the name of the spread, which will print on the graph. Again enter whether the option is a put or a call in column A, the strike price in column B (a positive strike price means you are buying a negative strike price indicates you are selling the option, and the cost of the option in C. Enter the strike prices from lowest to highest.

20-Mar-01		
Crude Oil	**Call**	**Put**
Strike Price	**June**	**June**
2550	2.16	1.07
2600	1.89	1.29
2650	1.62	1.52
2700	1.32	1.72
2750	1.11	2.01
2800	0.93	2.32
WSJ 3/20/01, C14		

Spread	**Call or Put**	**Strike Price (K)**	**Cost (C_t)**
9.18a Short Straddle = Sell Put and Call at same strike p**rice**	Call	-26.5	1.62
	Put	-26.5	1.52
9.18b Short Strangle = Sell call above, put below market	Call	-27.5	1.11
price	Put	-25.5	1.07
9.18c Bull Spread Call = buy call below market, sell call	Call	25.5	2.16
above market price	Call	-27.5	1.11
9.18d Bear Spread Call = buy call above market, sell call	Call	27.5	1.11
below market	Call	-25.5	2.16
9.18e Bull Spread Put = buy put below market, sell put above	Put	25.5	1.07

market	Put	-27.5	2.01
9.18e Bear Spread Put = buy put above market, sell put below	Put	27.5	2.01
market	Put	-25.5	1.07

19.19. Below are spreads that involve 3 option contracts. You can modify your file to include a 3^{rd} contract or you can use the worksheet 3 options in file http://dahl.mines.edu/ch19n-m.xls to graph the payoffs at different spot prices. The model for three contracts at a time is in cells A4.C7. The values you will have to fill in red font. Enter the strike prices from lowest to highest.

	Call	**Strike**	
Spread	**or Put**	**Price**	**Cost**
19.19a Put Ratio Vertical = Short more puts than long. Buy	Put	27.5	2.01
the higher strike price and sell the lower strike price. Same	Put	-26.5	1.52
expiration.	Put	-26.5	1.52
19.19b Call Ratio Vertical = Short more calls than long call. Buy	Call	25.5	2.16
the lower strike price and sell the higher strike price. Same	Call	-26.5	1.62
expiration.	Call	-26.5	1.62
19.19c Put Back Spread =Long more puts than shorts. Buy	Put	26.5	1.52
the lower strike price and sell the higher strike price. Same.	Put	26.5	1.52
expiration.	Put	-27.5	2.01
19.19d Call Back Spread = Long more calls than shorts. Buy	Call	26.5	1.62
the higher strike price and sell the lower strike price. Same	Call	26.5	1.62
expiration.	Call	-25.5	2.16

19.20. Below are spreads that involve 4 option contracts. These can all be modeled using the worksheet 4 options in file http://dahl.mines.edu/ch19n-m.xls. To model four contracts at a time change cells A4.C8. Enter the strike prices from lowest to highest.

	Call	**Strike**	
Spread	**or Put**	**Price**	**Cost**
19.20a Spread Calls = buy one call high price, sell two	Call	27.5	1.11
calls at intermediate price, and buy one call low price	Call	-26.5	1.62
	Call	-26.5	1.62

	Call	25.5	2.16
19.20b Butterfly Spread Puts = buy one put with low price, sell two puts at intermediate price, and buy one put at a high price	Put	25.5	1.07
	Put	-26.5	1.52
	Put	-26.5	1.52
	Put	27.5	2.01
19.20c Condor with Calls = buy one call at a low and one at a high price and sell two calls at two intermediate prices.	Call	27.5	1.11
	Call	-27.0	1.32
	Call	-26.0	1.89
	Call	25.5	2.16
19.20d Condor with Puts = buy one put at a low and one at a high price and sell two puts at two intermediate prices.	Put	25.5	1.07
	Put	-26.0	1.29
	Put	-27.0	1.72
	Put	27.5	2.01

19.22. You buy a call on oil with a strike price of $62 at $3. You also buy a $58 put at $2. Currently the price is at $60.

19.22a. What is this strategy called?

19.24b. What are you hoping will happen to the price, and what is the loss potential?

19.23. You buy a call on oil with a strike price of $60 at $3. You then buy a put at $60 also for $3. Currently the price is at $60.

19.23a. What is this strategy called?

19.23b. What are you hoping will happen to the price, and what is the loss potential?