Financial Engineering

Springer Semester 2025

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Trading strategies with options

1 Spreads

The term *spread* indicates a strategy that consists in the simultaneous purchase and sale of options of the same type on the same underlying asset, with the same expiration date but with different strike prices.

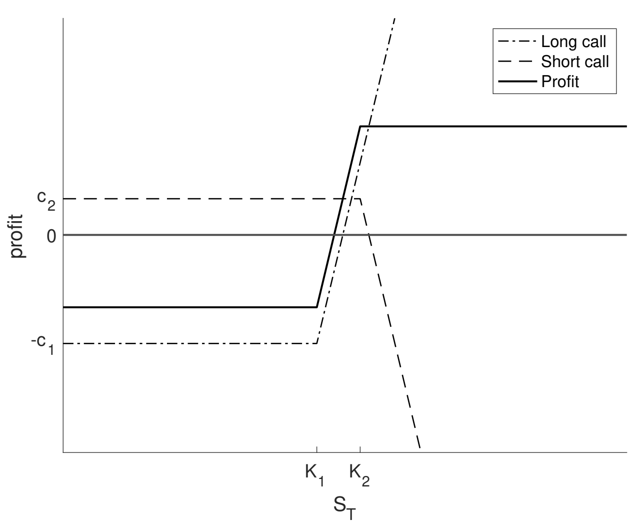
Bull spread [Using calls]

- Enter a long position in a call option on a stock with strike K_1, expiration date T, initial cost c_1 and final payoff Φ_1.
- Enter a short position in a call option on the same stock with strike $K_2 > K_1$, expiration date T, initial cost c_2 and final payoff Φ_2.

S_T	Φ_1	Φ_2	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K_1$	0	0	0
$K_1 < S_T < K_2$	$S_T - K_1$	0	$S_T - K_1 > 0$
$S_T \geq K_2$	$S_T - K_1$	$-(S_T - K_2)$	$K_2 - K_1 > 0$

A call price always decrease as the strike price increases, i.e. $K_1 < K_2 \implies c_1 > c_2$. Therefore, the value of the option sold is always less than the value of the option bought requiring an initial negative cash flow of $-c_1 + c_2 < 0$. The profit at maturity is given by:

$$\pi = \Phi_1 + \Phi_2 - c_1 + c_2$$



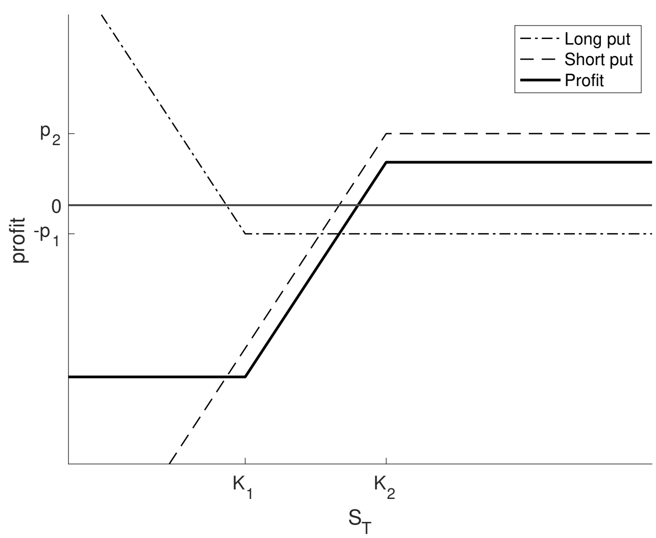
Bull spread [Using puts]

- Enter a long position in a put option on a stock with strike K_1, expiration date T, initial cost p_1 and final payoff Φ_1.
- Enter a short position in a put option on the same stock with strike $K_2 > K_1$, expiration date T, initial cost p_2 and final payoff Φ_2.

S_T	Φ_1	Φ_2	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K_1$	$K_1 - S_T$	$-(K_2 - S_T)$	$K_1 - K_2 < 0$
$K_1 < S_T < K_2$	0	$-(K_2 - S_T)$	$S_T - K_2 < 0$
$S_T \geq K_2$	0	0	0

A put price always increase as the strike price increases, i.e. $K_1 < K_2 \implies p_1 < p_2$. Therefore, the value of the option sold is always higher than the value of the option bought implying an initial positive cash flow of $p_2 - p_1 > 0$. The profit at maturity is given by:

$$\pi = \Phi_1 + \Phi_2 - p_1 + p_2$$



An investor who enters into a bull spread, either using calls or using puts, is hoping that the stock price will increase. In addition, this strategy limits the investor's upside as well as downside risk.

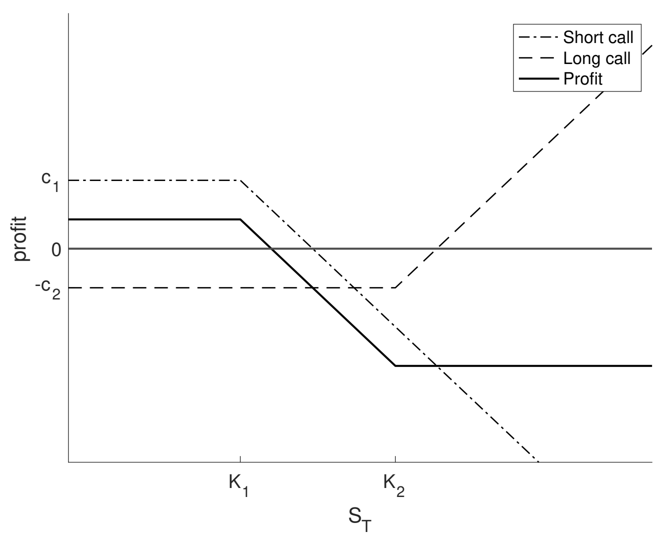
Bear spread [Using calls]

- Enter a short position in a call option on a stock with strike K_1, expiration date T, initial cost c_1 and final payoff Φ_1.
- Enter a long position in a call option on the same stock with strike $K_2 > K_1$, expiration date T, initial cost c_2 and final payoff Φ_2.

S_T	Φ_1	Φ_2	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K_1$	0	0	0
$K_1 < S_T < K_2$	$-(S_T - K_1)$	0	$K_1 - S_T < 0$
$S_T \geq K_2$	$-(S_T - K_1)$	$S_T - K_2$	$K_1 - K_2 < 0$

A call price always decrease as the strike price increases, i.e. $K_1 < K_2 \implies c_1 > c_2$. Therefore, the value of the option sold is always higher than the value of the option bought implying an initial positive cash flow of $c_2 - c_1 > 0$. The profit at maturity is given by:

$$\pi = \Phi 1 + \Phi_2 - c_1 + c_2$$



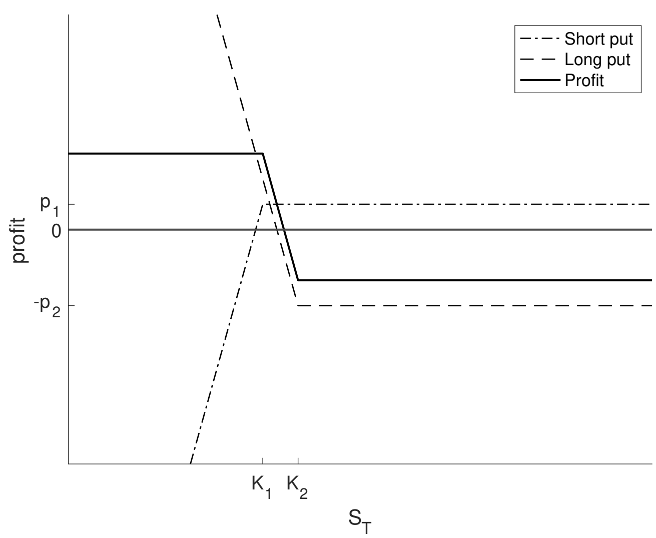
Bear spread [Using puts]

- Enter a short position in a put option on a stock with strike K_1, expiration date T, initial cost p_1 and final payoff Φ_1.
- Enter a long position in a put option on the same stock with strike $K_2 > K_1$, expiration date T, initial cost p_2 and final payoff Φ_2.

S_T	Φ_1	Φ_2	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K_1$	$-(K_1 - S_T)$	$K_2 - S_T$	$K_2 - K_1 > 0$
$K_1 < S_T < K_2$	0	$K_2 - S_T$	$K_2 - S_T > 0$
$S_T \geq K_2$	0	0	0

A put price always increase as the strike price increases, i.e. $K_1 < K_2 \implies p_1 < p_2$. Therefore, the value of the option sold is always lower than the value of the option bought implying an initial negative cash flow of $p_1 - p_2 < 0$. The profit at maturity is given by:

$$\pi = \Phi - p_1 + p_2$$



In contrast with the bull spread, investor who enters into a bear spread, either using calls or using puts, is hoping that the stock price will decrease. In addition, as in the bull spread, this strategy limits the investor's upside as well as downside risk.

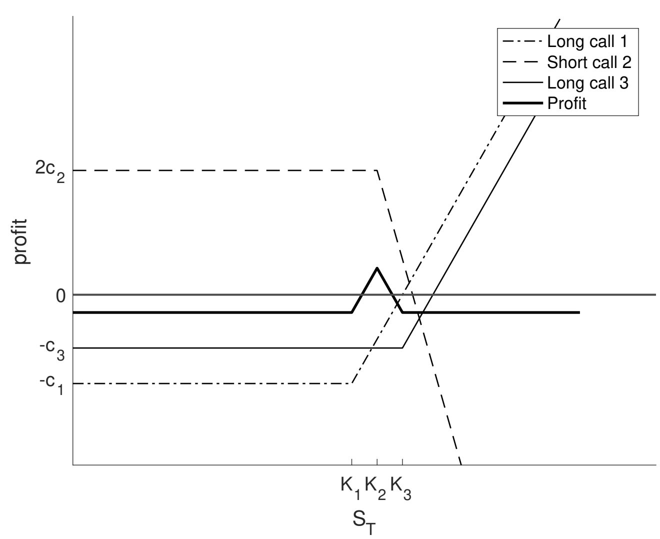
Butterfly spread [Using calls]

- Enter a long position in a call option on a stock with strike K_1, expiration date T, initial cost c_1 and final payoff Φ_1.
- Enter a long position in a call option on the same stock with strike $K_3 > K_1$, expiration date T, initial cost c_3 and final payoff Φ_3.
- Enter a short position in two call options on the same stock with strike $K_2 = \frac{K_1+K_3}{2}$, expiration date T, initial cost c_2 and final payoff Φ_2.

S_T	Φ_1	Φ_3	Φ_2	$\Phi = \Phi_1 + \Phi_2 + \Phi_3$
$S_T \leq K_1$	0	0	0	0
$K_1 < S_T < K_2$	$S_T - K_1$	0	0	$S_T - K_1 > 0$
$K_2 < S_T < K_3$	$S_T - K_1$	0	$-2(S_T - K_2)$	$K_3 - S_T > 0$
$S_T \geq K_3$	$S_T - K_1$	$S_T - K_3$	$-2(S_T - K_2)$	0

A call price always decrease as the strike price increases, i.e. $K_1 < K_2 < K_3 \implies c_1 > c_2 > c_3$. Due to the convexity of the map strike price to call cost, it is possible to show that the initial negative cash flow of $-c_1 - c_3 + 2c_2 < 0$ is negative. The profit at maturity is given by:

$$\pi = \Phi_1 + \Phi_2 + \Phi_3 - c_1 - c_2 + 2c_2$$



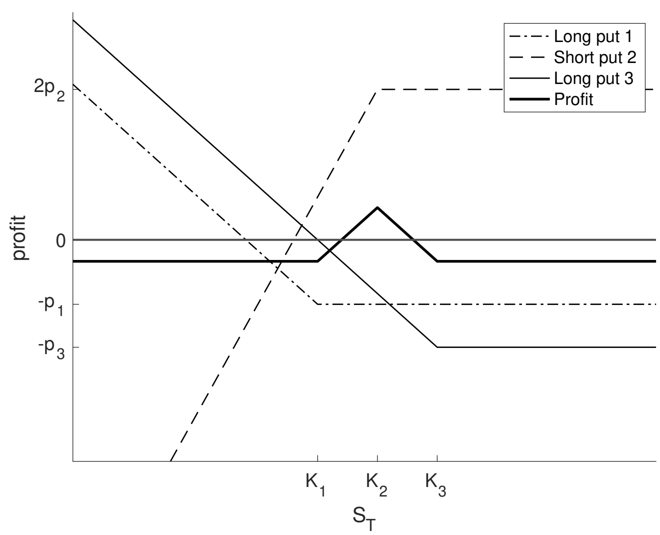
Butterfly spread [Using puts]

- Enter a long position in a put option on a stock with strike K_1, expiration date T, initial cost p_1 and final payoff Φ_1.
- Enter a long position in a put option on the same stock with strike $K_3 > K_1$, expiration date T, initial cost p_3 and final payoff Φ_3.
- Enter a short position in two put options on the same stock with strike $K_2 = \frac{K_1+K_3}{2}$, expiration date T, initial cost p_2 and final payoff Φ_2.

S_T	Φ_1	Φ_3	Φ_2	$\Phi = \Phi_1 + \Phi_2 + \Phi_3$
$S_T \leq K_1$	$K_1 - S_T$	$K_3 - S_T$	$-2(K_2 - S_T)$	0
$K_1 < S_T < K_2$	0	$K_3 - S_T$	$-2(K_2 - S_T)$	$S_T - K_1 > 0$
$K_2 < S_T < K_3$	0	$K_3 - S_T$	0	$K_3 - S_T > 0$
$S_T \geq K_3$	0	0	0	0

A put price always increase as the strike price increases, i.e. $K_1 < K_2 < K_3 \implies p_1 < p_2 < p_3$. Therefore, the value of the option sold is always higher than the value of the options bought implying an initial positive cash flow of $p_1 + p_3 - 2p_2 > 0$. The profit at maturity is given by:

$$\pi = \Phi_1 + \Phi_2 + \Phi_3 - p_1 - p_2 + 2p_2$$



Generally the strike price K_2 is close to the current stock price S_0 and a butterfly spread leads to a profit if the stock price at maturity is close to K_2, but gives rise to small losses if the stock price moves away from K_2 in either direction. Therefore, it is an appropriate strategy when the investor expects the stock price to remain stable.

2 Combinations

The term *combination* indicates a strategy that consists in the simultaneous purchase and sale of options of different types on the same underlying asset.

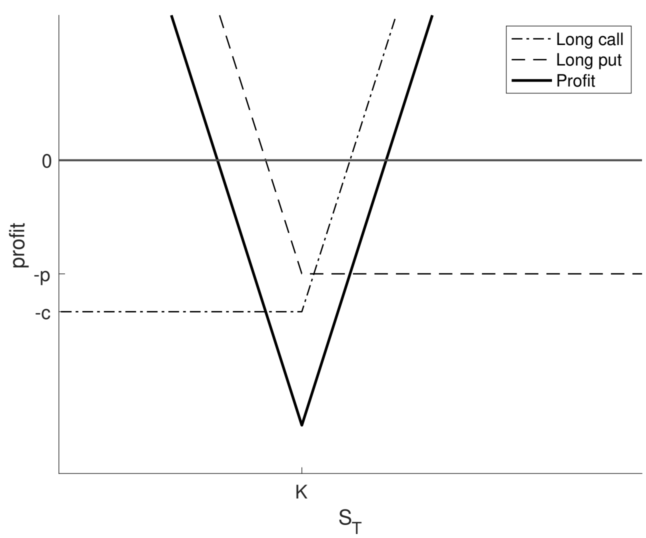
Bottom straddle or straddle purchase

- Enter a long position in a call option on a stock with strike K, expiration date T, initial cost c and final payoff Φ_c.
- Enter a long position in a put option on the same stock with strike K, expiration date T, initial cost p and final payoff Φ_p.

S_T	Φ_c	Φ_p	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K$	0	$K - S_T$	$K - S_T > 0$
$S_T > K$	$S_T - K$	0	$S_T - K > 0$

The profit at maturity is given by:

$$\pi = \Phi_c + \Phi_p - c - p$$



The bottom straddle leads to a loss if the stock price at maturity is close to the strike price K, but gives rise to large profits if the stock price moves away from K in either direction. Therefore, it is an appropriate strategy when the investor expects the stock price to be volatile.

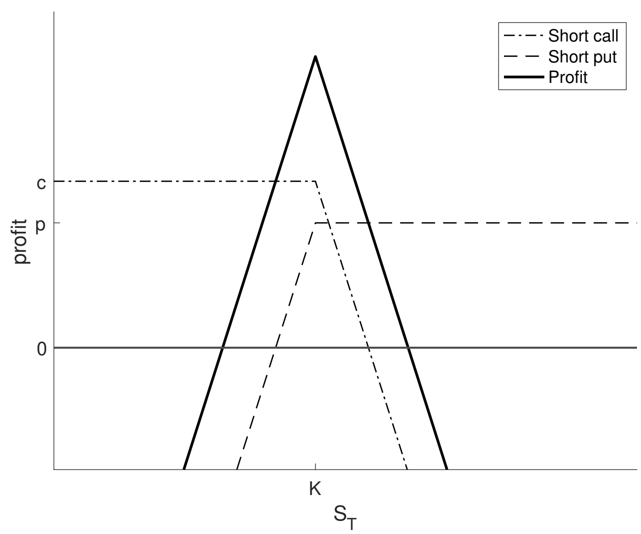
Top straddle or straddle write

- Enter a short position in a call option on a stock with strike K, expiration date T, initial cost c and final payoff Φ_c.
- Enter a short position in a put option on the same stock with strike K, expiration date T, initial cost p and final payoff Φ_p.

S_T	Φ_c	Φ_p	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K$	0	$-(K - S_T)$	$S_T - K < 0$
$S_T > K$	$-(S_T - K)$	0	$K - S_T < 0$

The profit at maturity is given by:

$$\pi = \Phi_c + \Phi_p + c + p$$



The top straddle leads to a profit if the stock price at maturity is close to the strike price K, but gives rise to large losses if the stock price moves away from K in either direction. Therefore, it is an appropriate strategy when the investor expects the stock price to be stable.

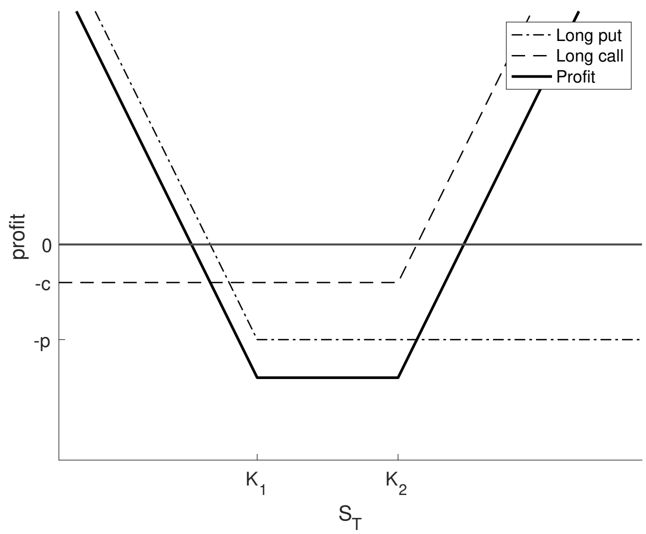
Strangle or bottom vertical combination

- Enter a long position in a put option on a stock with strike K_1, expiration date T, initial cost p and final payoff Φ_1.
- Enter a long position in a call option on the same stock with strike $K_2 > K_1$, expiration date T, initial cost c and final payoff Φ_2.

S_T	Φ_1	Φ_2	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K_1$	$K_1 - S_T$	0	$K_1 - S_T > 0$
$K_1 < S_T < K_2$	0	0	0
$S_T \geq K_2$	0	$S_T - K_2$	$S_T - K_2 > 0$

The profit at maturity is given by:

$$\pi = \Phi_1 + \Phi_2 - p - c$$



The bottom vertical combination leads to a loss if the stock price at maturity is close to the strike prices K_1 and K_2, but gives rise to large profits if the stock price moves away from K_1 and K_2 in either direction. The profit depends on how close the strike prices are: the farther apart the strike prices are, the more the stock price has to move for the investor to make a profit. In fact, the difference w.r.t. the bottom straddle is that the stock price has to move further in the bottom vertical combination than in a bottom straddle for the investor to make a profit, but on the other hand the risk if the stock price does not move is lower in the bottom vertical combination than in a bottom straddle.

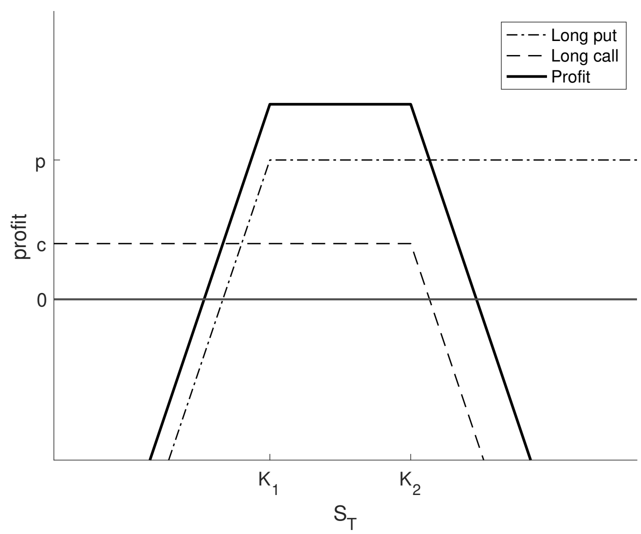
Strangle or top vertical combination

- Enter a short position in a put option on a stock with strike K_1, expiration date T, initial cost p and final payoff Φ_1.
- Enter a short position in a call option on the same stock with strike $K_2 > K_1$, expiration date T, initial cost c and final payoff Φ_2.

S_T	Φ_1	Φ_2	$\Phi = \Phi_1 + \Phi_2$
$S_T \leq K_1$	$-(K_1 - S_T)$	0	$S_T - K_1 < 0$
$K_1 < S_T < K_2$	0	0	0
$S_T \geq K_2$	0	$-(S_T - K_2)$	$K_2 - S_T < 0$

The profit at maturity is given by:

$$\pi = \Phi_1 + \Phi_2 + p + c$$



The top vertical combination leads to a profit if the stock price at maturity is close to the strike prices K_1 and K_2, but gives rise to large losses if the stock price moves away from K_1 and K_2 in either direction. The profit depends on how close the strike prices are: the farther apart the strike prices are, the more the stock price has to move for the investor to make a loss instead of a profit. In fact, the difference w.r.t. the top straddle is that the stock price has to move further in the top vertical combination than in a top straddle for the investor to make a loss, but on the other hand the profit if the stock price does not move is lower in the top vertical combination than in a top straddle.

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Problem set 5

Topics: Trading strategies with options

Exercise 1 Call options on a stock are available with strike prices of 15\$, 17.5\$, and 20\$, and expiration dates in 3 months. Their prices are 4\$, 2\$, and 0.5\$, respectively. Explain how the options can be used to create a butterfly spread. Construct a table showing how profit varies with stock price for the butterfly spread.

Exercise 2 A call option with a strike price of 50\$ costs 2\$. A put option with a strike price of 45\$ costs 3\$. Explain how a strangle can be created from these two options. What is the pattern of profits from the strangle?

Exercise 3 Suppose that put options on a stock with strike prices of 30\$ and 35\$ cost 4\$ and 7\$, respectively. How can the options be used to create a bull spread? And to create a bear spread? Construct a table that shows the profit and payoff for both spreads.

Exercise 4 Use put-call parity to show that the cost of a butterfly spread created from European puts is identical to the cost of a butterfly spread created from European calls.

Exercise 5 A call with a strike price of 60\$ costs 6\$. A put with the same strike price and expiration date costs 4\$. Construct a table that shows the profit from a straddle. For what range of stock prices would the straddle lead to a loss?

Exercise 6 Construct a table showing the payoff from a bull spread when puts with strike prices K_1 and K_2, with $K_2 > K_1$, are used.

Exercise 7 A trader creates a bear spread by selling a 6-month put option with a 25\$ strike price for 2.15\$ and buying a 6-month put option with a 29\$ strike price for 4.75\$. What is the initial investment? What is the total payoff (excluding the initial investment) when the stock price in 6 months is 23\$? And when it is 28\$? And when it is 33\$?

Exercise 8 A trader sells a strangle by selling a 6-month European call option with a strike price of 50\$ for 3\$ and selling a 6-month European put option with a strike price of 40\$ for 4\$. For what range of prices of the underlying asset in 6 months does the trader make a profit?

Exercise 9 Three put options on a stock have the same expiration date and strike prices of 55\$, 60\$, and 65\$. The market prices are 3\$, 5\$, and 8\$, respectively. Explain how a butterfly spread can be created. Construct a table showing the profit from the strategy. For what range of stock prices would the butterfly spread lead to a loss?

Exercise 10 For each of the following strategies, construct a table showing the relationship between profit and final stock price:

1. A bull spread using European call options with strike prices of 25\$ and 30\$, that cost 7.90\$ and 4.18\$, respectively, and maturity of 6 months.
2. A bear spread using European put options with strike prices of 25\$ and 30\$, that cost 0.28\$ and 1.44\$, respectively, and maturity of 6 months.
3. A butterfly spread using European call options with strike prices of 25\$, 30\$, and 35\$, that cost 8.92\$, 5.60\$, and 3.28\$, respectively, and maturity of 1 year.
4. A butterfly spread using European put options with strike prices of 25\$, 30\$, and 35\$, that cost 0.70\$, 2.14\$, and 4.58\$, respectively, and maturity of 1 year.
5. A straddle using options with a strike price of 30\$ that cost 4.18\$ (the call) and 1.44\$ (the put), and a 6-month maturity.
6. A strangle using options with strike prices of 25\$ (the put) and 35\$ (the call) that cost 0.28\$ (the put) and 1.85\$ (the call), and a 6-month maturity.

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Problem set 5

Topics: Trading strategies with options

Exercise 1 Call options on a stock are available with strike prices of 15$, 17.5$, and 20$, and expiration dates in 3 months. Their prices are 4$, 2$, and 0.5$, respectively. Explain how the options can be used to create a butterfly spread. Construct a table showing how profit varies with stock price for the butterfly spread.

Solution 1 An investor can create a butterfly spread by:

- Buying one call option with a strike price of 15 for 4.
- Selling two call options with a strike price of 17.5 for 2 each.
- Buying one call option with a strike price of 20 for 0.5.

The initial investment is:

$$c_1 - 2c_2 + c_3 = 4 - 2(2) + 0.5 = 0.5$$

and the payoff and the profit are:

Stock Price	Payoff	Profit
$S_T \leq 15$	0	-0.5
$15 < S_T \leq 17.5$	$S_T - 15$	$S_T - 15.5$
$17.5 < S_T \leq 20$	$20 - S_T$	$19.5 - S_T$
$S_T > 20$	0	-0.5

In particular, the maximum profit occurs when the stock price is $S_T = K_2 = 17.5$ and its is equal to 2.

Solution 2 An investor can create a strangle by buying both options. The initial investment is:

$$c + p = 2 + 3 = 5$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 45$	$45 - S_T$	$40 - S_T$
$45 \leq S_T < 50$	0	-5
$S_T \geq 50$	$S_T - 50$	$S_T - 55$

The maximum loss occurs when the stock price is $45 \leq S_T \leq 50$ and it is equal to 5, while if $S_T < 40$ or $S_T > 55$ a profit is made.

Exercise 2 A call option with a strike price of 50$ costs 2$. A put option with a strike price of 45$ costs 3$. Explain how a strangle can be created from these two options. What is the pattern of profits from the strangle?

Exercise 3 Suppose that put options on a stock with strike prices of 30$ and 35$ cost 4$ and 7$, respectively. How can the options be used to create a bull spread? And to create a bear spread? Construct a table that shows the profit and payoff for both spreads.

Solution 3 An investor can create a bull spread by:

1 Buying a put option with a strike price of 30 for 4.

2 Selling a put option with a strike price of 35 for 7.

The initial inflow is:

$$p_2 - p_1 = 7 - 4 = 3$$

The payoff and the profit are:

Stock Price	Payoff from [1]	Payoff from [2]	Profit
$S_T < 30$	$30 - S_T$	$-(35 - S_T)$	-2
$30 \leq S_T < 35$	0	$-(35 - S_T)$	$S_T - 32$
$S_T \geq 35$	0	0	3

In particular, a profit is made when $S_T > 32$. IN the same situation an investor can create a bear spread by:

1 Selling a put option with a strike price of 30 for 4.

2 Buying a put option with a strike price of 35 for 7.

The initial investment is:

$$p_2 - p_1 = 7 - 4 = 3$$

The payoff and the profit are:

Stock Price	Payoff from [1]	Payoff from [2]	Profit
$S_T < 30$	$-(30 - S_T)$	$35 - S_T$	2
$30 \leq S_T < 35$	0	$35 - S_T$	$32 - S_T$
$S_T \geq 35$	0	0	-3

In particular, a profit is made when $S_T < 32$.

Solution 4 In this case we have c_i the price of the call option with strike price K_i and p_i the price of the put option with strike price K_i, for $i = 1, 2, 3$. The initial cash flows are:

1 Cost of a butterfly spread created from European calls:

$$c_1 - 2c_2 + c_3$$

2 Cost of a butterfly spread created from European puts:

$$p_1 - 2p_2 + p_3$$

The put-call parity states that:

$$c_i + K_i e^{-rT} = p_i + S_0$$

Exercise 4 Use put-call parity to show that the cost of a butterfly spread created from European puts is identical to the cost of a butterfly spread created from European calls.

Thus, we can write [1] as:

$$\begin{aligned} c_1 - 2c_2 + c_3 &= p_1 + S_0 - 2(p_2 + S_0 e^{-rT}) + p_3 + S_0 \\ &= p_1 - 2p_2 + p_3 + S_0(1 - 2e^{-rT} + 1) \\ &= p_1 - 2p_2 + p_3 + S_0(2 - 2e^{-rT}) \\ &= p_1 - 2p_2 + p_3 \end{aligned}$$

Hence the cost of the butterfly spread created from European calls is equal to the cost of the butterfly spread created from European puts.

Solution 5 An investor can create a straddle by buying both options. The initial investment is:

$$c + p = 6 + 4 = 10$$

Exercise 5 A call with a strike price of 60$ costs 6$. A put with the same strike price and expiration date costs 4$. Construct a table that shows the profit from a straddle. For what range of stock prices would the straddle lead to a loss?

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 60$	$60 - S_T$	$50 - S_T$
$S_T \geq 60$	$S_T - 60$	$S_T - 70$

In particular, there is a loss for $50 \leq S_T \leq 70$.

Solution 6 Construct a table showing the payoff from a bull spread when puts with strike prices K_1 and K_2, with $K_2 > K_1$, are used. An investor can create a bull spread by:

Exercise 6 Construct a table showing the payoff from a bull spread when puts with strike prices K_1 and K_2, with $K_2 > K_1$, are used.

1 Buying a put option with a strike price of K_1 for p_1.

2 Selling a put option with a strike price of $K_2 > K_1$ for p_2.

The payoff is:

Stock Price	Payoff from [1]	Payoff from [2]	Total payoff
$S_T < K_1$	$K_1 - S_T$	$-(K_2 - S_T)$	$K_1 - K_2$
$K_1 \leq S_T < K_2$	0	$-(K_2 - S_T)$	$S_T - K_2$
$S_T \geq K_2$	0	0	0

Solution 7 A trader creates a bear spread by selling a 6-month put option with a 25 strike price for 2.15 and buying a 6-month put option with a 29 strike price for 4.75. What is the initial investment? What is the total payoff (excluding the initial investment) when the stock price in 6 months is 23? And when it is 28? And when it is 33?
The trader creates a bear spread by:

1 Selling a put option with a strike price of $K_1 = 25$ for $p_1 = 2.15$.

2 Buying a put option with a strike price of $K_2 = 29$ for $p_2 = 4.75$.

Exercise 7 A trader creates a bear spread by selling a 6-month put option with a 25$ strike price for 2.15$ and buying a 6-month put option with a 29$ strike price for 4.75$. What is the initial investment? What is the total payoff (excluding the initial investment) when the stock price in 6 months is 23$? And when it is 28$? And when it is 33$?

The initial investment is:

$$p_2 - p_1 = 4.75 - 2.15 = 2.60$$

The payoff is:

Stock Price	Payoff
$S_T < 25$	$-(25 - S_T) + (29 - S_T) = 4$
$25 \leq S_T < 29$	$0 + (29 - S_T) = 29 - S_T$
$S_T \geq 29$	$0 + 0 = 0$

Hence if the stock price in 6 months is 23, the payoff is 4; if it is 28, the payoff is 1; and if it is 33, the payoff is 0.

Solution 8 A trader sells a strangle by selling both options:

1 A put option with a strike price of 40 for 3.

2 A call option with a strike price of 50 for 4.

Exercise 8 A trader sells a strangle by selling a 6-month European call option with a strike price of 50$ for 3$ and selling a 6-month European put option with a strike price of 40$ for 4$. For what range of prices of the underlying asset in 6 months does the trader make a profit?

The initial inflow is:

$$c + p = 3 + 4 = 7$$

The payoff and the profit are:

Stock Price	Payoff from [1]	Payoff from [2]	Total payoff	Profit
$S_T < 40$	$-(40 - S_T)$	0	$S_T - 40$	$S_T - 33$
$40 \leq S_T < 50$	0	0	0	7
$S_T \geq 50$	0	$-(S_T - 50)$	$50 - S_T$	$57 - S_T$

In particular a profit is made when $33 < S_T < 57$.

Solution 9 An investor can create a butterfly spread by:

1 Buying a put option with a strike price of $K_1 = 55$ for $p_1 = 3$.

2 Selling two put options with a strike price of $K_2 = 60$ for $p_2 = 5$ each.

3 Buying a put option with a strike price of $K_3 = 65$ for $p_3 = 8$.

The initial investment is:

$$p_1 - 2p_2 + p_3 = 3 - 2(5) + 8 = 1$$

The payoff and the profit are:

Stock Price	Payoff from [1]	Payoff from [2]	Payoff from [3]	Profit
$S_T < 55$	$55 - S_T$	$-2(60 - S_T)$	$65 - S_T$	-1
$55 \leq S_T < 60$	0	$-2(60 - S_T)$	$65 - S_T$	$S_T - 56$
$60 \leq S_T < 65$	0	0	$65 - S_T$	$64 - S_T$
$S_T \geq 65$	0	0	0	-1

In particular, a loss is made when $S_T < 56$ or $S_T > 64$.

Exercise 9 Three put options on a stock have the same expiration date and strike prices of 55$, 60$, and 65$. The market prices are 3$, 5$, and 8$, respectively. Explain how a butterfly spread can be created. Construct a table showing the profit from the strategy. For what range of stock prices would the butterfly spread lead to a loss?

Exercise 10 For each of the following strategies, construct a table showing the relationship between profit and final stock price:

1 A bull spread using European call options with strike prices of 25\$ and 30\$, that cost 7.90\$ and 4.18\$, respectively, and maturity of 6 months.

2 A bear spread using European put options with strike prices of 25\$ and 30\$, that cost 0.28\$ and 1.44\$, respectively, and maturity of 6 months.

3 A butterfly spread using European call options with strike prices of 25\$, 30\$, and 35\$, that cost 8.92\$, 5.60\$, and 3.28\$, respectively, and maturity of 1 year.

4 A butterfly spread using European put options with strike prices of 25\$, 30\$, and 35\$, that cost 0.70\$, 2.14\$, and 4.58\$, respectively, and maturity of 1 year.

5 A straddle using options with a strike price of 30\$ that cost 4.18\$ (the call) and 1.44\$ (the put), and a 6-month maturity.

6 A strangle using options with strike prices of 25\$ (the put) and 35\$ (the call) that cost 0.28\$ (the put) and 1.85\$ (the call), and a 6-month maturity.

Solution 10

1 The cost of the bull spread is:

$$c_1 - c_2 = 7.90 - 4.18 = 3.72$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 25$	0	-3.72
$25 \leq S_T < 30$	$S_T - 25$	$S_T - 28.72$
$S_T \geq 30$	5	1.28

2 The cost of the bear spread is:

$$p_2 - p_1 = 1.44 - 0.28 = 1.16$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 25$	5	3.84
$25 \leq S_T < 30$	$30 - S_T$	$28.84 - S_T$
$S_T \geq 30$	0	-1.16

3 The cost of the butterfly spread is:

$$c_1 - 2c_2 + c_3 = 8.92 - 2(5.60) + 3.28 = 1$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 25$	0	-1
$25 \leq S_T < 30$	$S_T - 25$	$S_T - 26$
$30 \leq S_T < 35$	$35 - S_T$	$34 - S_T$
$S_T \geq 35$	0	-1

4 The cost of the butterfly spread is:

$$p_1 - 2p_2 + p_3 = 0.70 - 2(2.14) + 4.58 = 1$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 25$	0	-1
$25 \leq S_T < 30$	$S_T - 25$	$S_T - 26$
$30 \leq S_T < 35$	$35 - S_T$	$34 - S_T$
$S_T \geq 35$	0	-1

5 The cost of the straddle is:

$$c + p = 4.18 + 1.44 = 5.62$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 30$	$30 - S_T$	$24.38 - S_T$
$S_T \geq 30$	$S_T - 30$	$S_T - 35.62$

6 The cost of the strangle is:

$$c + p = 1.85 + 0.28 = 2.13$$

The payoff and the profit are:

Stock Price	Payoff	Profit
$S_T < 25$	$25 - S_T$	$22.87 - S_T$
$25 \leq S_T < 35$	0	-2.13
$S_T \geq 35$	$S_T - 35$	$S_T - 37.13$