151 Trading strategies implemented on python

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Abstract

I want to firstly thank **Zura Kakushadze** and **Juan Andrés Serur** for their work on 151 trading strategies. The aim of this work is to reproduce these strategies in Python and have a clear view on the P&L of each strategy. You can find the Python implementation on: Chenjie's Github Trading strategies.

1 introduction

conventional notation of our paper

- S_T is the stock price at expiration.
- S_0 is the initial stock price.
- K is the strike price of the call option.
- C is the premium received from writing the call option (expiring at $t = T$).
- D is the premium received from writing the put option
- $V$is the value of the long call option (expiring at $t = T'$)

Capital Gain Strategy: A capital gain strategy is designed to profit from significant movements in the price of the underlying asset, whether up or down. These strategies typically involve buying options, which have a limited downside (the premium paid) and unlimited upside potential. The goal is to achieve a substantial increase in the value of the options as the underlying asset's price moves favorably.

Net Credit Strategy: A net credit strategy involves selling options to collect premium income. The initial cash inflow from selling the options creates a net credit. These strategies are often designed to profit from a neutral or sideways market, where the underlying asset's price is not expected to move significantly.

Income Strategy: An income strategy focuses on generating regular income through the collection of premiums by writing (selling) options. These strategies are typically employed by traders who expect the underlying asset's price to remain within a certain range. Income strategies are designed to take advantage of time decay and the fact that most options expire worthless.

Contents

2 151 Trading Strategies

2.1 Strategy: Covered Call

Key Components

- **Stock Purchase**: Buy the underlying stock at the current price S_0.
- **Call Option Writing**: Sell a call option with a strike price K and receive a premium C.

While maintaining the long stock position, the trader can generate income by periodically selling OTM call options. The trader's outlook on the stock price is **neutral to bullish**

Payoff at Expiration

The payoff for the covered call strategy at expiration is given by the formula:

$$f_T = S_T - S_0 - \max(0, S_T - K) + C \tag{1}$$

- **Adjusted Stock Price** S_*:

$$S_* = S_0 - C \tag{2}$$

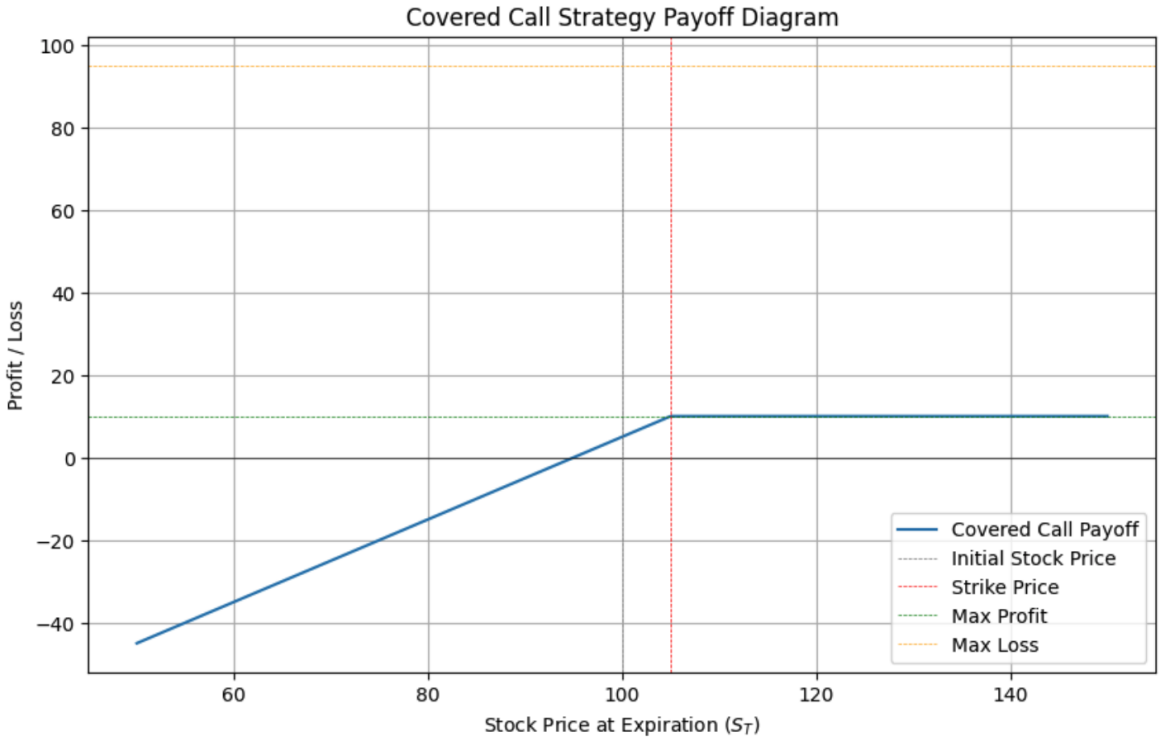
- **Maximum Profit** $P_{\max}$:

$$P_{\max} = K - S_0 + C \tag{3}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = S_0 - C \tag{4}$$

P&L



2.2 Strategy: Covered Put

Key Components

- **Stock Shorting**: Short the underlying stock at the current price S_0.
- **Put Option Writing**: Sell a put option with a strike price K and receive a premium C.

While maintaining the short stock position, the trader can generate income by periodically selling OTM put options. The trader's outlook on the stock price is **neutral to bearish**.

Payoff at Expiration

The payoff for the covered put strategy at expiration is given by the formula:

$$f_T = S_0 - S_T - \max(0, K - S_T) + C = S_0 - K - \max(0, S_T - K) + C \tag{5}$$

- **Adjusted Stock Price S_***:

$$S_* = S_0 + C \tag{6}$$

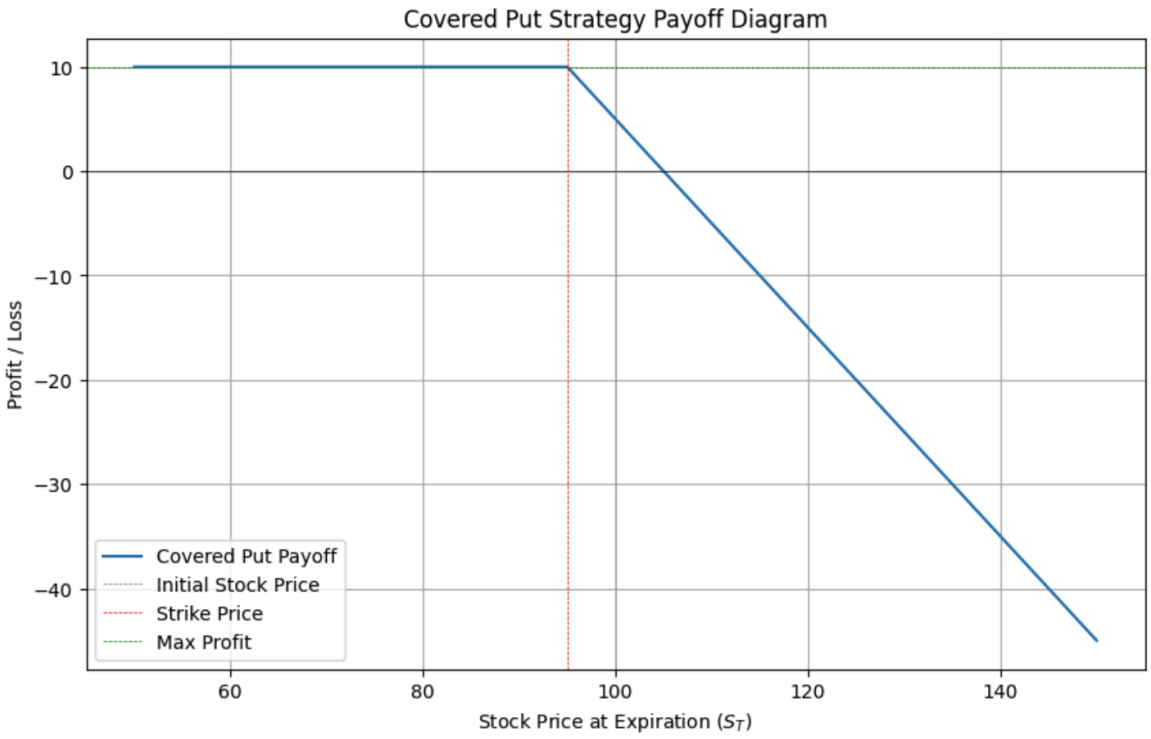
- **Maximum Profit $P_{\max}$**:

$$P_{\max} = S_0 - K + C \tag{7}$$

- **Maximum Loss $L_{\max}$**:

$$L_{\max} = \text{Unlimited} \tag{8}$$

P&L



2.3 Strategy: Protective Put

Key Components

- **Stock Purchase**: Buy the underlying stock at the current price S_0.
- **Put Option Purchase**: Buy a put option with a strike price $K \leq S_0$ and pay a premium D.

This strategy (a.k.a. "married put" or "synthetic call") amounts to buying stock and an ATM or OTM put option with a strike price $K \leq S_0$. The trader's outlook is bullish. This is a hedging strategy: the put option hedges the risk of the stock price falling.

Payoff at Expiration

The payoff for the protective put strategy at expiration is given by the formula:

$$f_T = S_T - S_0 + \max(0, K - S_T) - D = K - S_0 + \max(0, S_T - K) - D \tag{9}$$

- **Adjusted Stock Price** S_*:

$$S_* = S_0 + D \tag{10}$$

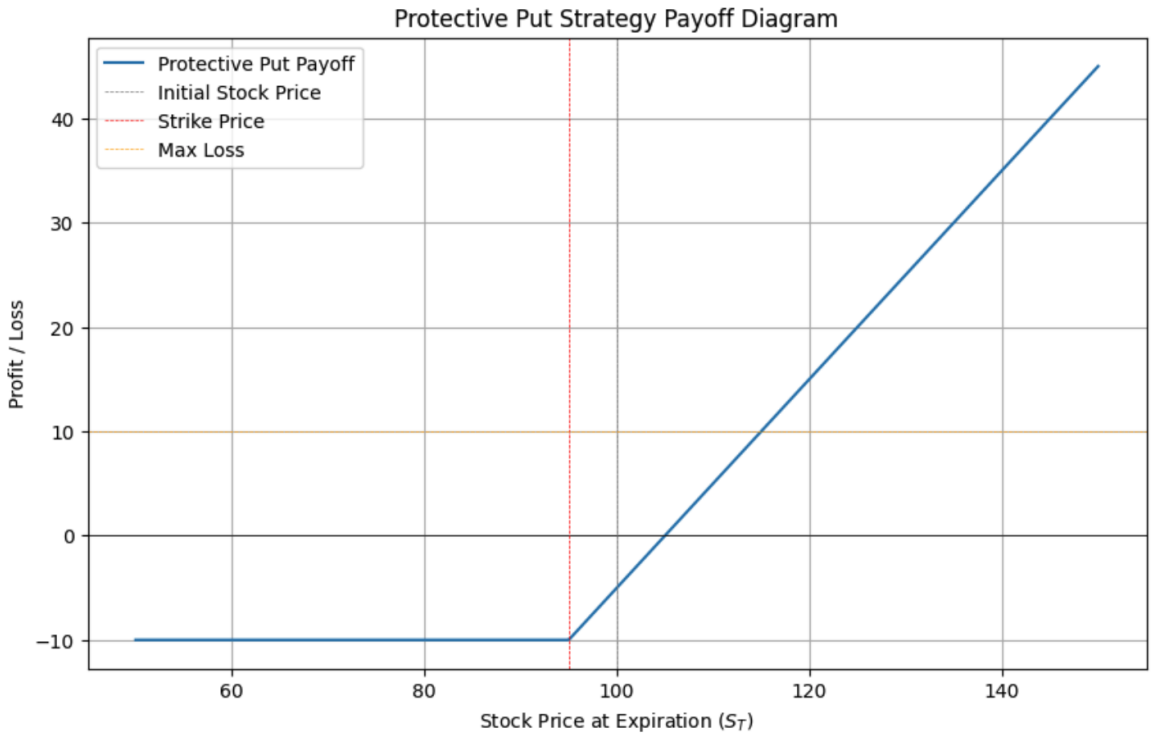
- **Maximum Profit** $P_{\max}$:

$$P_{\max} = \text{Unlimited} \tag{11}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = S_0 - K + D \tag{12}$$

P&L



2.4 Strategy: Protective Call

Key Components

- **Stock Shorting**: Short the underlying stock at the current price S_0.
- **Call Option Purchase**: Buy a call option with a strike price $K \geq S_0$ and pay a premium D.

This strategy (a.k.a. "married call" or "synthetic put") amounts to shorting stock and buying an ATM or OTM call option with a strike price $K \geq S_0$. The trader's outlook is bearish. This is a hedging strategy: the call option hedges the risk of the stock price rising.

Payoff at Expiration

The payoff for the protective call strategy at expiration is given by the formula:

$$f_T = S_0 - S_T + \max(0, S_T - K) - D = S_0 - K + \max(0, K - S_T) - D \tag{13}$$

- **Adjusted Stock Price** S_*:

$$S_* = S_0 - D \tag{14}$$

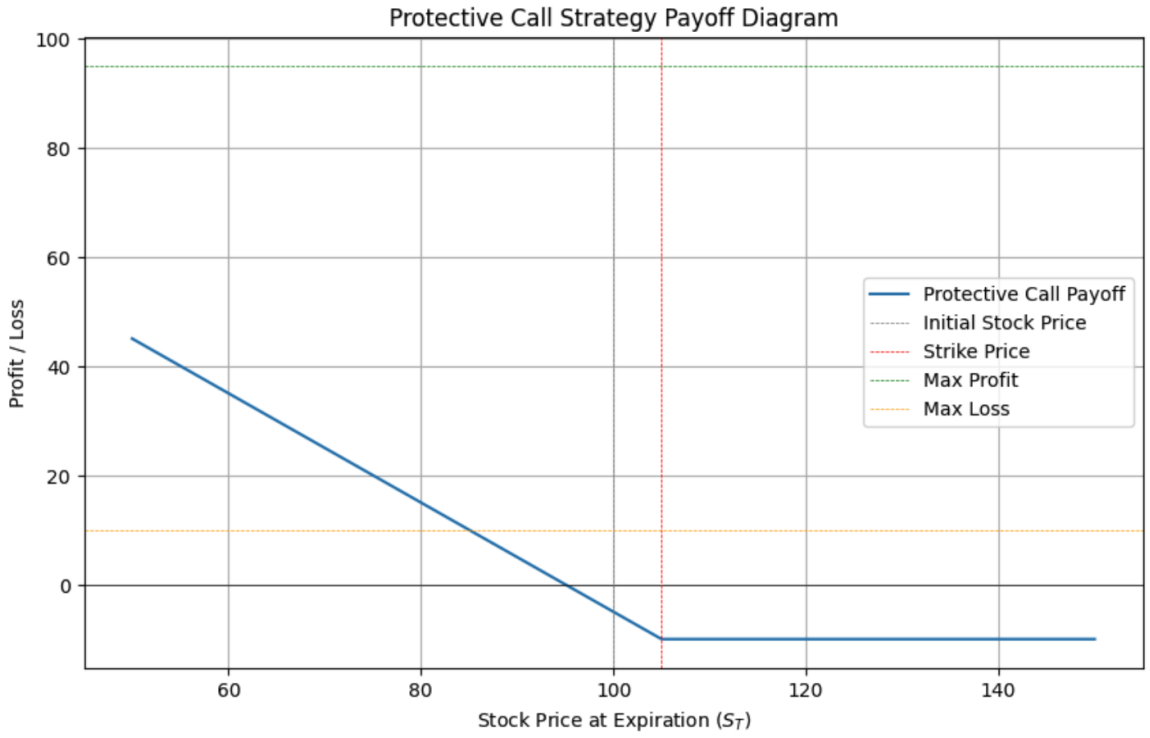
- **Maximum Profit** $P_{\max}$:

$$P_{\max} = S_0 - D \tag{15}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = K - S_0 + D \tag{16}$$

P&L



2.5 Strategy: Bull Call Spread

Key Components

- **Long Call Option**: Buy a call option with a strike price K_1 and pay a premium D.
- **Short Call Option**: Sell a call option with a higher strike price K_2 and receive a premium.

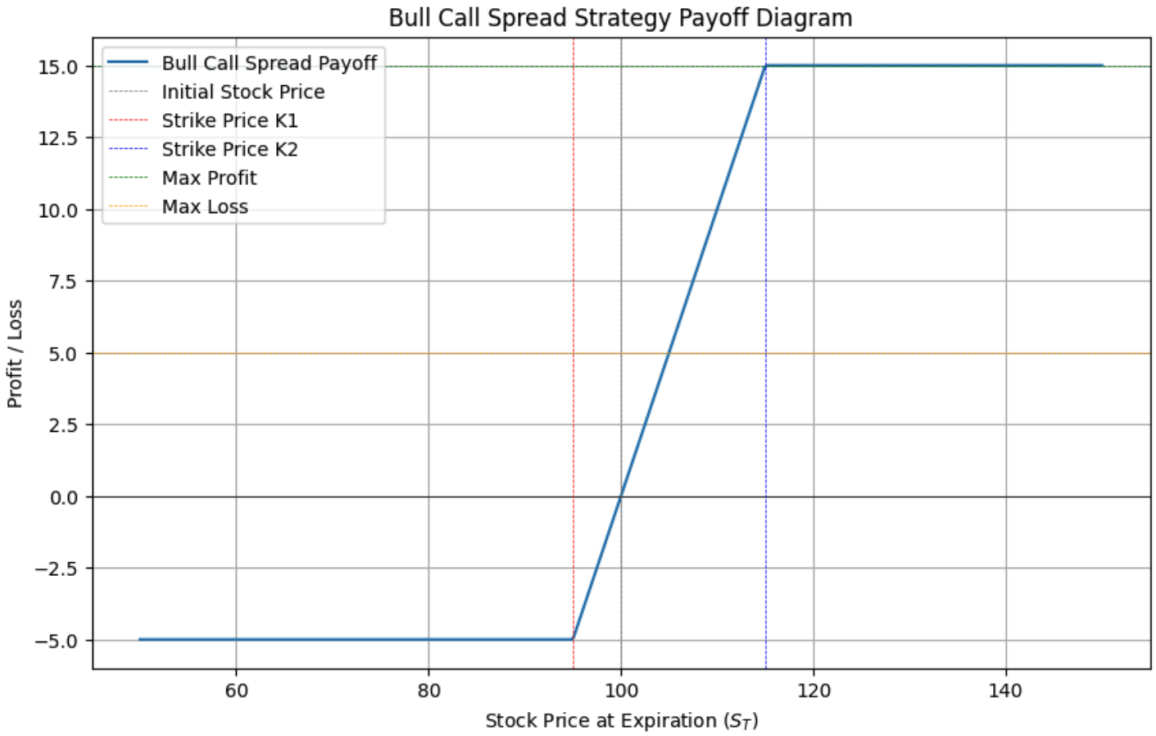
This is a vertical spread consisting of a long position in a close to ATM call option with a strike price K_1, and a short position in an OTM call option with a higher strike price K_2. This is a net debit trade. The trader's outlook is bullish: the strategy profits if the stock price rises. This is a capital gain strategy.

Payoff at Expiration

The payoff for the bull call spread strategy at expiration is given by the formula:

$$f_T = (\max(0, S_T - K_1)) - (\max(0, S_T - K_2)) - D \tag{17}$$

- **Adjusted Stock Price S_***:
$$S_* = K_1 + D \tag{18}$$
- **Maximum Profit $P_{\max}$**:
$$P_{\max} = K_2 - K_1 - D \tag{19}$$
- **Maximum Loss $L_{\max}$**:
$$L_{\max} = D \tag{20}$$



2.6 Strategy: Bull Put Spread

Key Components

- **Long Put Option**: Buy an OTM put option with a strike price K_1 and pay a premium.
- **Short Put Option**: Sell an OTM put option with a higher strike price K_2 and receive a premium C.

This is a vertical spread consisting of a long position in an OTM put option with a strike price K_1, and a short position in another OTM put option with a higher strike price K_2. This is a net credit trade. The trader's outlook is bullish. This is an income strategy.

Payoff at Expiration

The payoff for the bull put spread strategy at expiration is given by the formula:

$$f_T = (\max(0, K_1 - S_T)) - (\max(0, K_2 - S_T)) + C \tag{21}$$

- **Adjusted Stock Price** S_*:

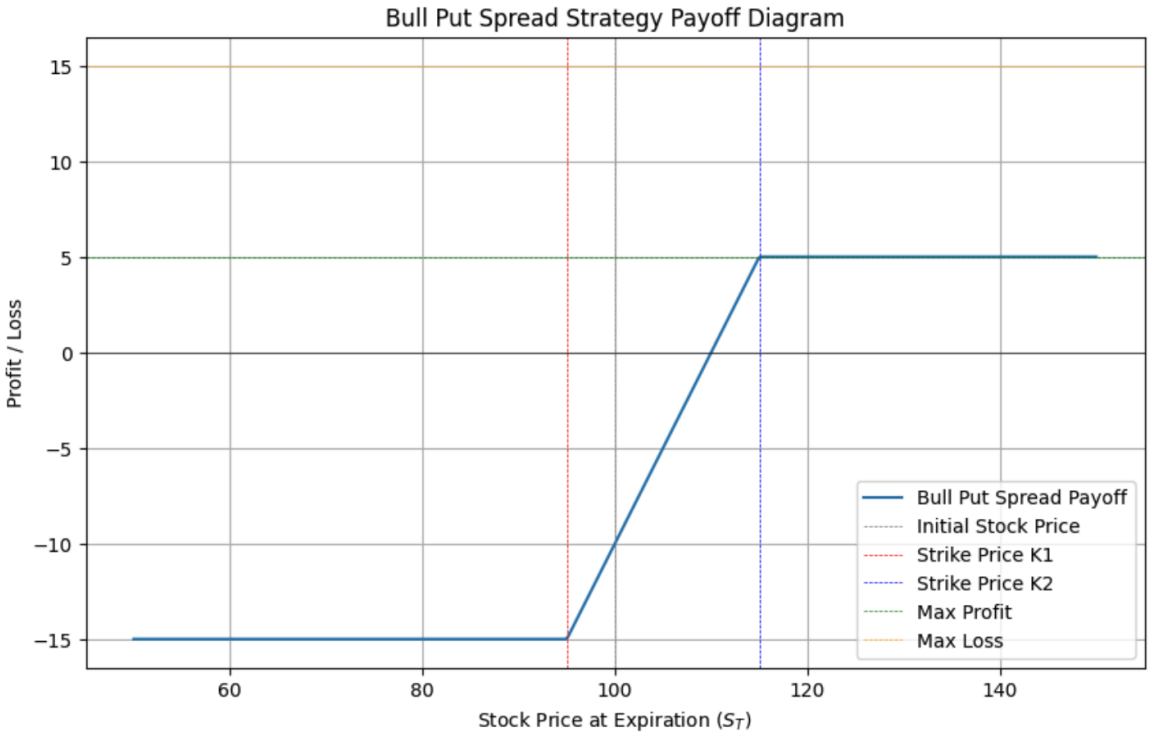
$$S_* = K_2 - C \tag{22}$$

- **Maximum Profit** $P_{\max}$:

$$P_{\max} = C \tag{23}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = K_2 - K_1 - C \tag{24}$$



2.7 Strategy: Bear Call Spread

Key Components

- **Long Call Option**: Buy an OTM call option with a strike price K_1 and pay a premium.
- **Short Call Option**: Sell an OTM call option with a lower strike price K_2 and receive a premium C.

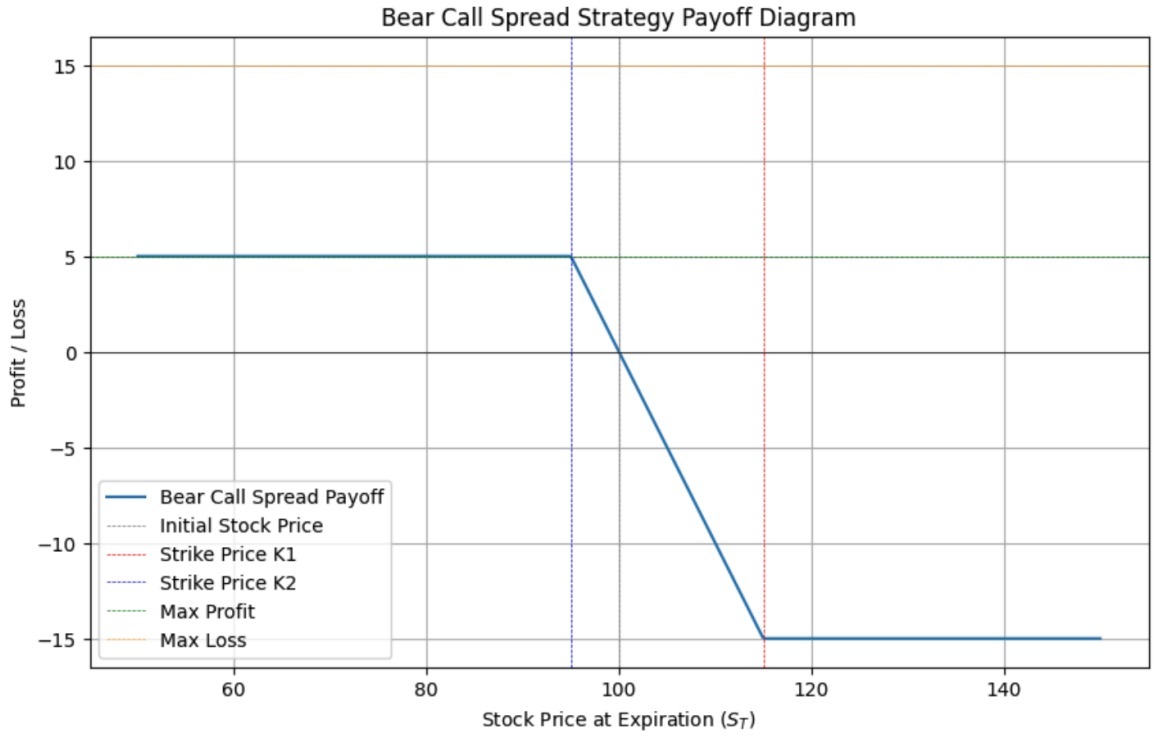
This is a vertical spread consisting of a long position in an OTM call option with a strike price K_1, and a short position in another OTM call option with a lower strike price K_2. This is a net credit trade. The trader's outlook is bearish. This is an income strategy.

Payoff at Expiration

The payoff for the bear call spread strategy at expiration is given by the formula:

$$f_T = (\max(0, S_T - K_1)) - (\max(0, S_T - K_2)) + C \tag{25}$$

- **Adjusted Stock Price S_***:
$$S_* = K_2 + C \tag{26}$$
- **Maximum Profit $P_{\max}$**:
$$P_{\max} = C \tag{27}$$
- **Maximum Loss $L_{\max}$**:
$$L_{\max} = K_1 - K_2 - C \tag{28}$$



2.8 Strategy: Bear Put Spread

Key Components

- **Long Put Option**: Buy a close to ATM put option with a strike price K_1 and pay a premium D.
- **Short Put Option**: Sell an OTM put option with a lower strike price K_2 and receive a premium.

This is a vertical spread consisting of a long position in a close to ATM put option with a strike price K_1, and a short position in an OTM put option with a lower strike price K_2. This is a net debit trade. The trader's outlook is bearish: this strategy profits if the stock price falls. This is a capital gain strategy.

Payoff at Expiration

The payoff for the bear put spread strategy at expiration is given by the formula:

$$f_T = (\max(0, K_1 - S_T)) - (\max(0, K_2 - S_T)) - D \tag{29}$$

- **Adjusted Stock Price** S_*:

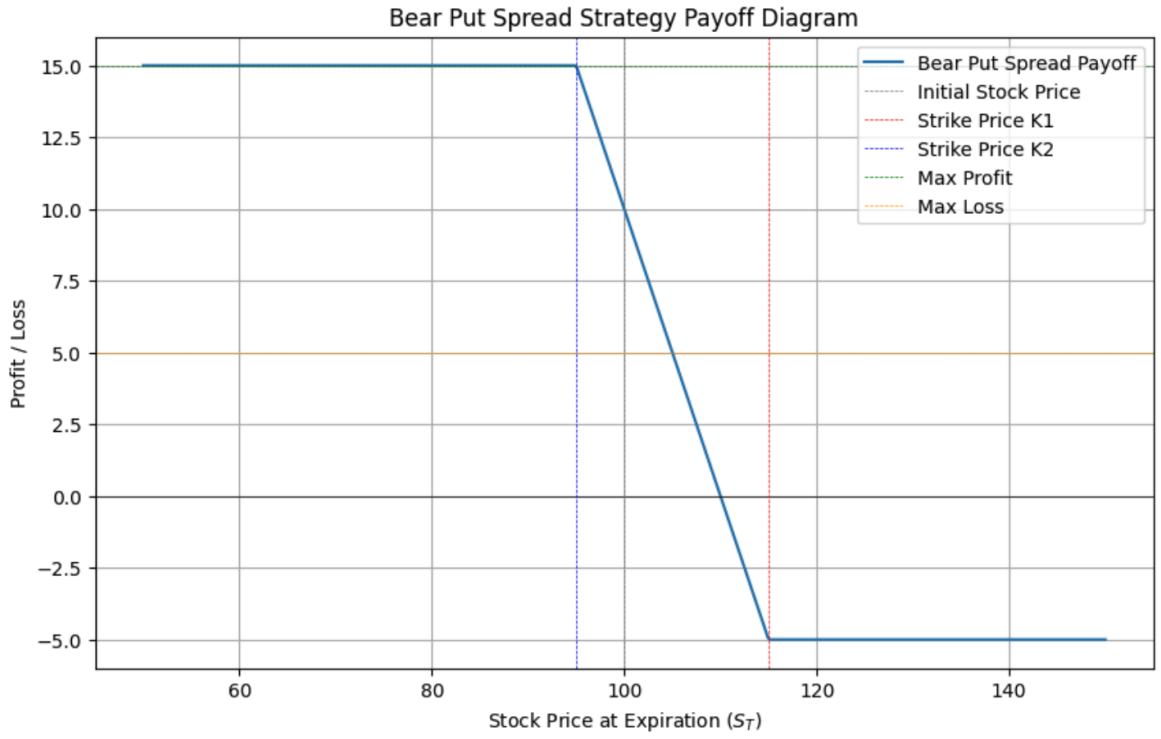
$$S_* = K_1 - D \tag{30}$$

- **Maximum Profit** $P_{\max}$:

$$P_{\max} = K_1 - K_2 - D \tag{31}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = D \tag{32}$$



2.9 Strategy: Long Synthetic Forward

Key Components

- **Long Call Option**: Buy an ATM call option with a strike price $K = S_0$ and pay a premium H.
- **Short Put Option**: Sell an ATM put option with a strike price $K = S_0$ and receive a premium.

This strategy amounts to buying an ATM call option and selling an ATM put option with a strike price $K = S_0$. This can be a net debit or net credit trade. Typically, $|H| \ll S_0$. The trader's outlook is bullish: this strategy mimics a long stock or futures position; it replicates a long forward contract with the delivery price K and the same maturity as the options. This is a capital gain strategy.

Payoff at Expiration

The payoff for the long synthetic forward strategy at expiration is given by the formula:

$$f_T = (\max(0, S_T - K)) - (\max(0, K - S_T)) - H = S_T - K - H \tag{33}$$

- **Adjusted Stock Price** S_*:

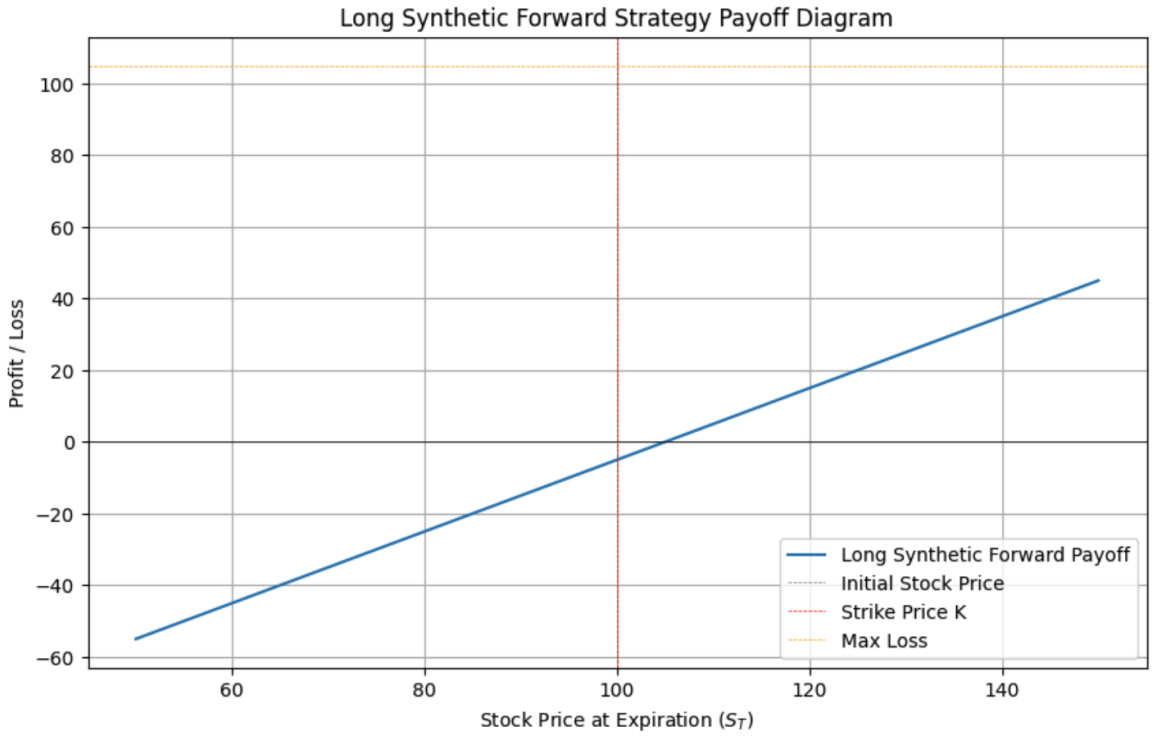
$$S_* = K + H \tag{34}$$

- **Maximum Profit** $P_{\max}$:

$$P_{\max} = \text{Unlimited} \tag{35}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = K + H \tag{36}$$



2.10 Strategy: Short Synthetic Forward

Key Components

- **Long Put Option**: Buy an ATM put option with a strike price $K = S_0$ and pay a premium H.
- **Short Call Option**: Sell an ATM call option with a strike price $K = S_0$ and receive a premium.

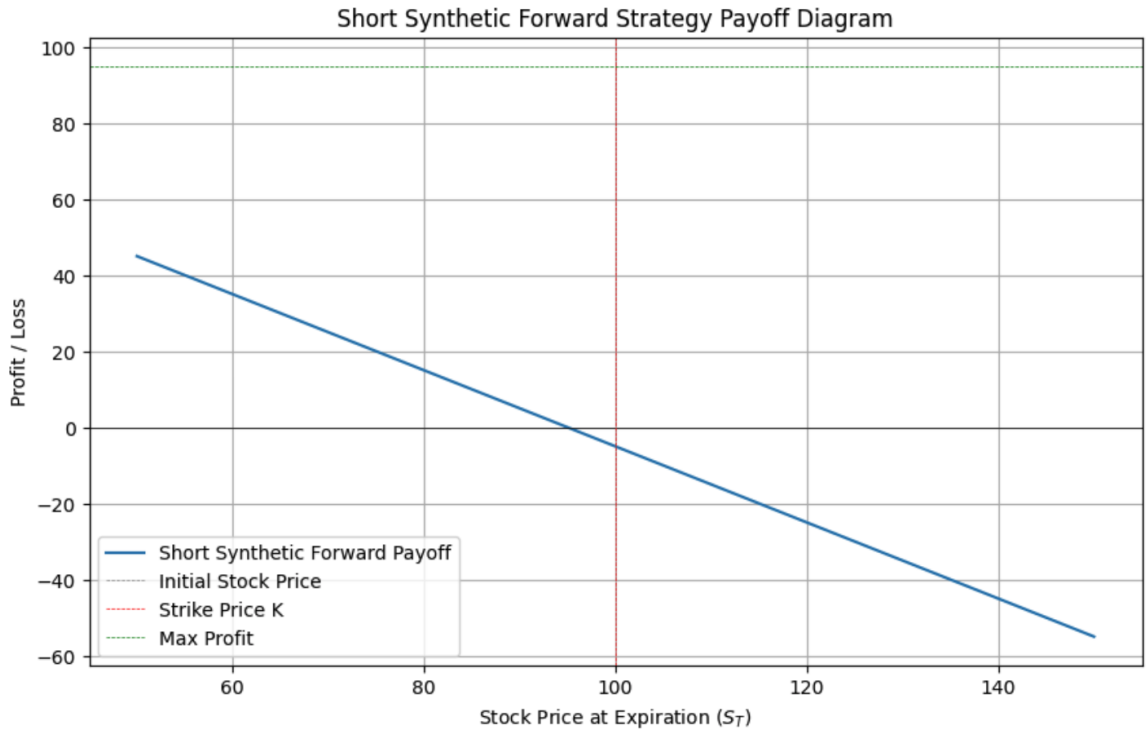
This strategy amounts to buying an ATM put option and selling an ATM call option with a strike price $K = S_0$. This can be a net debit or net credit trade. Typically, $|H| \ll S_0$. The trader's outlook is bearish: this strategy mimics a short stock or futures position; it replicates a short forward contract with the delivery price K and the same maturity as the options. This is a capital gain strategy.

Payoff at Expiration

The payoff for the short synthetic forward strategy at expiration is given by the formula:

$$f_T = (\max(0, K - S_T)) - (\max(0, S_T - K)) - H = K - S_T - H \tag{37}$$

- **Adjusted Stock Price S_***:
$$S_* = K - H \tag{38}$$
- **Maximum Profit $P_{\max}$**:
$$P_{\max} = K - H \tag{39}$$
- **Maximum Loss $L_{\max}$**:
$$L_{\max} = \text{Unlimited} \tag{40}$$



2.11 Strategy: Long Combo

Key Components

- **Long Call Option**: Buy an OTM call option with a strike price K_1 and pay a premium H.
- **Short Put Option**: Sell an OTM put option with a strike price K_2 and receive a premium.

This strategy (a.k.a. "long risk reversal") amounts to buying an OTM call option with a strike price K_1 and selling an OTM put option with a strike price K_2. The trader's outlook is bullish. This is a capital gain strategy.

Payoff at Expiration

The payoff for the long combo strategy at expiration is given by the formula:

$$f_T = (\max(0, S_T - K_1)) - (\max(0, K_2 - S_T)) - H \tag{41}$$

- **Adjusted Stock Price** S_*:

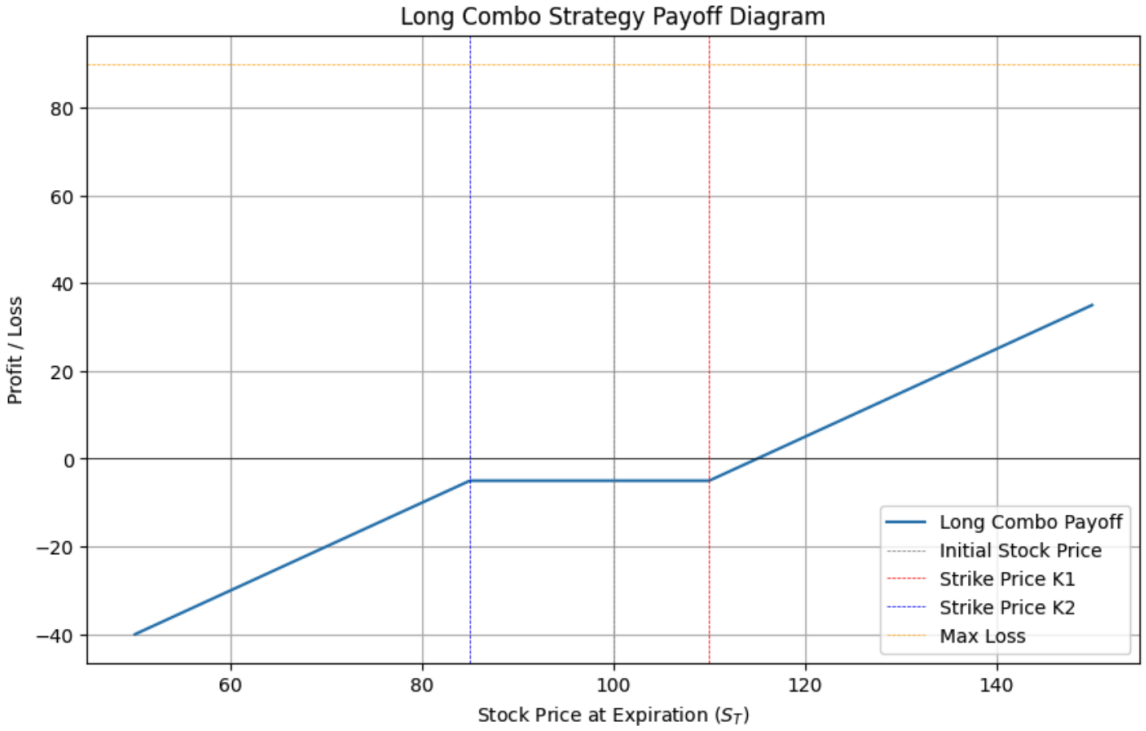
$$S_* = \begin{cases} K_1 + H, & \text{if } H > 0 \\ K_2 + H, & \text{if } H < 0 \\ K_2 \leq S_* \leq K_1, & \text{if } H = 0 \end{cases} \tag{42}$$

- **Maximum Profit** $P_{\max}$:

$$P_{\max} = \text{Unlimited} \tag{43}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = K_2 + H \tag{44}$$



2.12 Strategy: Short Combo

Key Components

- **Long Put Option**: Buy an OTM put option with a strike price K_1 and pay a premium H.
- **Short Call Option**: Sell an OTM call option with a strike price K_2 and receive a premium.

This strategy (a.k.a. "short risk reversal") amounts to buying an OTM put option with a strike price K_1 and selling an OTM call option with a strike price K_2. The trader's outlook is bearish. This is a capital gain strategy.

Payoff at Expiration

The payoff for the short combo strategy at expiration is given by the formula:

$$f_T = (\max(0, K_1 - S_T)) - (\max(0, S_T - K_2)) - H \tag{45}$$

- **Adjusted Stock Price** S_*:

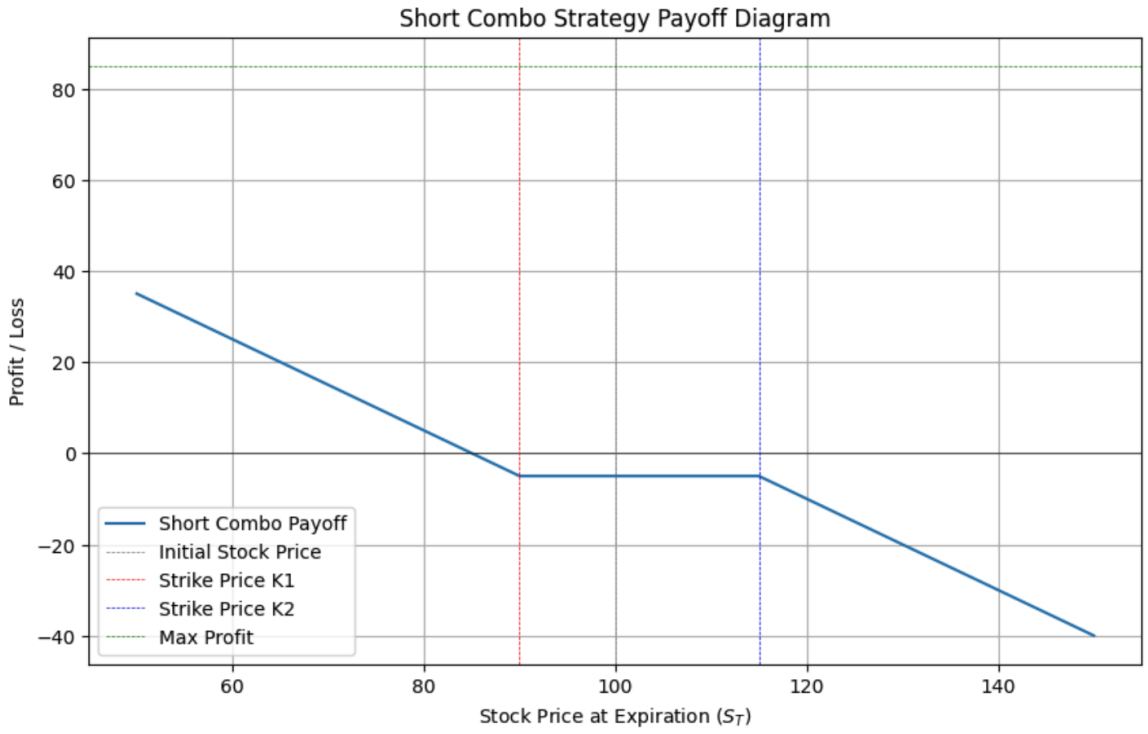
$$S_* = \begin{cases} K_1 - H, & \text{if } H > 0 \\ K_2 - H, & \text{if } H < 0 \\ K_1 \leq S_* \leq K_2, & \text{if } H = 0 \end{cases} \tag{46}$$

- **Maximum Profit** $P_{\max}$:

$$P_{\max} = K_1 - H \tag{47}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = \text{Unlimited} \tag{48}$$



2.13 Strategy: Bull Call Ladder

Key Components

- **Long Call Option**: Buy a close to ATM call option with a strike price K_1 and pay a premium H.
- **Short Call Option 1**: Sell an OTM call option with a strike price K_2 and receive a premium.
- **Short Call Option 2**: Sell another OTM call option with a higher strike price K_3 and receive a premium.

This is a vertical spread consisting of a long position in a close to ATM call option with a strike price K_1, a short position in an OTM call option with a strike price K_2, and a short position in another OTM call option with a higher strike price K_3. A bull call ladder is a bull call spread financed by selling another OTM call option (with the strike price K_3). This adjusts the trader's outlook from bullish (bull call spread) to conservatively bullish or even non-directional (with an expectation of low volatility).

Payoff at Expiration

The payoff for the bull call ladder strategy at expiration is given by the formula:

$$f_T = (\max(0, S_T - K_1)) - (\max(0, S_T - K_2)) - (\max(0, S_T - K_3)) - H \tag{49}$$

- **Adjusted Stock Price S_***:

$$S_{*down} = K_1 + H, \quad H > 0 \tag{50}$$

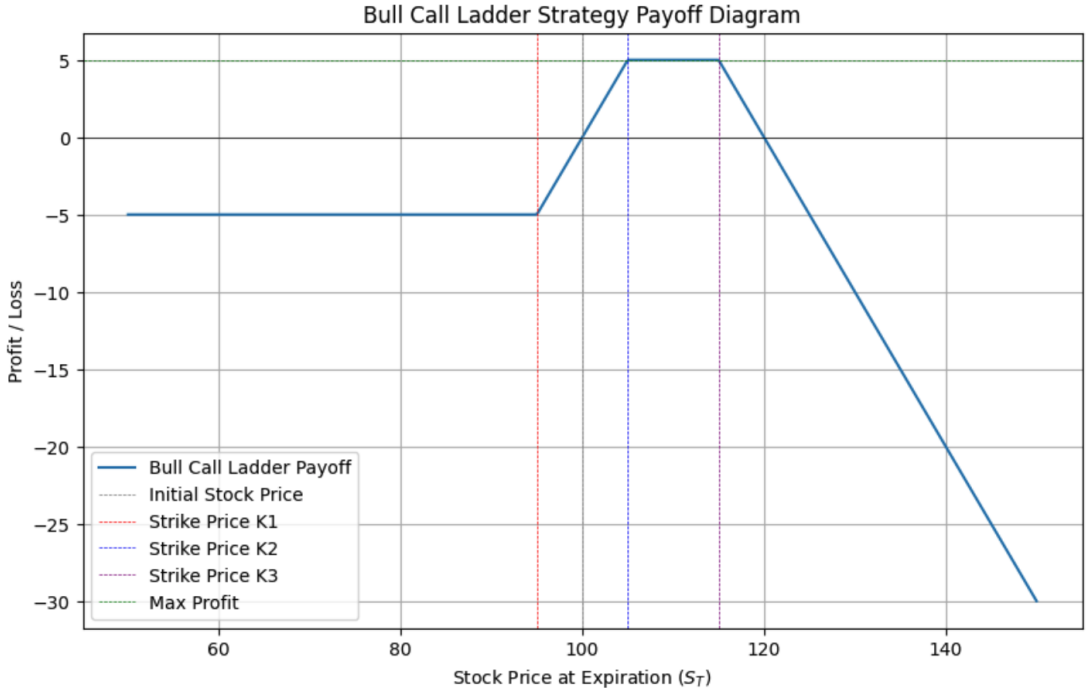
$$S_{*up} = K_3 + K_2 - K_1 - H \tag{51}$$

- **Maximum Profit $P_{\max}$**:

$$P_{\max} = K_2 - K_1 - H \tag{52}$$

- **Maximum Loss $L_{\max}$**:

$$L_{\max} = \text{Unlimited} \tag{53}$$



2.14 Strategy: Bull Put Ladder

Key Components

- **Short Put Option**: Sell a close to ATM put option with a strike price K_1 and receive a premium.
- **Long Put Option 1**: Buy an OTM put option with a lower strike price K_2 and pay a premium.
- **Long Put Option 2**: Buy another OTM put option with a lower strike price K_3 and pay a premium.

This is a vertical spread consisting of a short position in a close to ATM put option with a strike price K_1, a long position in an OTM put option with a lower strike price K_2, and a long position in another OTM put option with a lower strike price K_3. A bull put ladder typically arises when a bull put spread (a bullish strategy) goes wrong (the stock trades lower), so the trader buys another OTM put option (with the strike price K_3) to adjust the position to bearish.

Payoff at Expiration

The payoff for the bull put ladder strategy at expiration is given by the formula:

$$f_T = (\max(0, K_3 - S_T)) + (\max(0, K_2 - S_T)) - (\max(0, K_1 - S_T)) - H \tag{54}$$

- **Adjusted Stock Price S_***:

$$S_{*up} = K_1 + H, \quad H < 0 \tag{55}$$

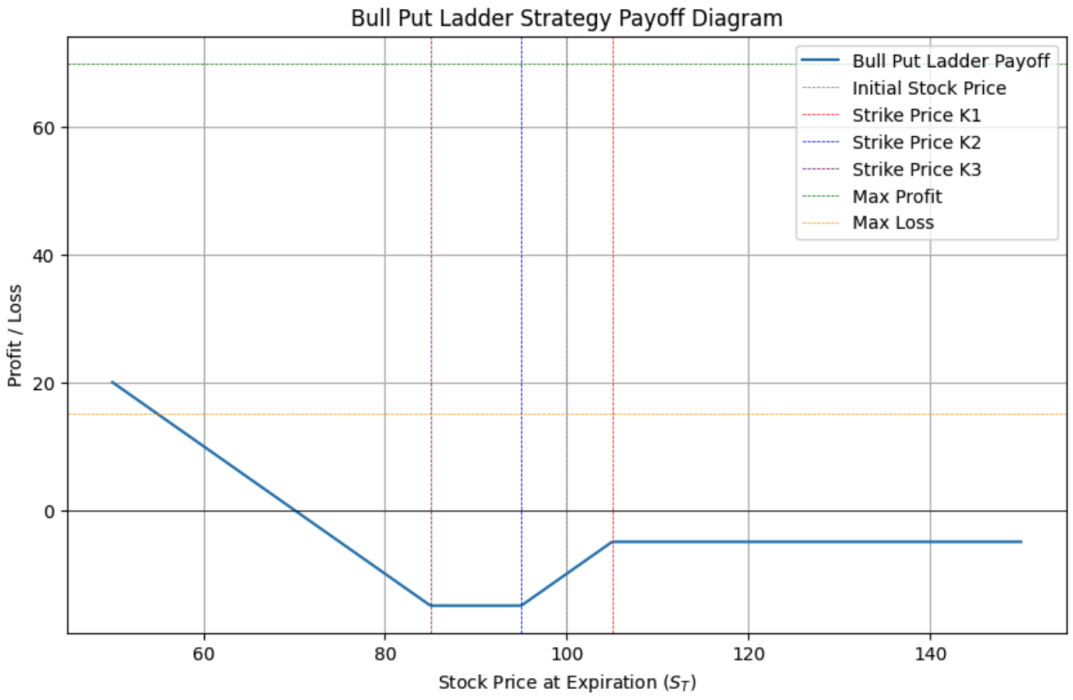
$$S_{*down} = K_3 + K_2 - K_1 - H \tag{56}$$

- **Maximum Profit $P_{\max}$**:

$$P_{\max} = K_3 + K_2 - K_1 - H \tag{57}$$

- **Maximum Loss $L_{\max}$**:

$$L_{\max} = K_1 - K_2 + H \tag{58}$$



2.15 Strategy: Bear Call Ladder

Key Components

- **Short Call Option**: Sell a close to ATM call option with a strike price K_1 and receive a premium.
- **Long Call Option 1**: Buy an OTM call option with a higher strike price K_2 and pay a premium.
- **Long Call Option 2**: Buy another OTM call option with a higher strike price K_3 and pay a premium.

This is a vertical spread consisting of a short position in a close to ATM call option with a strike price K_1, a long position in an OTM call option with a higher strike price K_2, and a long position in another OTM call option with a higher strike price K_3. A bear call ladder typically arises when a bear call spread (a bearish strategy) goes wrong (the stock trades higher), so the trader buys another OTM call option (with the strike price K_3) to adjust the position to bullish.

Payoff at Expiration

The payoff for the bear call ladder strategy at expiration is given by the formula:

$$f_T = (\max(0, S_T - K_3)) + (\max(0, S_T - K_2)) - (\max(0, S_T - K_1)) - H \tag{59}$$

- **Adjusted Stock Price S_***:

$$S_{*down} = K_1 - H, \quad H < 0 \tag{60}$$

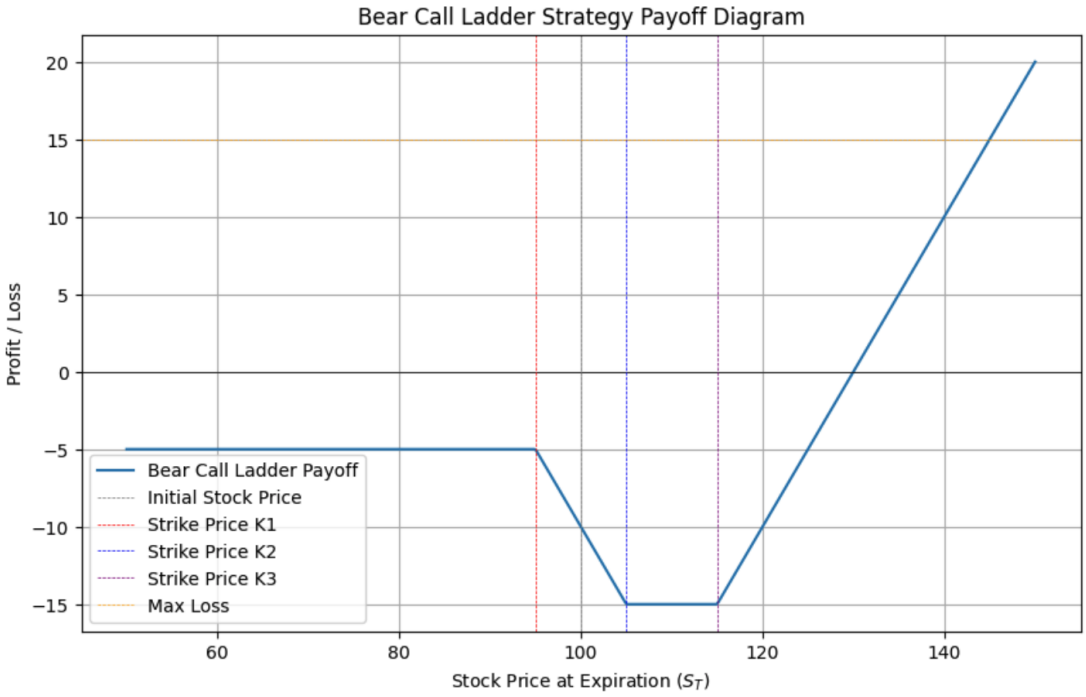
$$S_{*up} = K_3 + K_2 - K_1 - H \tag{61}$$

- **Maximum Profit $P_{\max}$**:

$$P_{\max} = \text{Unlimited} \tag{62}$$

- **Maximum Loss $L_{\max}$**:

$$L_{\max} = K_2 - K_1 + H \tag{63}$$



2.16 Strategy: Bear Put Ladder

Key Components

- **Long Put Option 1**: Buy a close to ATM put option with a strike price K_1 and pay a premium H.
- **Short Put Option**: Sell an OTM put option with a lower strike price K_2 and receive a premium.
- **Short Put Option 2**: Sell another OTM put option with a lower strike price K_3 and receive a premium.

This is a vertical spread consisting of a long position in a close to ATM put option with a strike price K_1, a short position in an OTM put option with a lower strike price K_2, and a short position in another OTM put option with a lower strike price K_3. A bear put ladder is a bear put spread financed by selling another OTM put option (with the strike price K_3). This adjusts the trader's outlook from bearish (bear put spread) to conservatively bearish or even non-directional (with an expectation of low volatility).

Payoff at Expiration

The payoff for the bear put ladder strategy at expiration is given by the formula:

$$f_T = (\max(0, K_1 - S_T)) - (\max(0, K_2 - S_T)) - (\max(0, K_3 - S_T)) - H \tag{64}$$

- **Adjusted Stock Price** S_*:

$$S_{*up} = K_1 - H, \quad H > 0 \tag{65}$$

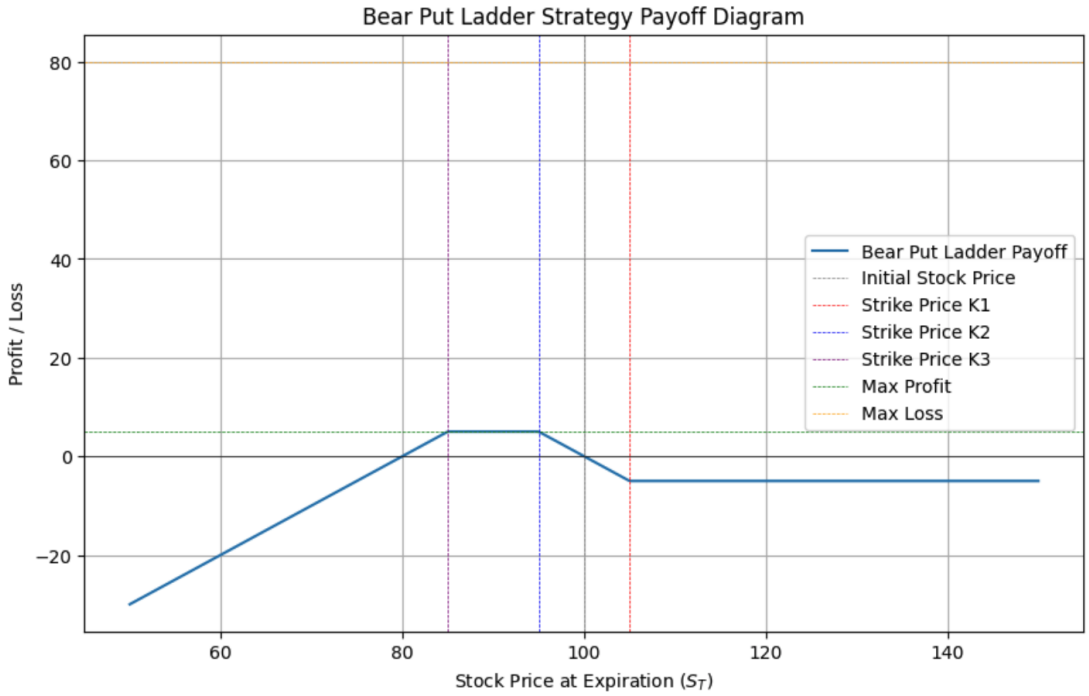
$$S_{*down} = K_3 + K_2 - K_1 + H \tag{66}$$

- **Maximum Profit** $P_{\max}$:

$$P_{\max} = K_1 - K_2 - H \tag{67}$$

- **Maximum Loss** $L_{\max}$:

$$L_{\max} = K_3 + K_2 - K_1 + H \tag{68}$$



2.17 Strategy: Calendar Call Spread

Key Components

- **Long Call Option**: Buy a close to ATM call option with a strike price K and TTM T' and pay a premium D.
- **Short Call Option**: Sell a call option with the same strike price K and shorter TTM $T < T'$ and receive a premium.

This is a horizontal spread consisting of a long position in a close to ATM call option with TTM T' and a short position in another call option with the same strike price K but shorter TTM $T < T'$. This is a net debit trade. The trader's outlook is neutral to bullish. At the expiration of the short call option ($t = T$), the best case scenario is if the stock price is right at the strike price ($S_T = K$). At $t = T$, let V be the value of the long call option (expiring at $t = T'$) assuming $S_T = K$.

Payoff at Expiration

$$P_{\max} = V - D \tag{69}$$

$$L_{\max} = D \tag{70}$$

Using the Black-Scholes Model

To model the Calendar Call Spread strategy accurately, we need to account for the value of the long call option at the expiration of the short call option. The Black-Scholes model is used to calculate the theoretical price of options, considering factors such as the current stock price (S), the strike price (K), the time to maturity (T), the risk-free rate (r), and the volatility (σ) of the stock.

The Black-Scholes formula for the price of a call option is given by:

$$C(S, K, T, r, \sigma) = S \cdot N(d_1) - K \cdot e^{-rT} \cdot N(d_2) \tag{71}$$

where

$$d_1 = \frac{\ln(S/K) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{72}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{73}$$

Here, $N(\cdot)$ represents the cumulative distribution function of the standard normal distribution.

Parameters Used

For our example, we use the following parameters:

- Current stock price (S_0): 50
- Strike price (K): 50
- Time to expiration for the short call (T): 2 months (2/12 years)
- Time to expiration for the long call (T'): 12 months (12/12 years)
- Volatility (σ): 20% (0.2)
- Risk-free rate (r): 3% (0.03)
- Net premium paid (D): 2

Calculating the Value of the Long Call Option

At the expiration of the short call option, the remaining time to expiration for the long call option is $T' - T$. Using the Black-Scholes model, we calculate the value of the long call option at this time as:

$$C_{\text{long}} = C(S_T, K, T' - T, r, \sigma) \tag{74}$$

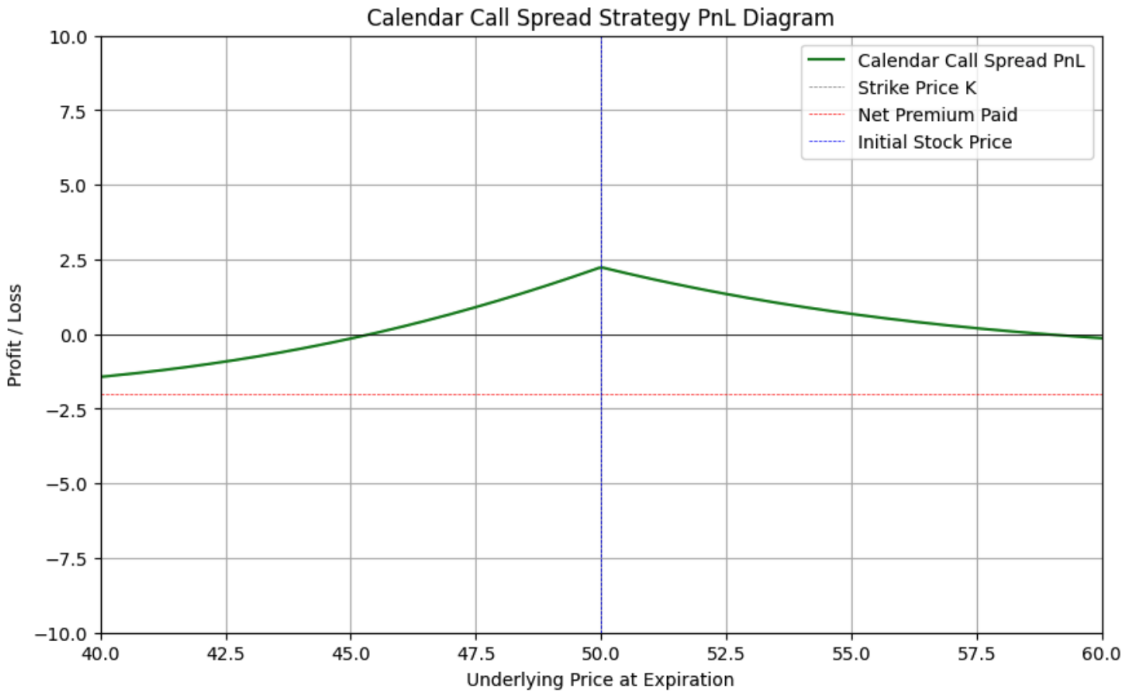
Total PnL Calculation

The total profit or loss (PnL) for the Calendar Call Spread at the expiration of the short call option is given by:

$$\text{PnL} = C_{\text{long}} - \text{Payoff}_{\text{short call}} - D \tag{75}$$

where $\text{Payoff}_{\text{short call}} = \max(S_T - K, 0)$ is the payoff of the short call option at expiration.

P&L



2.18 Strategy: Calendar Put Spread

Key Components

- **Long Put Option**: Buy a close to ATM put option with a strike price K and TTM T' and pay a premium D.
- **Short Put Option**: Sell a put option with the same strike price K and shorter TTM $T < T'$ and receive a premium.

This is a horizontal spread consisting of a long position in a close to ATM put option with TTM T' and a short position in another put option with the same strike price K but shorter TTM $T < T'$. This is a net debit trade. The trader's outlook is neutral to bearish. At the expiration of the short put option ($t = T$), the best case scenario is if the stock price is right at the strike price ($S_T = K$). At $t = T$, let V be the value of the long put option (expiring at $t = T'$) assuming $S_T = K$.

Payoff at Expiration

$$P_{\max} = V - D \tag{76}$$

$$L_{\max} = D \tag{77}$$

Using the Black-Scholes Model

To model the Calendar Put Spread strategy accurately, we need to account for the value of the long put option at the expiration of the short put option. The Black-Scholes model is used to calculate the theoretical price of options, considering factors such as the current stock price (S), the strike price (K), the time to maturity (T), the risk-free rate (r), and the volatility (σ) of the stock.

The Black-Scholes formula for the price of a put option is given by:

$$P(S, K, T, r, \sigma) = K \cdot e^{-rT} \cdot N(-d_2) - S \cdot N(-d_1) \tag{78}$$

where

$$d_1 = \frac{\ln(S/K) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{79}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{80}$$

Here, $N(\cdot)$ represents the cumulative distribution function of the standard normal distribution.

Parameters Used

For our example, we use the following parameters:

- Current stock price (S_0): 50
- Strike price (K): 50
- Time to expiration for the short put (T): 2 months (2/12 years)
- Time to expiration for the long put (T'): 12 months (12/12 years)
- Volatility (σ): 20% (0.2)
- Risk-free rate (r): 3% (0.03)
- Net premium paid (D): 2
- V is the value of the long put option (expiring at $t = T'$)

Calculating the Value of the Long Put Option

At the expiration of the short put option, the remaining time to expiration for the long put option is $T' - T$. Using the Black-Scholes model, we calculate the value of the long put option at this time as:

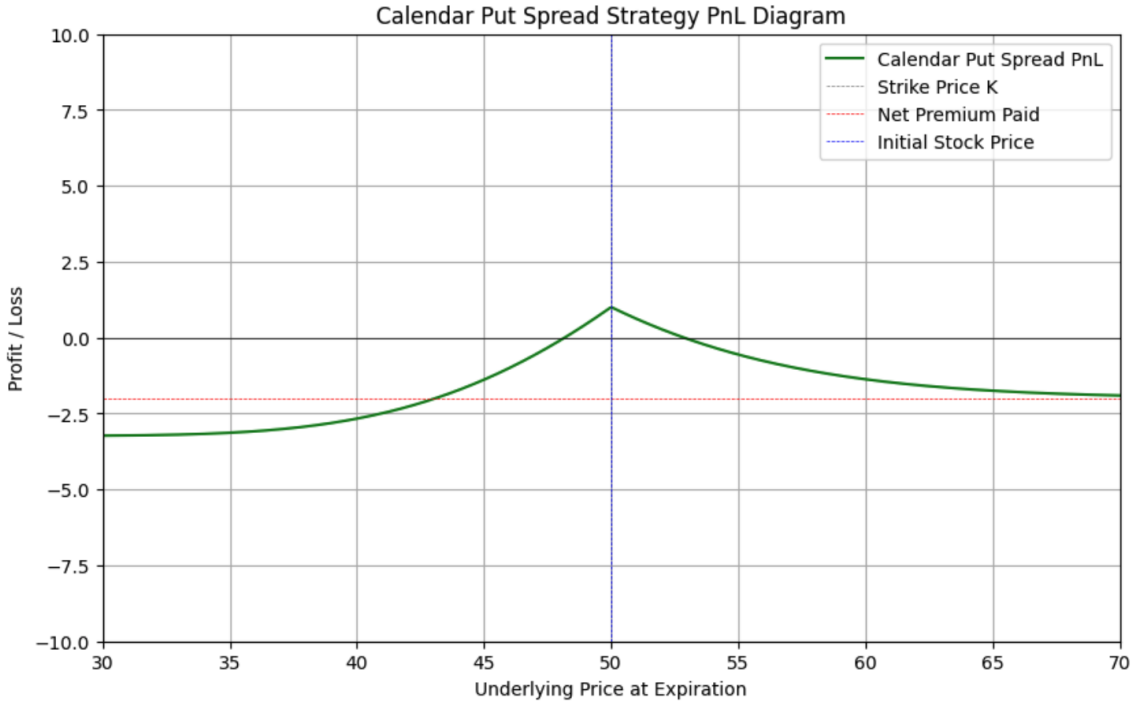
$$P_{\text{long}} = P(S_T, K, T' - T, r, \sigma) \tag{81}$$

Total PnL Calculation

The total profit or loss (PnL) for the Calendar Put Spread at the expiration of the short put option is given by:

$$\text{PnL} = P_{\text{long}} - \text{Payoff}_{\text{short put}} - D \tag{82}$$

where $\text{Payoff}_{\text{short put}} = \max(K - S_T, 0)$ is the payoff of the short put option at expiration.



2.19 Strategy: Diagonal Call Spread

Key Components

- **Long Call Option**: Buy a deep ITM call option with a strike price K_1 and TTM T' and pay a premium D.
- **Short Call Option**: Sell an OTM call option with a higher strike price K_2 and shorter TTM $T < T'$ and receive a premium.

This is a diagonal spread consisting of a long position in a deep ITM call option with TTM T' and a short position in another OTM call option with a higher strike price K_2 but shorter TTM $T < T'$. This is a net debit trade. The trader's outlook is bullish. At the expiration of the short call option ($t = T$), the best case scenario is if the stock price is right at the strike price of the short call option ($S_T = K_2$). At $t = T$, let V be the value of the long call option (expiring at $t = T'$) assuming $S_T = K_2$.

Payoff at Expiration

$$P_{\max} = V - D \tag{83}$$

$$L_{\max} = D \tag{84}$$

Using the Black-Scholes Model

To model the Diagonal Call Spread strategy accurately, we need to account for the value of the long call option at the expiration of the short call option. The Black-Scholes model is used to calculate the theoretical price of options, considering factors such as the current stock price (S), the strike price (K), the time to maturity (T), the risk-free rate (r), and the volatility (σ) of the stock.

The Black-Scholes formula for the price of a call option is given by:

$$C(S, K, T, r, \sigma) = S \cdot N(d_1) - K \cdot e^{-rT} \cdot N(d_2) \tag{85}$$

where

$$d_1 = \frac{\ln(S/K) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{86}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{87}$$

Here, $N(\cdot)$ represents the cumulative distribution function of the standard normal distribution.

Parameters Used

For our example, we use the following parameters:

- Current stock price (S_0): 50
- Strike price of long call (K_1): 45
- Strike price of short call (K_2): 60
- Time to expiration for the short call (T): 2 months (2/12 years)
- Time to expiration for the long call (T'): 12 months (12/12 years)
- Volatility (σ): 20% (0.2)
- Risk-free rate (r): 3% (0.03)
- Net premium paid (D): 2
- V is the value of the long call option (expiring at $t = T'$)

Calculating the Value of the Long Call Option

At the expiration of the short call option, the remaining time to expiration for the long call option is $T' - T$. Using the Black-Scholes model, we calculate the value of the long call option at this time as:

$$C_{\text{long}} = C(S_T, K_1, T' - T, r, \sigma) \tag{88}$$

Total PnL Calculation

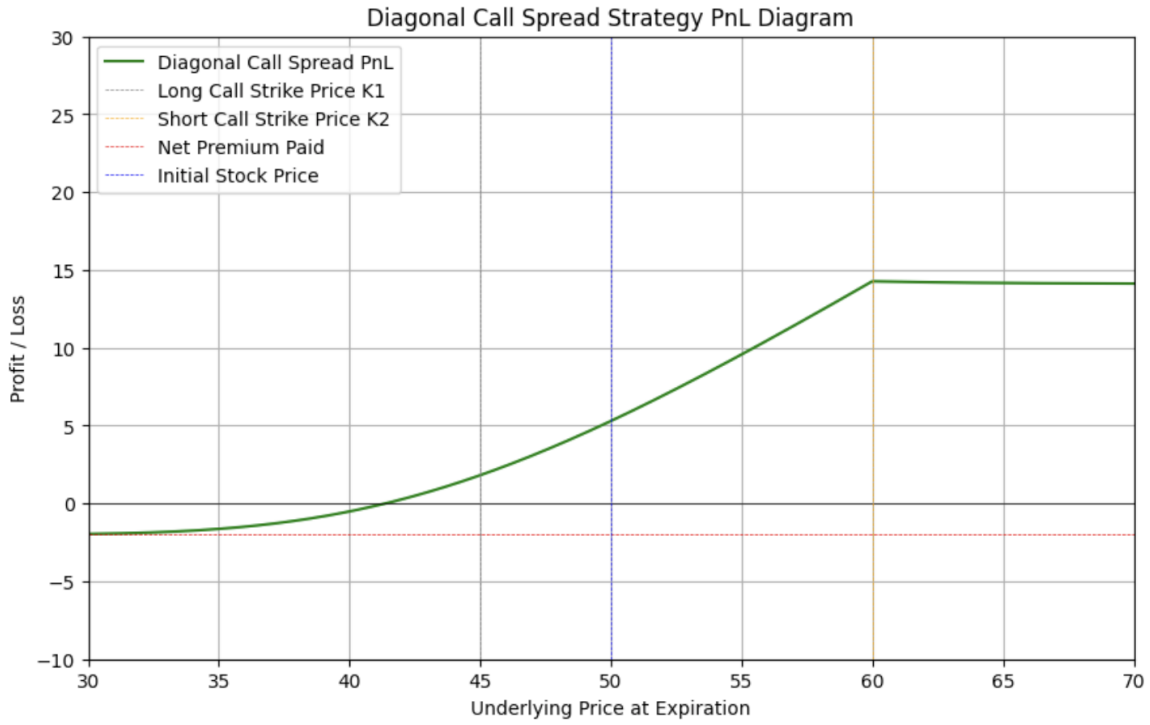
The total profit or loss (PnL) for the Diagonal Call Spread at the expiration of the short call option is given by:

$$\text{PnL} = C_{\text{long}} - \text{Payoff}_{\text{short call}} - D \tag{89}$$

where $\text{Payoff}_{\text{short call}} = \max(S_T - K_2, 0)$ is the payoff of the short call option at expiration.

PnL Diagram

To visualize the PnL of the Diagonal Call Spread strategy, we plot the PnL against different underlying prices at expiration.



2.20 Strategy: Diagonal Put Spread

Key Components

- **Long Put Option**: Buy a deep ITM put option with a strike price K_1 and TTM T' and pay a premium D.
- **Short Put Option**: Sell an OTM put option with a lower strike price K_2 and shorter TTM $T < T'$ and receive a premium.

This is a diagonal spread consisting of a long position in a deep ITM put option with TTM T' and a short position in another OTM put option with a lower strike price K_2 but shorter TTM $T < T'$. This is a net debit trade. The trader's outlook is bearish. At the expiration of the short put option ($t = T$), the best case scenario is if the stock price is right at the strike price of the short put option ($S_T = K_2$). At $t = T$, let V be the value of the long put option (expiring at $t = T'$) assuming $S_T = K_2$.

Payoff at Expiration

$$P_{\max} = V - D \tag{90}$$

$$L_{\max} = D \tag{91}$$

Using the Black-Scholes Model

To model the Diagonal Put Spread strategy accurately, we need to account for the value of the long put option at the expiration of the short put option. The Black-Scholes model is used to calculate the theoretical price of options, considering factors such as the current stock price (S), the strike price (K), the time to maturity (T), the risk-free rate (r), and the volatility (σ) of the stock.

The Black-Scholes formula for the price of a put option is given by:

$$P(S, K, T, r, \sigma) = K \cdot e^{-rT} \cdot N(-d_2) - S \cdot N(-d_1) \tag{92}$$

where

$$d_1 = \frac{\ln(S/K) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{93}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{94}$$

Here, $N(\cdot)$ represents the cumulative distribution function of the standard normal distribution.

Parameters Used

For our example, we use the following parameters:

- Current stock price (S_0): 50
- Strike price of long put (K_1): 55
- Strike price of short put (K_2): 45
- Time to expiration for the short put (T): 2 months (2/12 years)
- Time to expiration for the long put (T'): 12 months (12/12 years)
- Volatility (σ): 20% (0.2)
- Risk-free rate (r): 3% (0.03)
- Net premium paid (D): 2
- V is the value of the long put option (expiring at $t = T'$)

Calculating the Value of the Long Put Option

At the expiration of the short put option, the remaining time to expiration for the long put option is $T' - T$. Using the Black-Scholes model, we calculate the value of the long put option at this time as:

$$P_{\text{long}} = P(S_T, K_1, T' - T, r, \sigma) \tag{95}$$

Total PnL Calculation

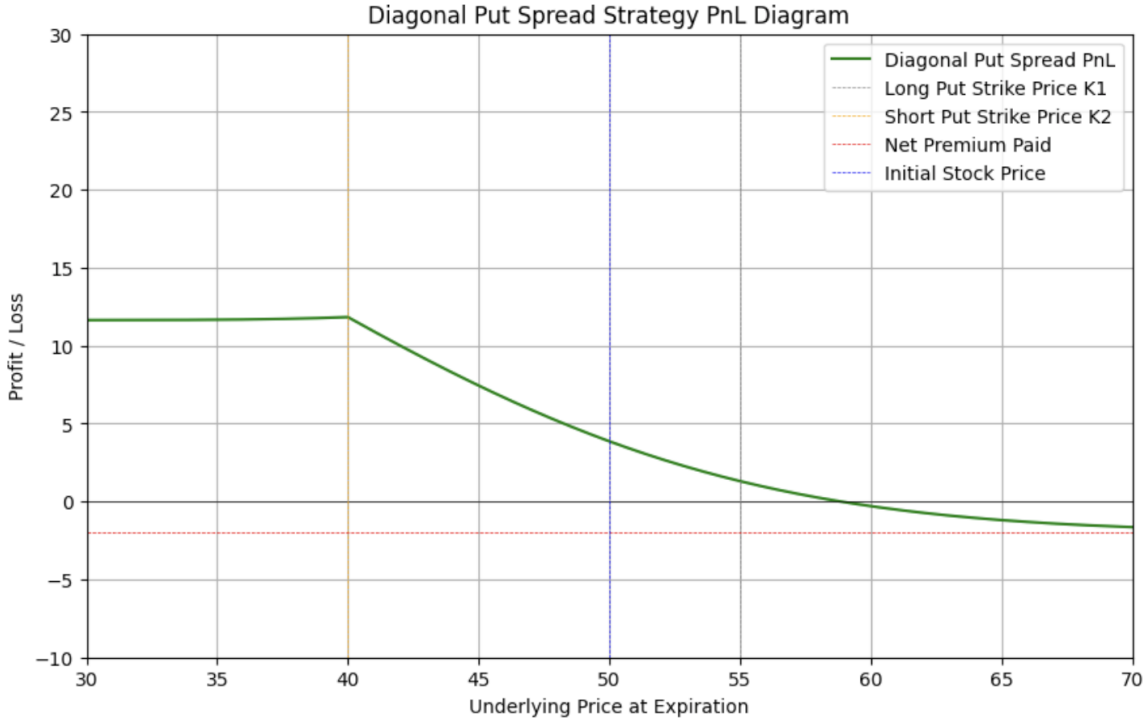
The total profit or loss (PnL) for the Diagonal Put Spread at the expiration of the short put option is given by:

$$\text{PnL} = P_{\text{long}} - \text{Payoff}_{\text{short put}} - D \tag{96}$$

where $\text{Payoff}_{\text{short put}} = \max(K_2 - S_T, 0)$ is the payoff of the short put option at expiration.

PnL Diagram

To visualize the PnL of the Diagonal Put Spread strategy, we plot the PnL against different underlying prices at expiration.



2.21 Strategy: Long Straddle

This is a volatility strategy consisting of a long position in an ATM call option, and a long position in an ATM put option with a strike price K. This is a net debit trade. The trader's outlook is neutral. This is a capital gain strategy.

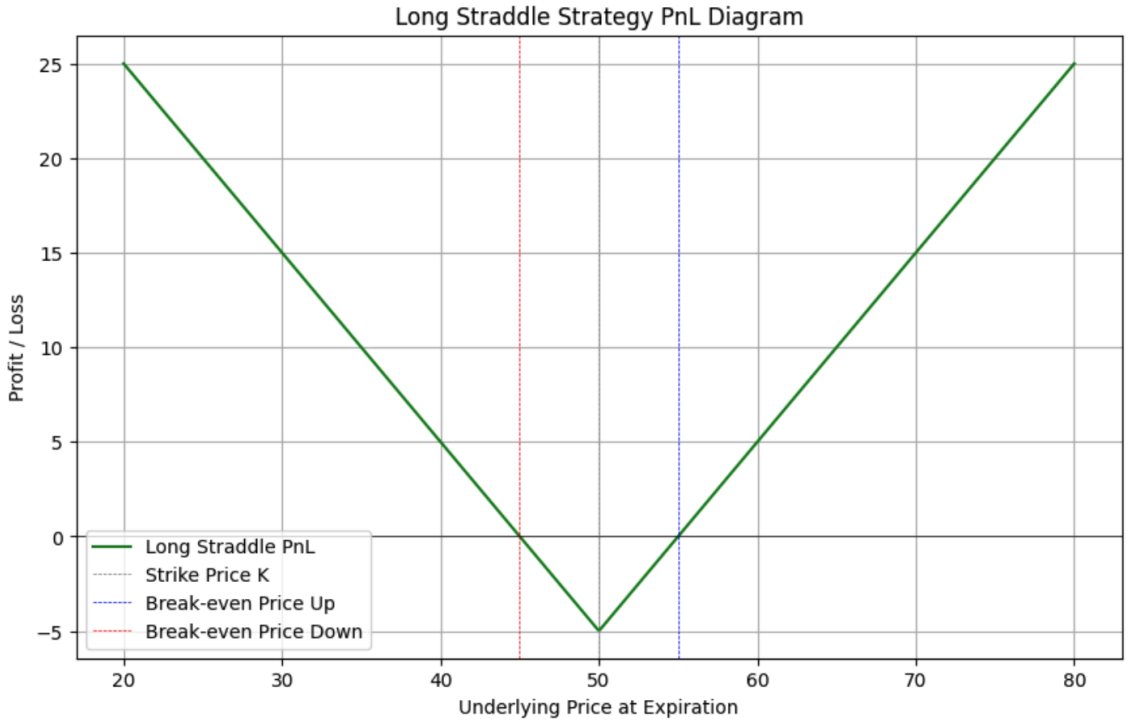
Key Components

- **Long Call Option**: Buy an ATM call option with a strike price K and pay a premium D.
- **Long Put Option**: Buy an ATM put option with a strike price K and pay a premium D.

Payoff at Expiration

$$f_T = (S_T - K)^+ + (K - S_T)^+ - D \tag{97}$$

- $S_{\text{up}} = K + D$
- $S_{\text{down}} = K - D$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D$



2.22 Strategy: Long Strangle

This is a volatility strategy consisting of a long position in an OTM call option with a strike price K_1, and a long position in an OTM put option with a strike price K_2. This is a net debit trade. However, because both call and put options are OTM, this strategy is less costly to establish than a long straddle position. The trader's outlook is neutral. This is a capital gain strategy.

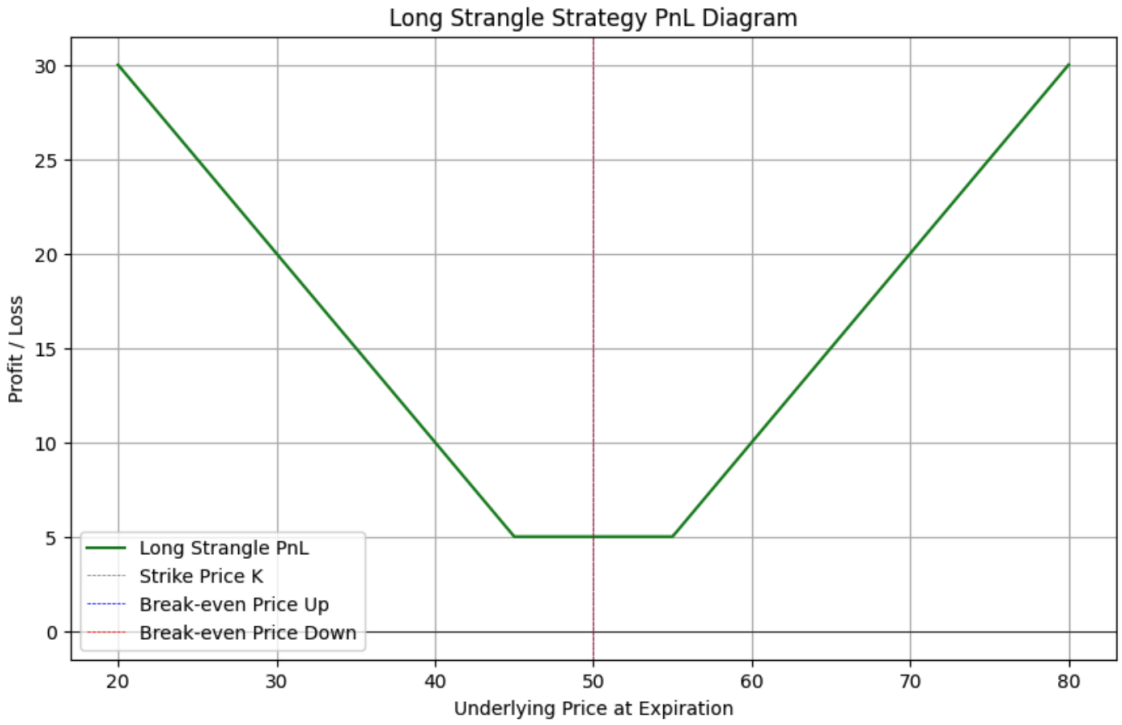
Key Components

- **Long Call Option**: Buy an OTM call option with a strike price K_1 and pay a premium D.
- **Long Put Option**: Buy an OTM put option with a strike price K_2 and pay a premium D.

Payoff at Expiration

$$f_T = (S_T - K_1)^+ + (K_2 - S_T)^+ - D \tag{98}$$

- $S_{\text{up}} = K_1 + D$
- $S_{\text{down}} = K_2 - D$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D$



2.23 Strategy: Long Guts

This is a volatility strategy consisting of a long position in an ITM call option with a strike price K_1, and a long position in an ITM put option with a strike price K_2. This is a net debit trade. Since both call and put options are ITM, this strategy is more costly to establish than a long straddle position. The trader's outlook is neutral. This is a capital gain strategy.

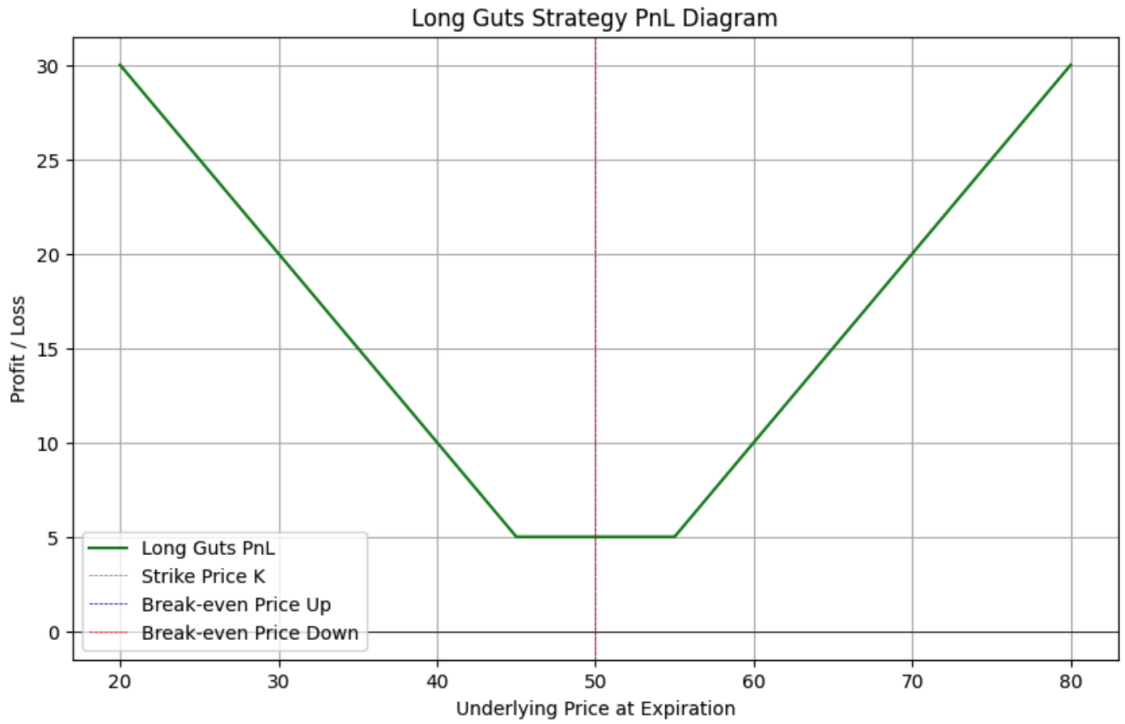
Key Components

- **Long Call Option**: Buy an ITM call option with a strike price K_1 and pay a premium D.
- **Long Put Option**: Buy an ITM put option with a strike price K_2 and pay a premium D.

Payoff at Expiration

$$f_T = (S_T - K_1)^+ + (K_2 - S_T)^+ - D \tag{99}$$

- $S_{\text{up}} = K_1 + D$
- $S_{\text{down}} = K_2 - D$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D$



2.24 Strategy: Short Straddle

This is a sideways strategy consisting of a short position in an ATM call option, and a short position in an ATM put option with a strike price K. This is a net credit trade. The trader's outlook is neutral. This is an income strategy.

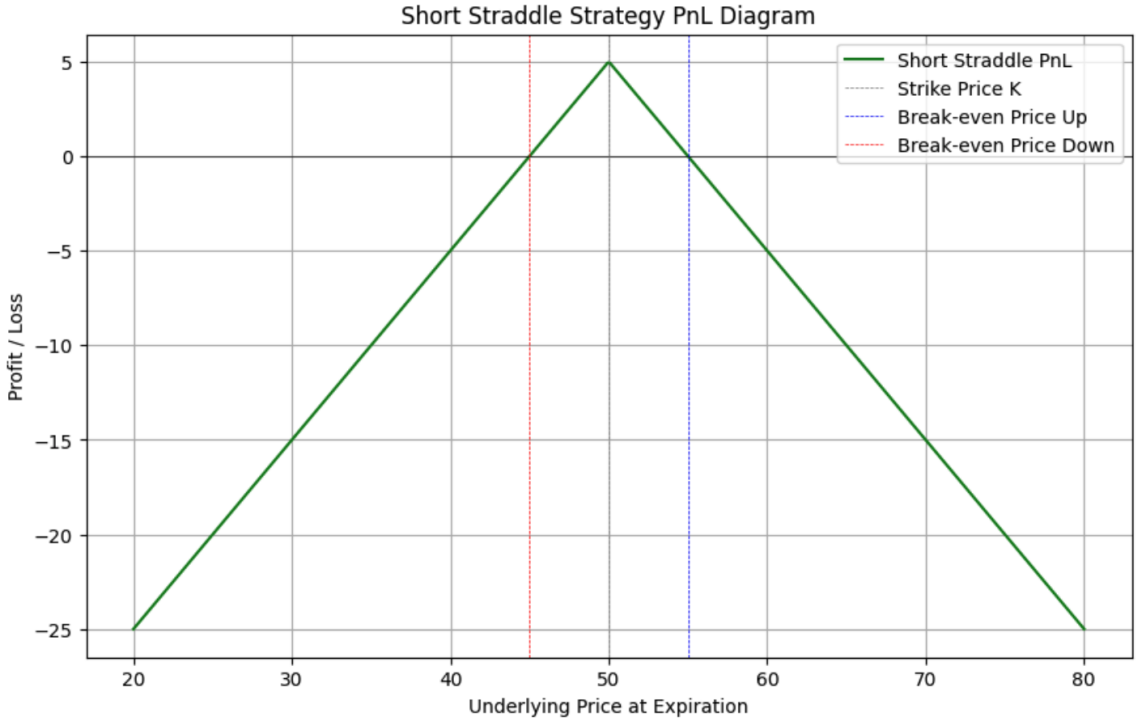
Key Components

- **Short Call Option**: Sell an ATM call option with a strike price K and receive a premium C.
- **Short Put Option**: Sell an ATM put option with a strike price K and receive a premium C.

Payoff at Expiration

$$f_T = -(S_T - K)^+ - (K - S_T)^+ + C \tag{100}$$

- $S_{\text{up}} = K + C$
- $S_{\text{down}} = K - C$
- $P_{\text{max}} = C$
- $L_{\text{max}} =$ unlimited



2.25 Strategy: Short Strangle

This is a sideways strategy consisting of a short position in an OTM call option with a strike price K_1, and a short position in an OTM put option with a strike price K_2. This is a net credit trade. Since both call and put options are OTM, this strategy is less risky than a short straddle position. The trader's outlook is neutral. This is an income strategy.

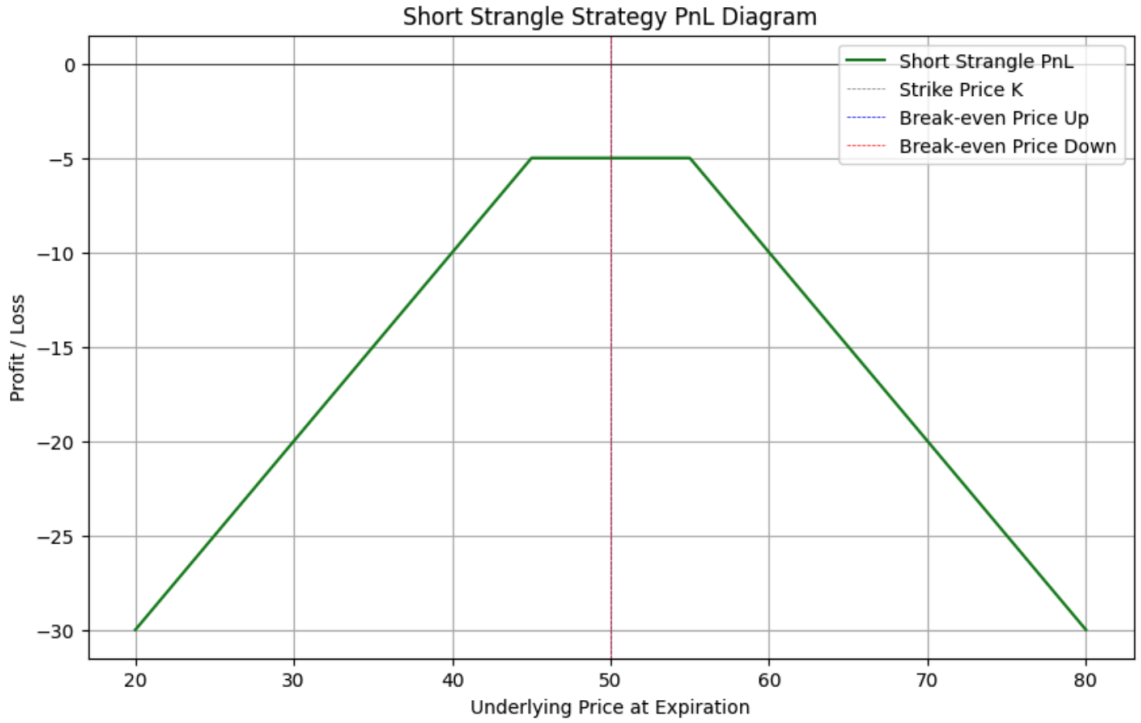
Key Components

- **Short Call Option**: Sell an OTM call option with a strike price K_1 and receive a premium C.
- **Short Put Option**: Sell an OTM put option with a strike price K_2 and receive a premium C.

Payoff at Expiration

$$f_T = -(S_T - K_1)^+ - (K_2 - S_T)^+ + C \tag{101}$$

- $S_{\text{up}} = K_1 + C$
- $S_{\text{down}} = K_2 - C$
- $P_{\text{max}} = C$
- $L_{\text{max}} =$ unlimited



2.26 Strategy: Short Guts

This is a sideways strategy consisting of a short position in an ITM call option with a strike price K_1, and a short position in an ITM put option with a strike price K_2. This is a net credit trade. Since both call and put options are ITM, the initial credit is higher than in a short straddle position. The trader's outlook is neutral. This is an income strategy.

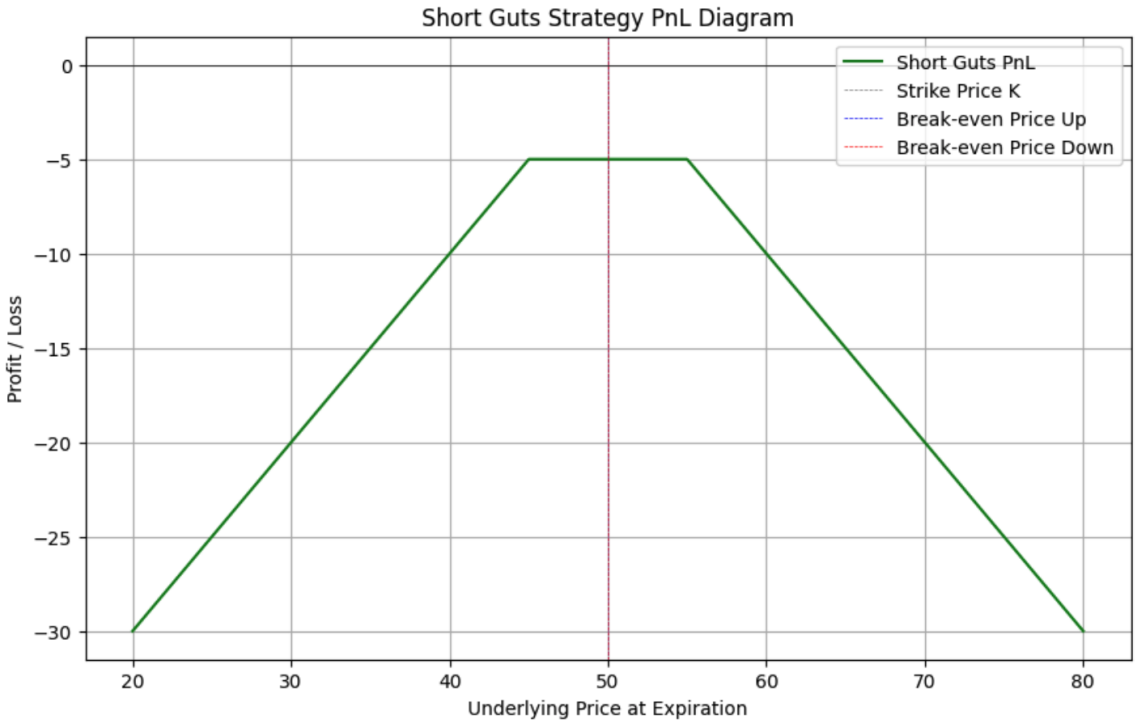
Key Components

- **Short Call Option**: Sell an ITM call option with a strike price K_1 and receive a premium C.
- **Short Put Option**: Sell an ITM put option with a strike price K_2 and receive a premium C.

Payoff at Expiration

$$f_T = -(S_T - K_1)^+ - (K_2 - S_T)^+ + C \tag{102}$$

- $S_{\text{up}} = K_1 + C$
- $S_{\text{down}} = K_2 - C$
- $P_{\text{max}} = C - (K_2 - K_1)$
- $L_{\text{max}} =$ unlimited



2.27 Strategy: Long Call Synthetic Straddle

This volatility strategy (which is the same as a long straddle with the put replaced by a synthetic put) amounts to shorting stock and buying two ATM (or the nearest ITM) call options with a strike price K. The trader's outlook is neutral. This is a capital gain strategy. We have (assuming $S_0 \leq K$ and $D > S_0 - K$):

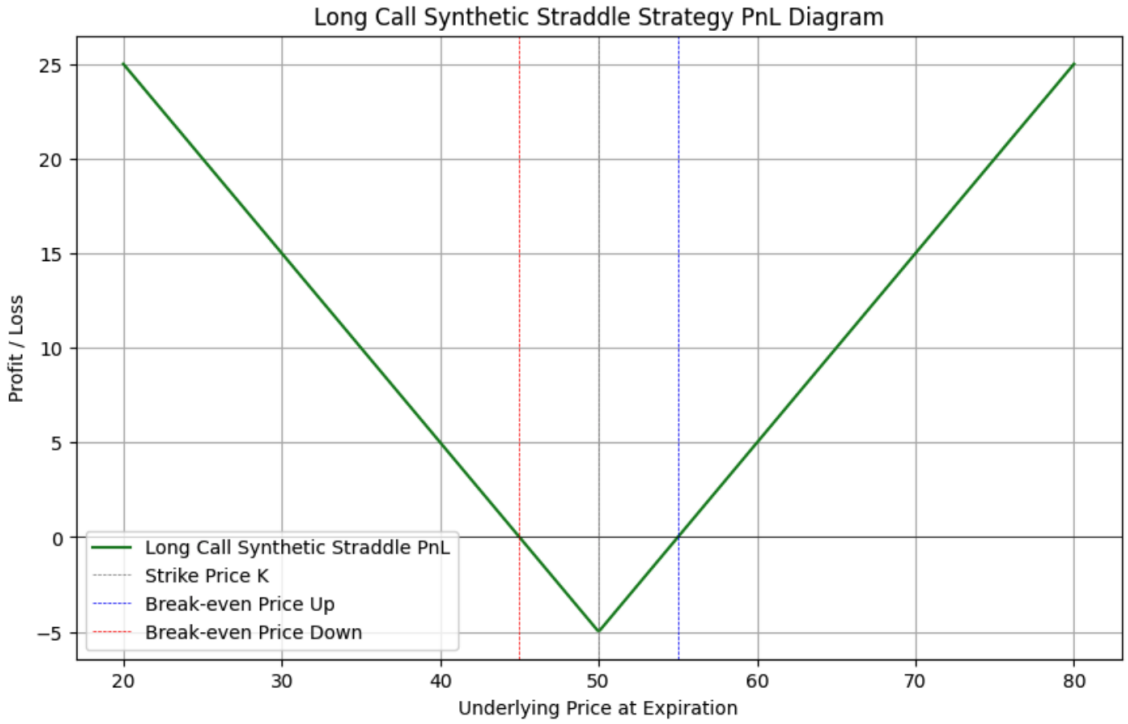
Key Components

- **Short Stock**: Short the underlying stock.
- **Long Call Options**: Buy two ATM call options with a strike price K and pay a premium D.

Payoff at Expiration

$$f_T = S_0 - S_T + 2 \times (S_T - K)^+ - D \tag{103}$$

- $S_{\text{up}} = 2 \times K - S_0 + D$
- $S_{\text{down}} = S_0 - D$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D - (S_0 - K)$



2.28 Strategy: Long Put Synthetic Straddle

This volatility strategy (which is the same as a long straddle with the call replaced by a synthetic call) amounts to buying stock and buying two ATM (or the nearest ITM) put options with a strike price K. The trader's outlook is neutral. This is a capital gain strategy. We have (assuming $S_0 \leq K$ and $D > K - S_0$):

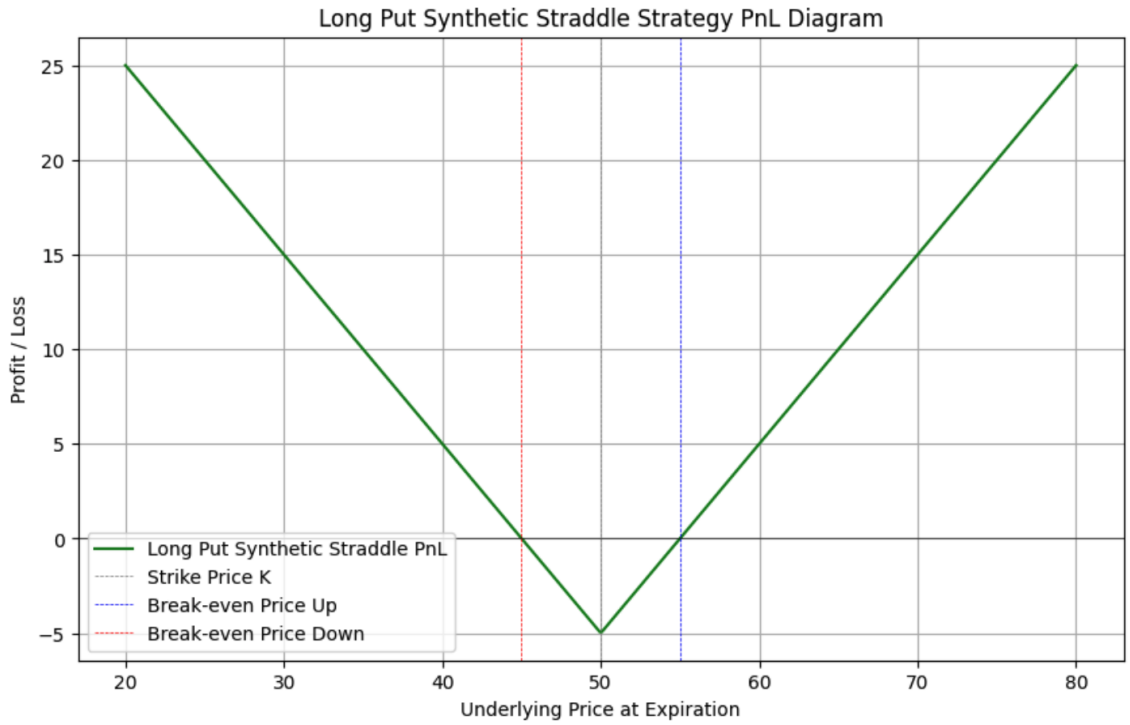
Key Components

- **Long Stock**: Buy the underlying stock.
- **Long Put Options**: Buy two ATM put options with a strike price K and pay a premium D.

Payoff at Expiration

$$f_T = S_T - S_0 + 2 \times (K - S_T)^+ - D \tag{104}$$

- $S_{\text{up}} = S_0 + D$
- $S_{\text{down}} = 2 \times K - S_0 - D$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D - (K - S_0)$



2.29 Strategy: Short Call Synthetic Straddle

This sideways strategy (which is the same as a short straddle with the call replaced by a synthetic put) amounts to buying stock and selling two ATM (or the nearest OTM) call options with a strike price K. The trader's outlook is neutral. This is a capital gain strategy. We have (assuming $S_0 \leq K$):

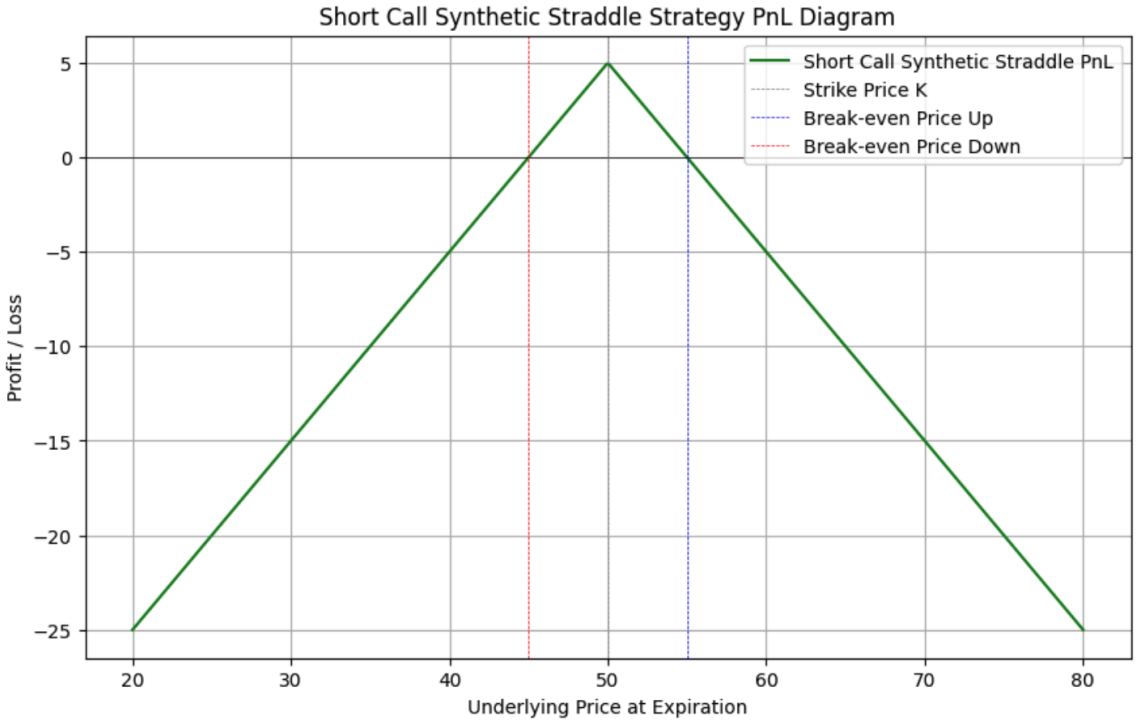
Key Components

- **Long Stock**: Buy the underlying stock.
- **Short Call Options**: Sell two ATM call options with a strike price K and receive a premium C.

Payoff at Expiration

$$f_T = S_T - S_0 - 2 \times (S_T - K)^+ + C \tag{105}$$

- $S_{\text{up}} = 2 \times K - S_0 + C$
- $S_{\text{down}} = S_0 - C$
- $P_{\max} = K - S_0 + C$
- $L_{\max} =$ unlimited



2.30 Strategy: Short Put Synthetic Straddle

This sideways strategy (which is the same as a short straddle with the put replaced by a synthetic call) amounts to shorting stock and selling two ATM (or the nearest OTM) put options with a strike price K. The trader's outlook is neutral. This is a capital gain strategy. We have (assuming $S_0 \geq K$):

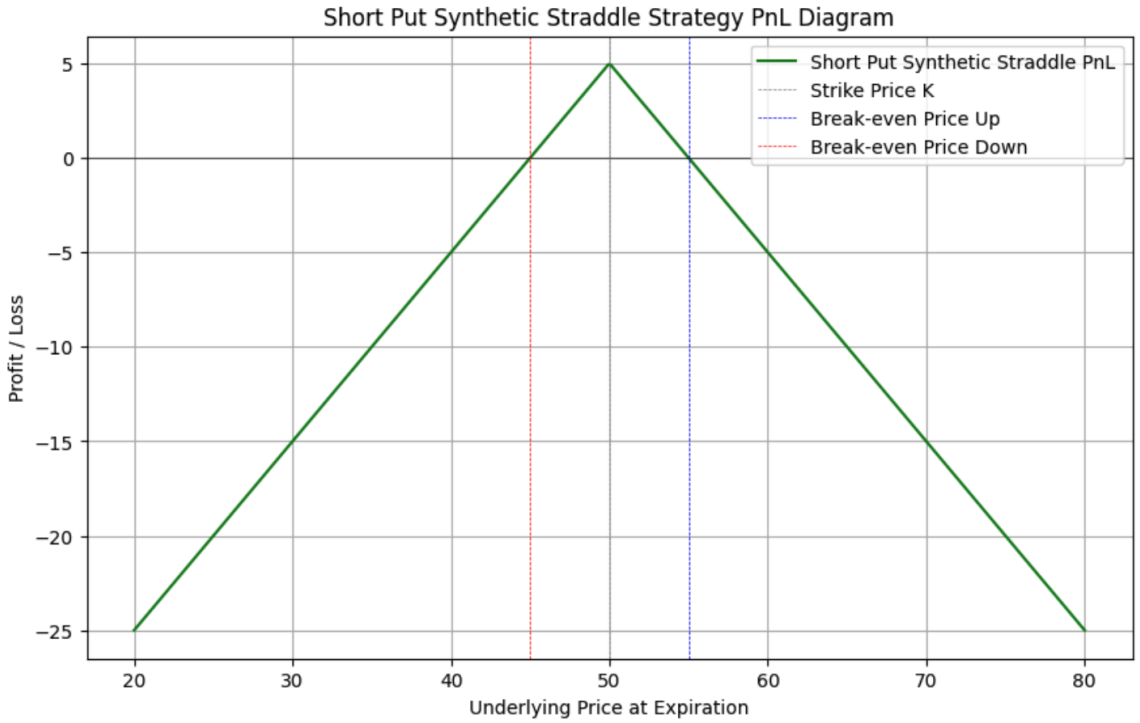
Key Components

- **Short Stock**: Short the underlying stock.
- **Short Put Options**: Sell two ATM put options with a strike price K and receive a premium C.

Payoff at Expiration

$$f_T = S_0 - S_T - 2 \times (K - S_T)^+ + C \tag{106}$$

- $S_{\text{up}} = S_0 + C$
- $S_{\text{down}} = 2 \times K - S_0 - C$
- $P_{\max} = S_0 - K + C$
- $L_{\max} =$ unlimited



2.31 Strategy: Covered Short Straddle

This strategy amounts to augmenting a covered call by writing a put option with the same strike price K and TTM as the sold call option and thereby increasing the income. The trader's outlook is bullish. We have:

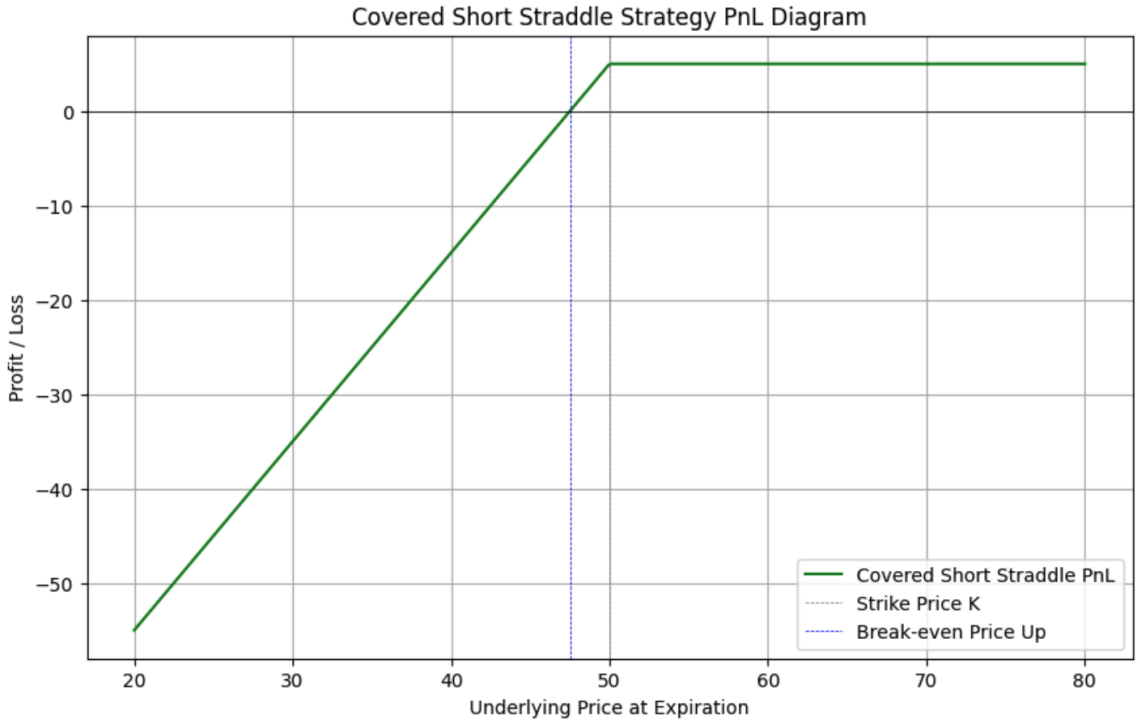
Key Components

- **Long Stock**: Buy the underlying stock.
- **Short Call Option**: Sell an ATM call option with a strike price K and receive a premium C.
- **Short Put Option**: Sell an ATM put option with a strike price K and receive a premium C.

Payoff at Expiration

$$f_T = S_T - S_0 - (S_T - K)^+ - (K - S_T)^+ + C \tag{107}$$

- $S_{\text{up}} = \frac{1}{2}(S_0 + K - C)$
- $P_{\max} = K - S_0 + C$
- $L_{\max} = S_0 + K - C$



2.32 Strategy: Covered Short Strangle

This strategy amounts to augmenting a covered call by writing an OTM put option with a strike price K' and the same TTM as the sold call option (whose strike price is K) and thereby increasing the income. The trader's outlook is bullish. We have:

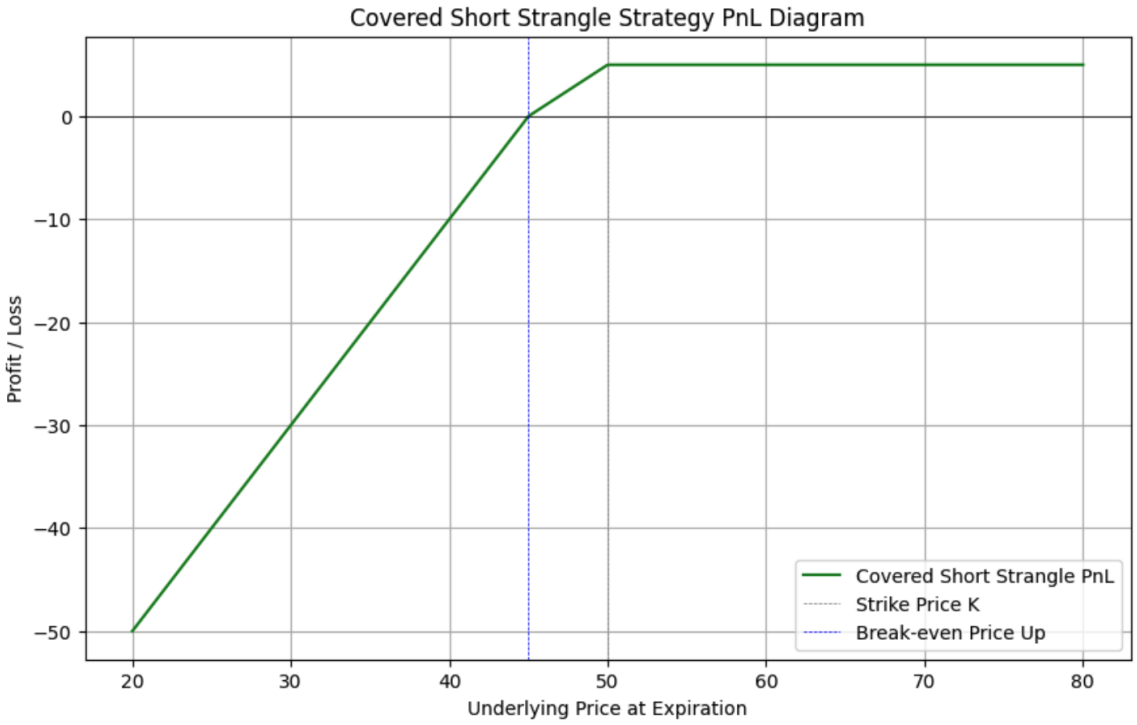
Key Components

- **Long Stock**: Buy the underlying stock.
- **Short Call Option**: Sell an ATM call option with a strike price K and receive a premium C.
- **Short Put Option**: Sell an OTM put option with a strike price K' and receive a premium C.

Payoff at Expiration

$$f_T = S_T - S_0 - (S_T - K)^+ - (K' - S_T)^+ + C \tag{108}$$

- $P_{\max} = K - S_0 + C$
- $L_{\max} = S_0 + K' - C$



2.33 Strategy: Strap

This is a volatility strategy consisting of a long position in two ATM call options, and a long position in an ATM put option with a strike price K. This is a net debit trade. The trader's outlook is bullish. This is a capital gain strategy. We have:

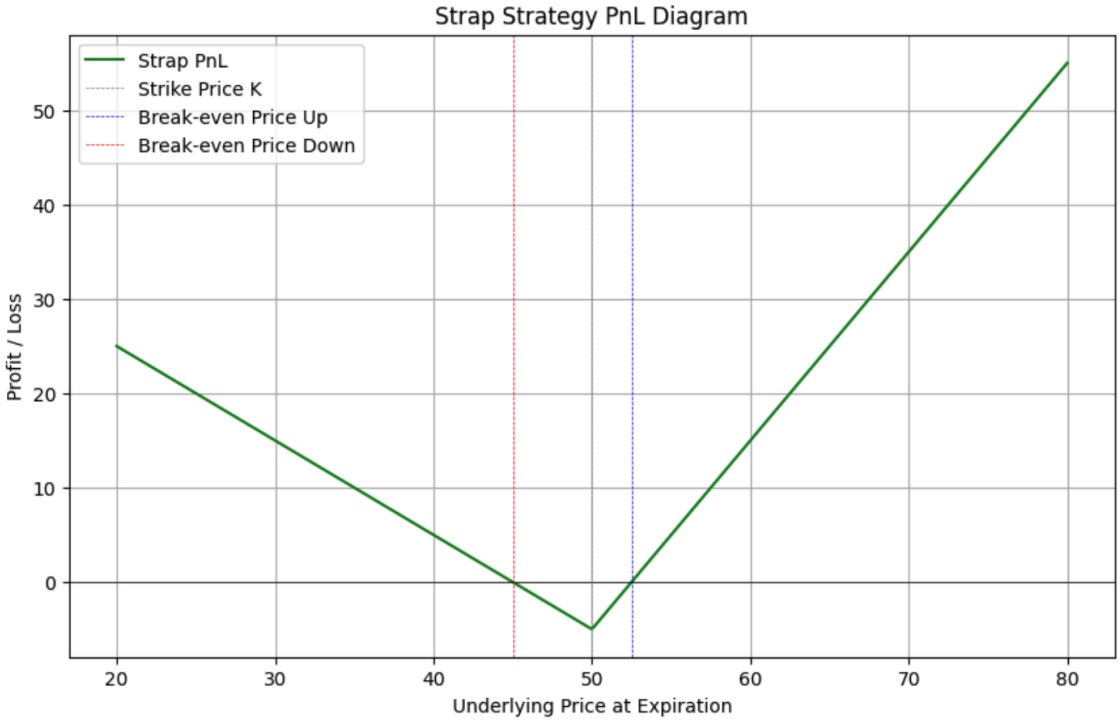
Key Components

- **Long Call Options**: Buy two ATM call options with a strike price K and pay a premium D.
- **Long Put Option**: Buy an ATM put option with a strike price K and pay a premium D.

Payoff at Expiration

$$f_T = 2 \times (S_T - K)^+ + (K - S_T)^+ - D \tag{109}$$

- $S_{\text{up}} = K + \frac{D}{2}$
- $S_{\text{down}} = K - D$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D$



2.34 Strategy: Strip

This is a volatility strategy consisting of a long position in an ATM call option, and a long position in two ATM put options with a strike price K. This is a net debit trade. The trader's outlook is bearish. This is a capital gain strategy. We have:

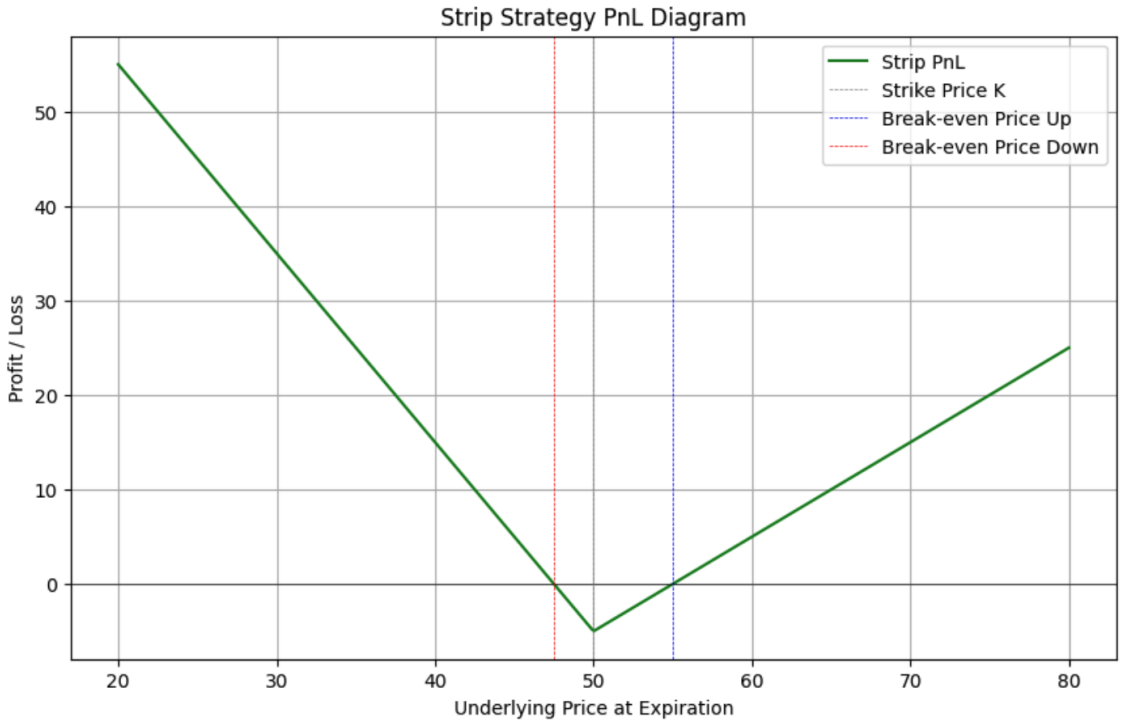
Key Components

- **Long Call Option**: Buy an ATM call option with a strike price K and pay a premium D.
- **Long Put Options**: Buy two ATM put options with a strike price K and pay a premium D.

Payoff at Expiration

$$f_T = (S_T - K)^+ + 2 \times (K - S_T)^+ - D \tag{110}$$

- $S_{\text{up}} = K + D$
- $S_{\text{down}} = K - \frac{D}{2}$
- $P_{\text{max}} = \text{unlimited}$
- $L_{\text{max}} = D$



2.35 Strategy: Call Ratio Backspread

This strategy consists of a short position in N_S close to ATM call options with a strike price K_1, and a long position in N_L OTM call options with a strike price K_2, where $N_L > N_S$. Typically, $N_L = 2$ and $N_S = 1$, or $N_L = 3$ and $N_S = 2$. The trader's outlook is strongly bullish. This is a capital gain strategy. We have:

Key Components

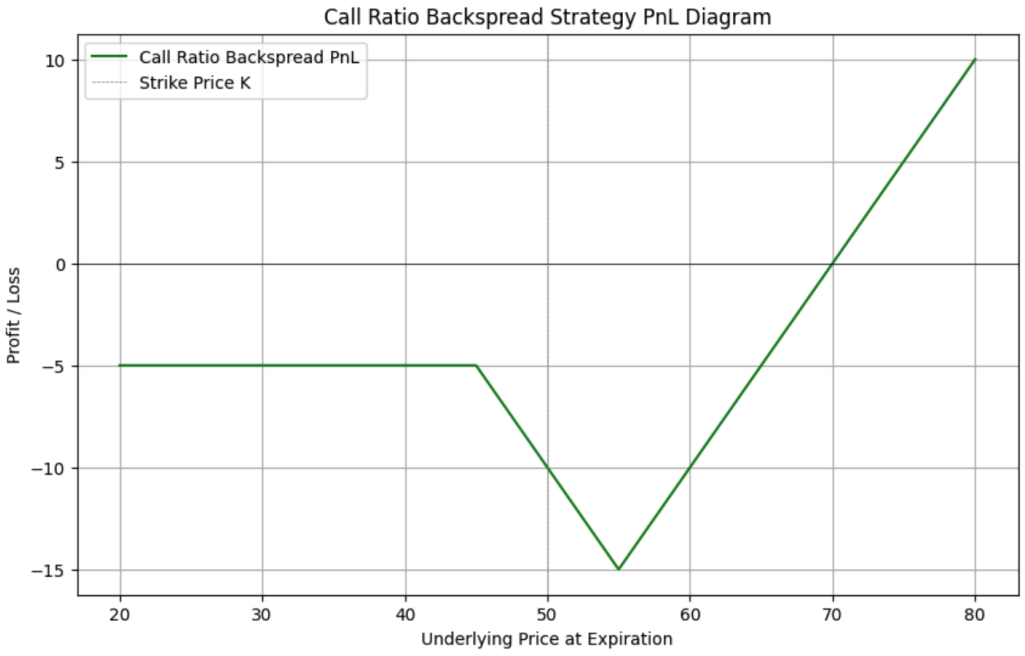
- **Short Call Options**: Sell N_S close to ATM call options with a strike price K_1 and receive a premium H.
- **Long Call Options**: Buy N_L OTM call options with a strike price K_2 and pay a premium H.

Payoff at Expiration

$$f_T = N_L \times (S_T - K_2)^+ - N_S \times (S_T - K_1)^+ - H \tag{111}$$

- $S_{\text{down}} = K_1 + \frac{H}{N_S}$
- $S_{\text{up}} = \frac{N_L \times K_2 - N_S \times K_1 + H}{N_L - N_S}$
- $P_{\max} = \text{unlimited}$
- $L_{\max} = N_S \times (K_2 - K_1) + H$

- $S_0 = 50$ (Current stock price)
- $K_1 = 45$ (Lower strike price)
- $K_2 = 55$ (Higher strike price)
- $N_S = 1$ (Number of short options)
- $N_L = 2$ (Number of long options)
- $H = 5$ (Premium difference)



2.36 Strategy: Put Ratio Backspread

This strategy consists of a short position in N_S close to ATM put options with a strike price K_1, and a long position in N_L OTM put options with a strike price K_2, where $N_L > N_S$. Typically, $N_L = 2$ and $N_S = 1$, or $N_L = 3$ and $N_S = 2$. The trader's outlook is strongly bearish. This is a capital gain strategy. We have:

Key Components

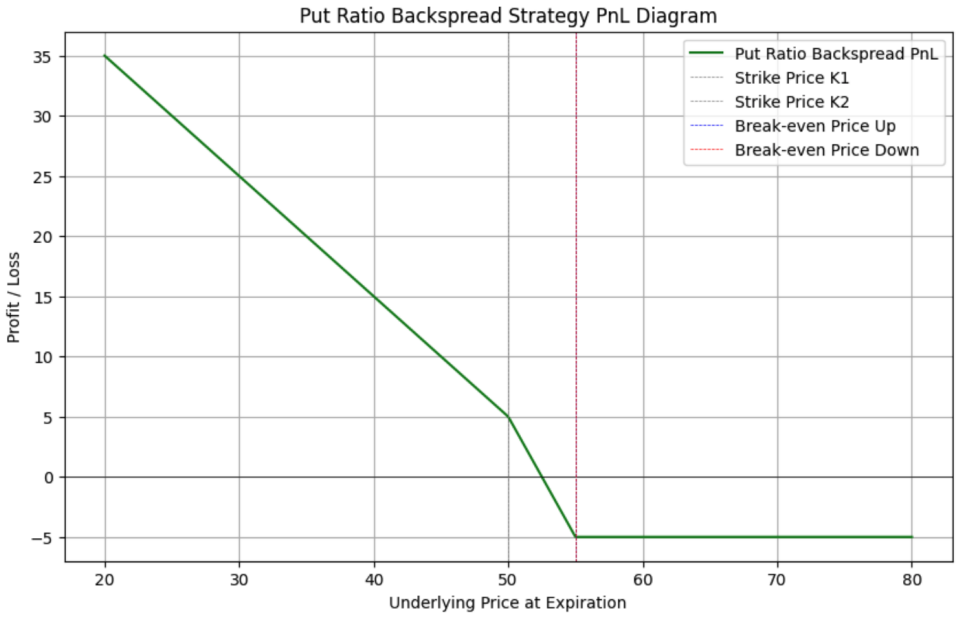
- **Short Put Options**: Sell N_S close to ATM put options with a strike price K_1 and receive a premium H.
- **Long Put Options**: Buy N_L OTM put options with a strike price K_2 and pay a premium H.

Payoff at Expiration

$$f_T = N_L \times (K_2 - S_T)^+ - N_S \times (K_1 - S_T)^+ - H \tag{112}$$

- $S_{\text{up}} = K_1 + \frac{H}{N_S}$
- $S_{\text{down}} = \frac{N_L \times K_2 - N_S \times K_1 - H}{N_L - N_S}$
- $P_{\max} = N_L \times K_2 - N_S \times K_1 - H$
- $L_{\max} = N_S \times (K_1 - K_2) + H$

- $S_0 = 50$ (Current stock price)
- $K_1 = 45$ (Lower strike price)
- $K_2 = 55$ (Higher strike price)
- $N_S = 1$ (Number of short options)
- $N_L = 2$ (Number of long options)
- $H = 5$ (Premium difference)



2.37 Strategy: Ratio Call Spread

This strategy consists of a short position in N_S close to ATM call options with a strike price K_1, and a long position in N_L ITM call options with a strike price K_2, where $N_L < N_S$. Typically, $N_L = 1$ and $N_S = 2$, or $N_L = 2$ and $N_S = 3$. This is an income strategy if it is structured as a net credit trade. The trader's outlook is neutral to bearish. We have:

Key Components

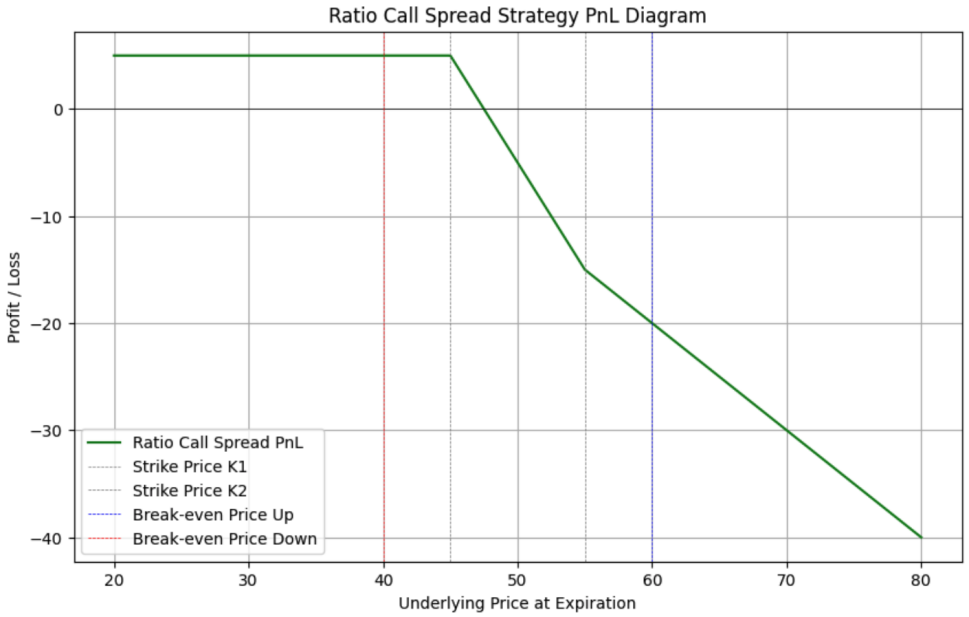
- **Short Call Options**: Sell N_S close to ATM call options with a strike price K_1 and receive a premium H.
- **Long Call Options**: Buy N_L ITM call options with a strike price K_2 and pay a premium H.

Payoff at Expiration

$$f_T = N_L \times (S_T - K_2)^+ - N_S \times (S_T - K_1)^+ + H \tag{113}$$

- $S_{\text{up}} = K_2 + \frac{H}{N_L}$
- $S_{\text{down}} = \frac{N_S \times K_1 - N_L \times K_2 + H}{N_S - N_L}$
- $P_{\max} = N_L \times (K_2 - K_1) - H$
- $L_{\max} = \text{unlimited}$

- $S_0 = 50$ (Current stock price)
- $K_1 = 45$ (Lower strike price)
- $K_2 = 55$ (Higher strike price)
- $N_S = 2$ (Number of short options)
- $N_L = 1$ (Number of long options)
- $H = 5$ (Premium difference)



2.38 Strategy: Ratio Put Spread

This strategy consists of a short position in N_S close to ATM put options with a strike price K_1, and a long position in N_L OTM put options with a strike price K_2, where $N_L > N_S$. Typically, $N_L = 2$ and $N_S = 1$, or $N_L = 3$ and $N_S = 2$. The trader's outlook is neutral to bullish. We have:

Key Components

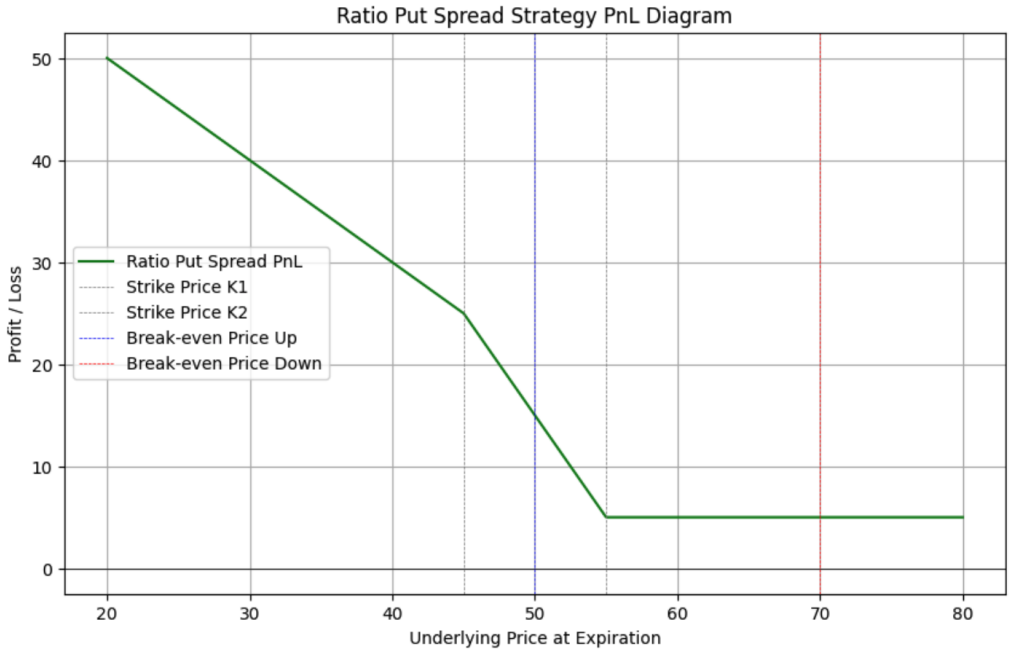
- **Short Put Options**: Sell N_S close to ATM put options with a strike price K_1 and receive a premium H.
- **Long Put Options**: Buy N_L OTM put options with a strike price K_2 and pay a premium H.

Payoff at Expiration

$$f_T = N_L \times (K_2 - S_T)^+ - N_S \times (K_1 - S_T)^+ + H \tag{114}$$

- $S_{\text{up}} = K_1 + \frac{H}{N_S}$
- $S_{\text{down}} = \frac{N_L \times K_2 - N_S \times K_1 + H}{N_L - N_S}$
- $P_{\max} = N_L \times (K_2 - K_1) + H$
- $L_{\max} = \text{unlimited}$

- $S_0 = 50$ (Current stock price)
- $K_1 = 45$ (Lower strike price)
- $K_2 = 55$ (Higher strike price)
- $N_S = 1$ (Number of short options)
- $N_L = 2$ (Number of long options)
- $H = 5$ (Premium difference)



2.39 Strategy: Long Call Butterfly

This is a sideways strategy consisting of a long position in an OTM call option with a strike price K_1, a short position in two ATM call options with a strike price K_2, and a long position in an ITM call option with a strike price K_3. The strikes are equidistant: $K_2 - K_1 = K_3 - K_2 = \kappa$. This is a relatively low-cost net debit trade. The trader's outlook is neutral. This is a capital gain strategy. We have:

Key Components

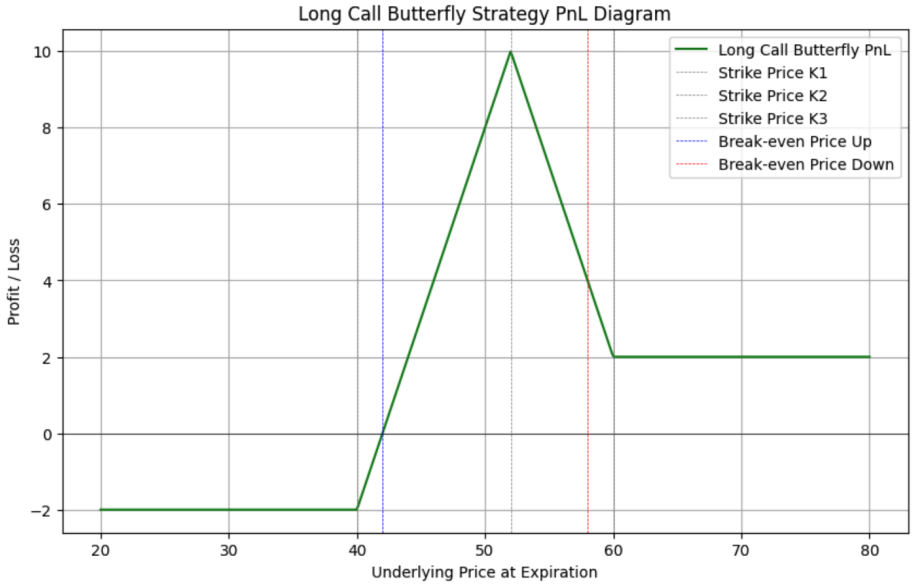
- **Long Call Options**: Buy an OTM call option with a strike price K_1 and pay a premium D.
- **Short Call Options**: Sell two ATM call options with a strike price K_2 and receive a premium D.
- **Long Call Options**: Buy an ITM call option with a strike price K_3 and pay a premium D.

Payoff at Expiration

$$f_T = (S_T - K_1)^+ + (S_T - K_3)^+ - 2 \times (S_T - K_2)^+ - D \tag{115}$$

- $S_{\text{up}} = K_1 - D$
- $S_{\text{down}} = K_3 + D$
- $P_{\max} = \kappa - D$
- $L_{\max} = D$

- $S_0 = 50$ (Current stock price)
- $K_1 = 40$ (Lower strike price)
- $K_2 = 52$ (Higher strike price)
- $K_3 = 60$ (Higher strike price)
- $D = 2$ (Premium paid)
- $Kappa = K_2 - K_1$ (strike distance)



2.40 Strategy: Modified Call Butterfly

This is a variation of the long call butterfly strategy where the strikes are no longer equidistant; instead, we have $K_1 - K_2 < K_2 - K_3$. This results in a sideways strategy with a bullish bias. We have:

Key Components

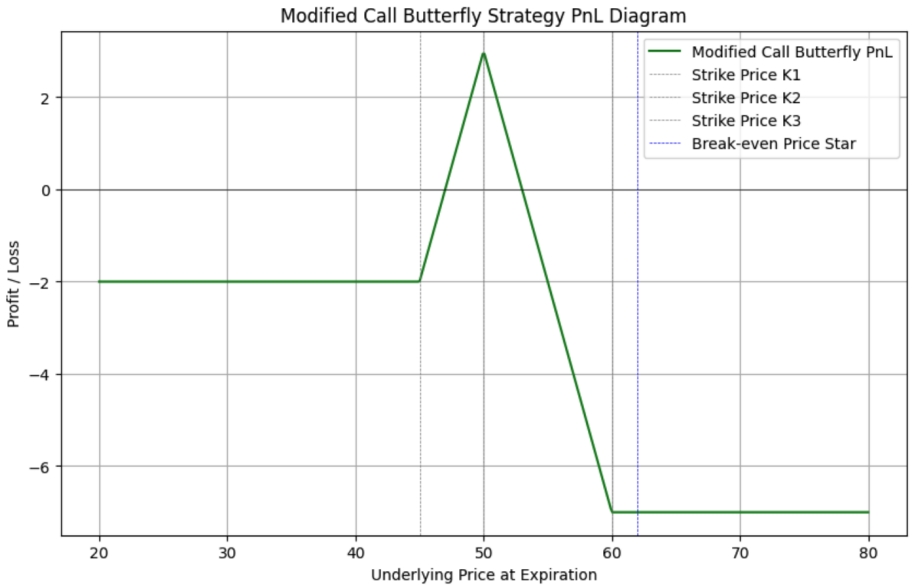
- **Long Call Options**: Buy an OTM call option with a strike price K_1 and pay a premium D.
- **Short Call Options**: Sell two ATM call options with a strike price K_2 and receive a premium D.
- **Long Call Options**: Buy an ITM call option with a strike price K_3 and pay a premium D.

Payoff at Expiration

$$f_T = (S_T - K_1)^+ + (S_T - K_3)^+ - 2 \times (S_T - K_2)^+ - D \tag{116}$$

- $S_* = K_3 + D$
- $P_{\max} = K_2 - K_3 - D$
- $L_{\max} = D$

- $S_0 = 50$ (Current stock price)
- $K_1 = 45$ (Lower strike price)
- $K_2 = 50$ (Higher strike price)
- $K_3 = 60$ (Higher strike price)
- $D = 2$ (Premium paid)



2.41 Strategy: Long Put Butterfly

This is a sideways strategy consisting of a long position in an OTM put option with a strike price K_1, a short position in two ATM put options with a strike price K_2, and a long position in an ITM put option with a strike price K_3. The strikes are equidistant: $K_3 - K_2 = K_2 - K_1 = \kappa$. This is a relatively low-cost net debit trade. The trader's outlook is neutral. This is a capital gain strategy. We have:

Key Components

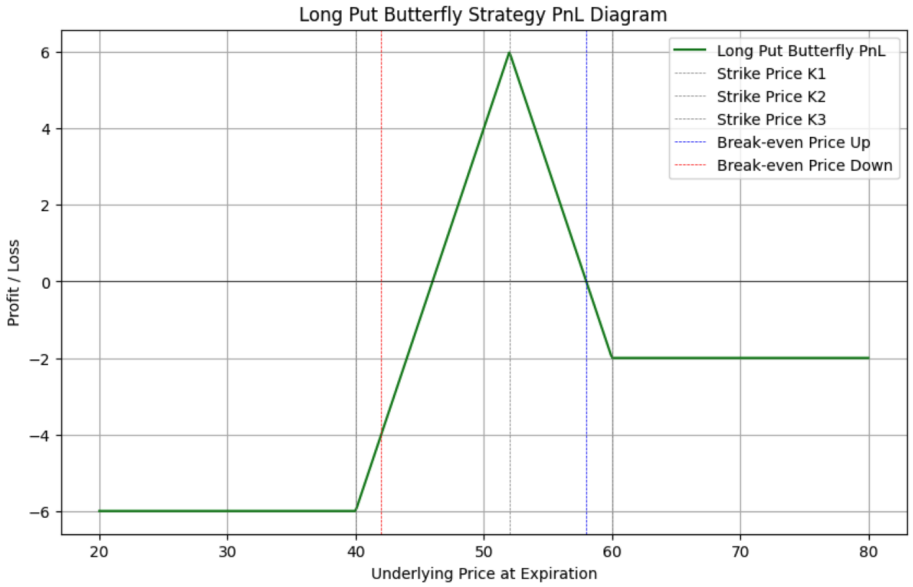
- **Long Put Options**: Buy an OTM put option with a strike price K_1 and pay a premium D.
- **Short Put Options**: Sell two ATM put options with a strike price K_2 and receive a premium D.
- **Long Put Options**: Buy an ITM put option with a strike price K_3 and pay a premium D.

Payoff at Expiration

$$f_T = (K_1 - S_T)^+ + (K_3 - S_T)^+ - 2 \times (K_2 - S_T)^+ - D \tag{117}$$

- $S_{\text{up}} = K_3 - D$
- $S_{\text{down}} = K_1 + D$
- $P_{\max} = \kappa - D$
- $L_{\max} = D$

- $S_0 = 50$ (Current stock price)
- $K_1 = 40$ (Lower strike price)
- $K_2 = 52$ (Higher strike price)
- $K_3 = 60$ (Higher strike price)
- $D = 2$ (Premium paid)
- $Kappa = K_2 - K_1$ (strike distance)



2.42 Strategy: Modified Put Butterfly

This is a variation of the long put butterfly strategy where the strikes are no longer equidistant; instead, we have $K_3 - K_2 < K_2 - K_1$. This results in a sideways strategy with a bullish bias. We have (for $H > 0$ there is also $S_{\text{up}} = K_3 - H$):

Key Components

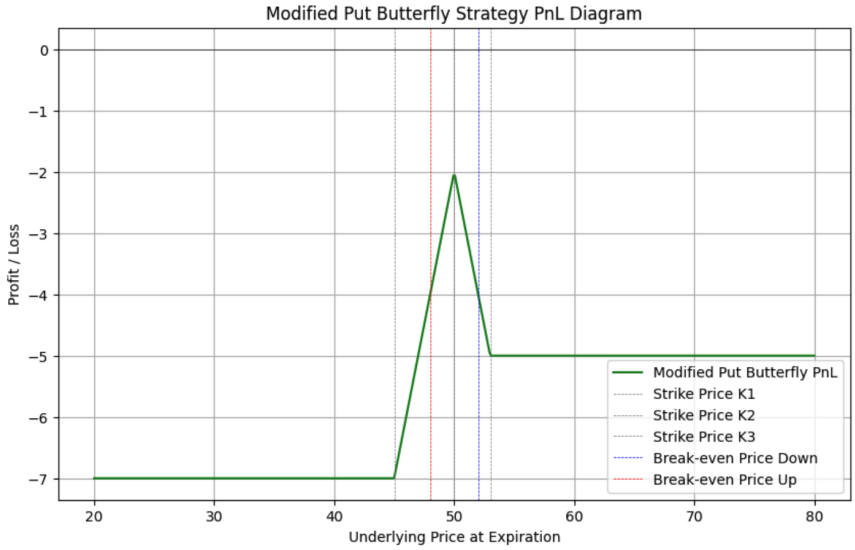
- **Long Put Options**: Buy an OTM put option with a strike price K_1 and pay a premium H.
- **Short Put Options**: Sell two ATM put options with a strike price K_2 and receive a premium H.
- **Long Put Options**: Buy an ITM put option with a strike price K_3 and pay a premium H.

Payoff at Expiration

$$f_T = (K_1 - S_T)^+ + (K_3 - S_T)^+ - 2 \times (K_2 - S_T)^+ - H \tag{118}$$

- $S_{\text{down}} = 2 \times K_2 - K_3 + H$
- $P_{\text{max}} = K_3 - K_2 - H$
- $L_{\text{max}} = 2 \times K_2 - K_1 - K_3 + H$

- $S_0 = 50$ (Current stock price)
- $K_1 = 45$ (Lower strike price)
- $K_2 = 50$ (Higher strike price)
- $K_3 = 53$ (Higher strike price)
- $H = 5$ (Premium paid)



References

151 Trading Strategies
Zura KakushadzeZura Kakushadze's affiliation. Juan Andrés SerurJuan Andrés Serur's affiliation.