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Morgan Stanley

Group 43

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Assessment Submission Form

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Module Co-ordinator	Dr Richard McGee

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Table of Content

1 Introduction

In this report we analyse stock options on Morgan Stanley with expiry on 17th October 2025 using data from 19th September 2025 to maturity. Using Bloomberg closing prices we test whether put–call parity holds across all strikes on the trade date, identify any violations, calculate implied volatility, compare it with 22-day historical volatility and assess the effectiveness of delta hedging under both volatility measures. We also design and evaluate volatility-based trading strategies using the same option set.

By examining these elements, we aim to provide a clear view of how Morgan Stanley options were priced between 19th September 2025 and 17th October 2025, how the market embedded expectations of volatility, how hedging choices affect realised performance and where potential arbitrage or mispricing risks may arise.

1.1 Morgan Stanley

Morgan Stanley is a global financial services firm operating across investment banking, sales and trading, wealth management and institutional asset management. The firm serves corporations, governments and private clients worldwide, with a business model anchored in capital markets expertise and a large fee-generating wealth management franchise. In recent years the company has expanded its wealth and investment management divisions following its acquisitions of E*TRADE and Eaton Vance, which has strengthened its recurring revenue base and reduced reliance on trading income (Morgan Stanley Annual Report, 2024). The firm remains a major dealer in equity and fixed-income derivatives, providing liquidity, risk management and structured solutions across global markets.

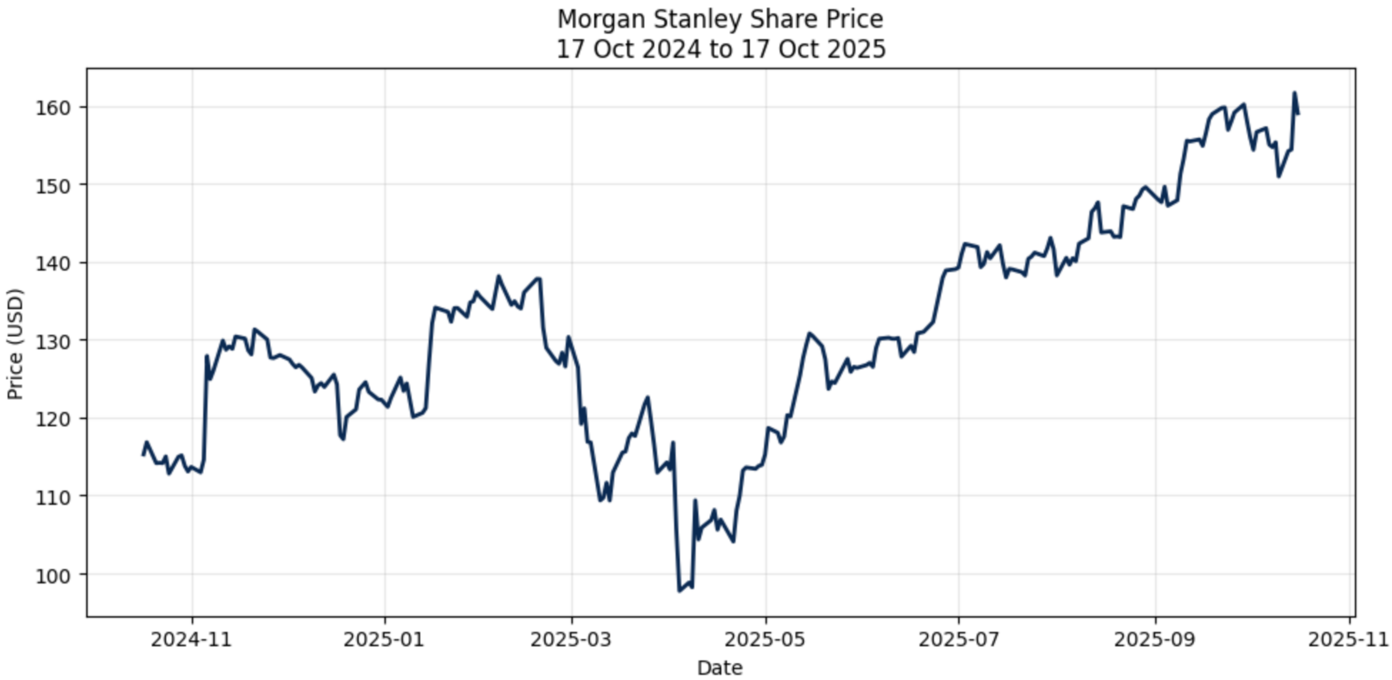

Figure 1.1: Morgan Stanley Share Price 17 Oct 2024 to 17 Oct 2025 showing moderate volatility and increasing price.

1.2 Data Collection

The data for this analysis was sourced from Bloomberg for Morgan Stanley common stock (ticker: MS US Equity). The full option chain for contracts expiring on 17th October 2025 on the trade date 19th September 2025, including all listed calls and puts at each strike was extracted. For the at-the-money option the 160-strike call (MS US 10/17/25 C160 Equity) was used and daily prices from 19th September 2025 to 17th October 2025 were also collected.

Option prices use Bloomberg closing quotes on each date. Where necessary, particularly in the cross section of strikes on the trade date, we use the midpoint of bid and ask quotes as the effective option price to reduce the impact of wide spreads.

Although MS equity options are American style, for the purposes of pricing, put–call parity tests and delta hedging we treat them as European. Given the short time to maturity and our focus on relative pricing, the early exercise premium is assumed to be negligible.
Data processing, analysis and graph plotting are carried out in both Python and excel.

To align discounting with the maturity of our option sample, we use US Treasury yields from the Federal Reserve Economic Data database (FRED, 2025). Since the options expire on 17th October 2025 and the trade date is 19th September 2025, the time to maturity is roughly 28 days, which corresponds most closely to the 1-month constant maturity Treasury bill rather than the 3-month tenor. We therefore take the DGS1MO series, the market yield on 1-month US Treasury securities

Figure 1.2: Trading volume across strikes showing options exist between K=50 and K=195 and liquidity is present between k=125 and k= 190.

2 Put–Call Parity

2.1 Put–Call Parity Theory

Put–call parity is a no arbitrage principle in option pricing. It states that a European call and a European put with the same strike price and expiry must together replicate the payoff of a forward contract with that strike and expiry, meaning they share the same value in an efficient market (Hull, 2014):

$$C + Ke^{-rt} = P + S$$

Any deviation away from this parity would indicate a theoretical arbitrage opportunity, although there are several market frictions which would lead to a slight deviation in prices. For example, option liquidity, bid ask spread and transaction costs.

2.2 Put–Call Parity Analysis

Strike (K)	Call Price (C)	Put Price (P)	Put–Call Parity
$140	$21.5500	$0.5350	$0.6649
$145	$16.9750	$1.1550	$0.4542
$150	$12.7500	$1.7150	$0.6534
$155	$8.9500	$2.8950	$0.6577
$160	$5.7500	$4.7250	$0.6120
$165	$3.3500	$7.3750	$0.5463
$170	$1.7700	$11.1750	$0.1506
$175	$0.8600	$15.1250	$0.2748
$180	$0.5150	$19.5750	$0.4641
$185	$0.2350	$24.5000	$0.2434

Table 2.1: Put–Call Parity table across liquid strike prices.

The put–call parity results (Table 2.1) show small but persistent deviations across strike prices. Most deviations are small which is consistent with an active and largely efficient market. These discrepancies are well within the range expected from market frictions such as liquidity and transaction costs. The largest deviations occur at strikes with lower volume which is due to illiquidity of contracts at these strikes and is not something that could be traded. Overall, the parity relationship holds closely across the chain indicating no clear arbitrage opportunities once realistic trading costs and market frictions are considered.

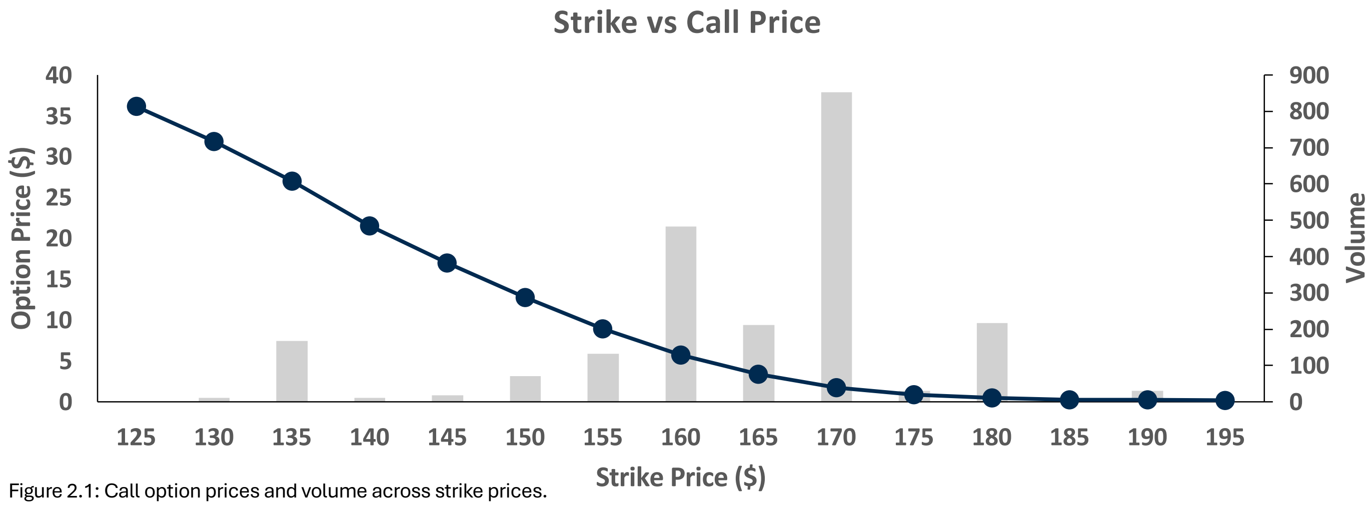

Figure 2.1: Call option prices and volume across strike prices.

Call prices decline smoothly as the strike price increases (Figure 2.1), consistent with the lower intrinsic value and a reduced likelihood of finishing in-the-money (ITM) at higher strikes. Volumes are concentrated at a strike price of $170 and at $160 (ATM option), where the market participation and expectations are the strongest. Deep ITM and far out-of-the-money (OTM) strikes exhibit limited volume, consistent with the wider bid/ask spreads and lower liquidity.

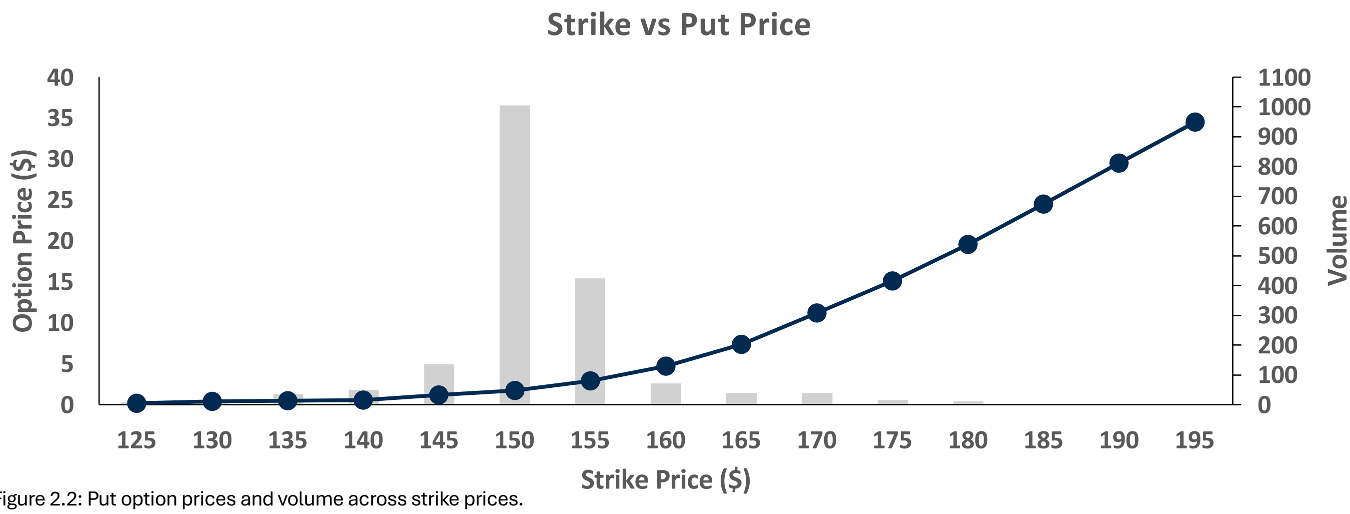

Figure 2.2: Put option prices and volume across strike prices.

Put prices rise steadily with the strike prices (Figure 2.2), reflecting higher intrinsic value and an increase likelihood of finishing ITM. Trading volume clusters around the strike price $150, while strikes far from the underlying show little activity due to the low liquidity and wider spreads (matching the call options). The price curve and clustered volume profile highlight meaningful activity focused around the relevant strikes

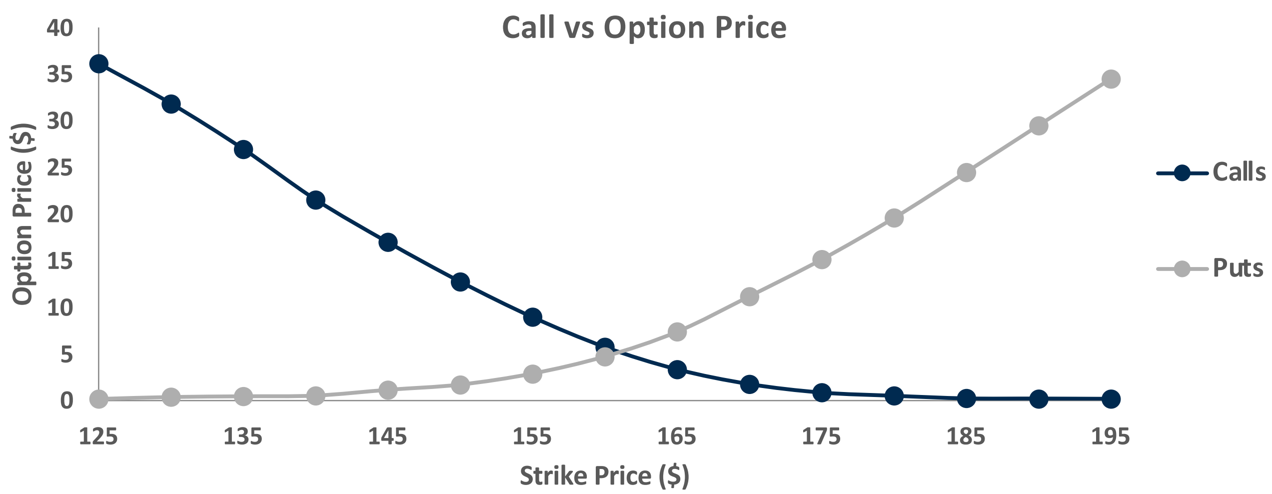

Figure 2.3: Call and put prices converge near the underlying stock price.

Morgan Stanley options exhibit an inverse relationship between call and put prices, with the two intersecting just above the strike price of $160 (Figure 2.3). The curves show a steady decline across the option chain, driven by the decreasing likelihood that the underlying stock will reach these strike prices and with no material distortions from illiquidity. The curvature in the wings reflects the standard volatility skew characteristic of equity options.

The current underlying stock price is $159.91; although the pricing doesn't precisely match the at-the-money (ATM) option, the options are consistently priced at the observed market levels.

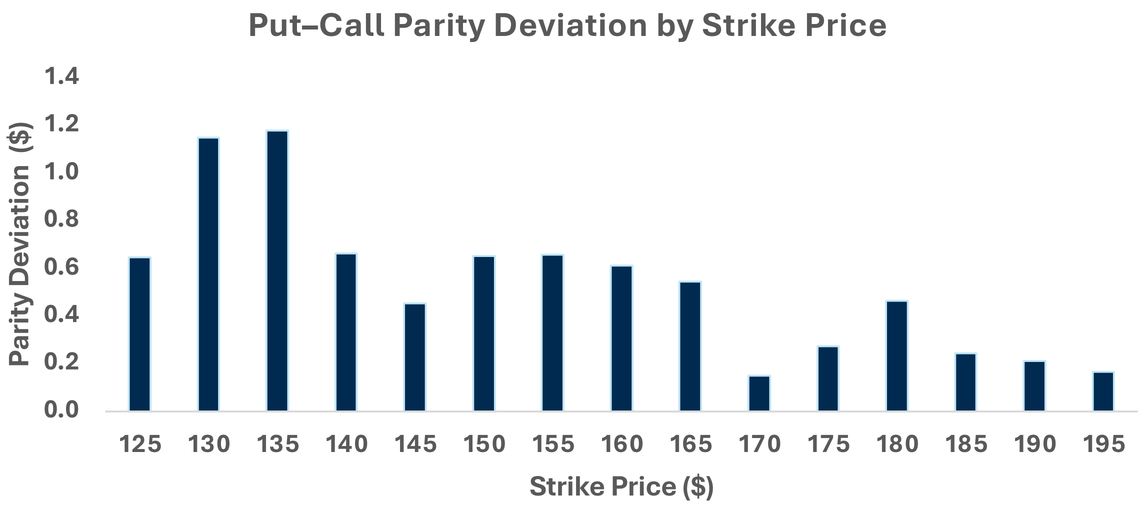

Figure 2.4: Deviation from put–call parity across strike prices for the option chain.

Put-call parity deviations vary across strike prices (Figure 2.4), with the deviations in line with the normal bid/ask and liquidity frictions rather than indicating arbitrage. The noticeable spikes around strike prices $130 and $135 appear to reflect pricing around protection rather than persistent mispricing. While fluctuations continue across the higher strike range, the pattern doesn't indicate any systematic distortion in option valuation and overall put–call parity holds broadly as expected across the option surface.

3 Implied Volatility

3.1 Implied Volatility Theory

Implied volatility represents the level of future uncertainty that the market embeds in an option's price. It is the volatility input to the Black–Scholes model that makes the theoretical price match the observed market price. Unlike historical volatility, which is calculated from past returns, implied volatility is forward looking and reflects real time expectations of risk, supply and demand imbalances and the pricing of tail events. It also varies across strikes and maturities, producing patterns such as volatility smiles and skews that provide insight into how the market assigns probabilities to extreme movements in the underlying asset (Hull, 2014).

We apply the Black–Scholes framework to back out the level of volatility that equates the model price with the option's actual market price.

The Black-Scholes formula for calls and puts are as follows:

$$C = S_0 N(d_1) - Ke^{-rt} N(d_2)$$

$$P = Ke^{-rt} N(-d_2) - S_0\, N(-d_1)$$

Where,

$$d_1 = \frac{\ln\frac{S_0}{K} + (r + \frac{\sigma^2}{2})}{\sigma\sqrt{T}}$$

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

3.2 Implied Volatility Analysis

3.2.1 Call Option Implied Volatility

The implied volatility curve for Morgan Stanley call options drops sharply from inflated levels at deep in-the-money strikes where illiquidity and wide bid and ask spreads distort the Black Scholes output, then settles near the at-the-money region into a smoother shape. This reflects more efficient pricing occurring due to active trading. Trading activity is concentrated in the centre of the and this liquidity supports the more stable implied volatilities observed there. Outside where there is volume the structure falls away, so the wings of the curve show distorted IV readings that mostly reflect illiquidity, rather than genuine shifts in market expectations.

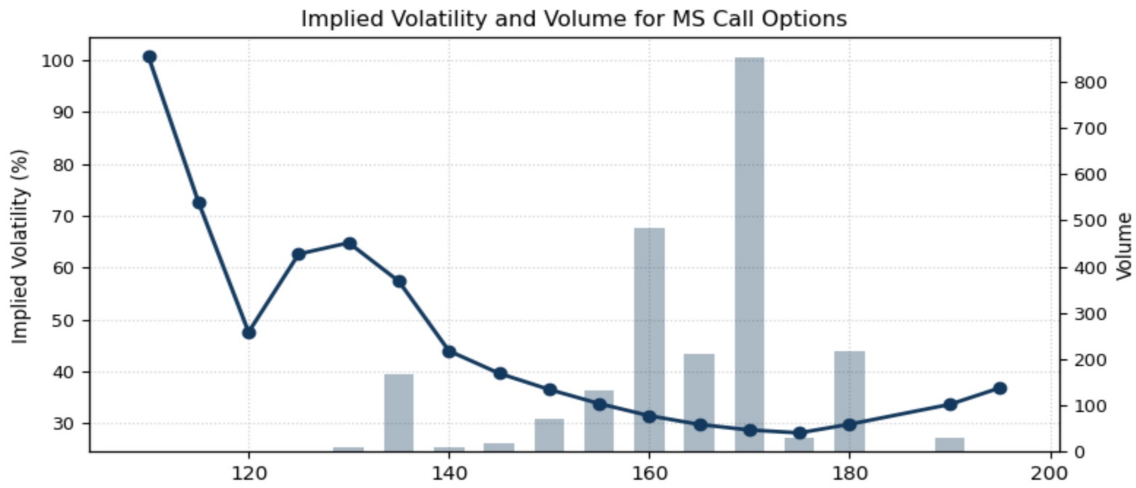

Figure 3.1: Implied volatility stabilises around actively traded at the money strikes while deep wing values rise due to illiquidity and wide bid and ask spreads.

3.2.2 Put Option Implied Volatility

For puts, implied volatility slopes downward as strike increases, producing a clear volatility skew. Deep out of the money puts trade at the highest implied volatilities, consistent with investors paying a premium for “market crash” protection on Morgan Stanley’s equity. The structure is most stable between strikes 145 and 160 where trading activity is concentrated and bid ask spreads are tight.

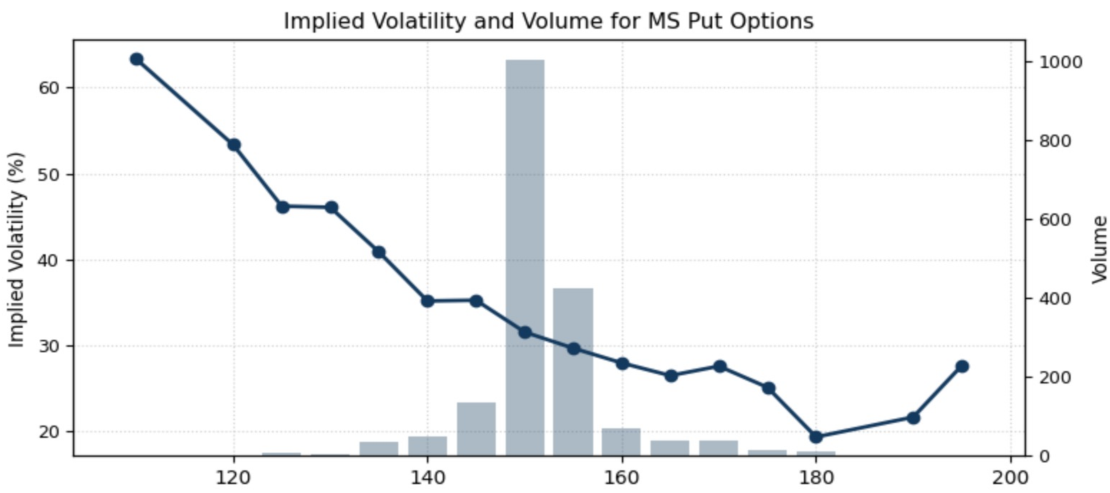

Figure 3.2: Put implied volatility is stable around liquid strikes near the underlying price and increases sharply in the wings where trading is illiquid.

3.2.3 Implied Volatility Spread

The volatility spread between calls and puts is highest at the lower strikes and narrows steadily as the strike increases (Figure 3.3). This pattern reflects strong downside demand in the put market at strikes below 140, which keeps put implied volatility elevated relative to call implied volatility. As trading becomes more active near the centre of the chain, pricing grows more efficient and the spread compresses to low single digits. The small rise at the 180 strike indicates reduced liquidity and wider quoting at the far wing. Overall, the spread distribution shows that the most reliable, arbitrage consistent pricing occurs around the actively traded middle strikes, while the wings display greater imbalance between call and put volatility.

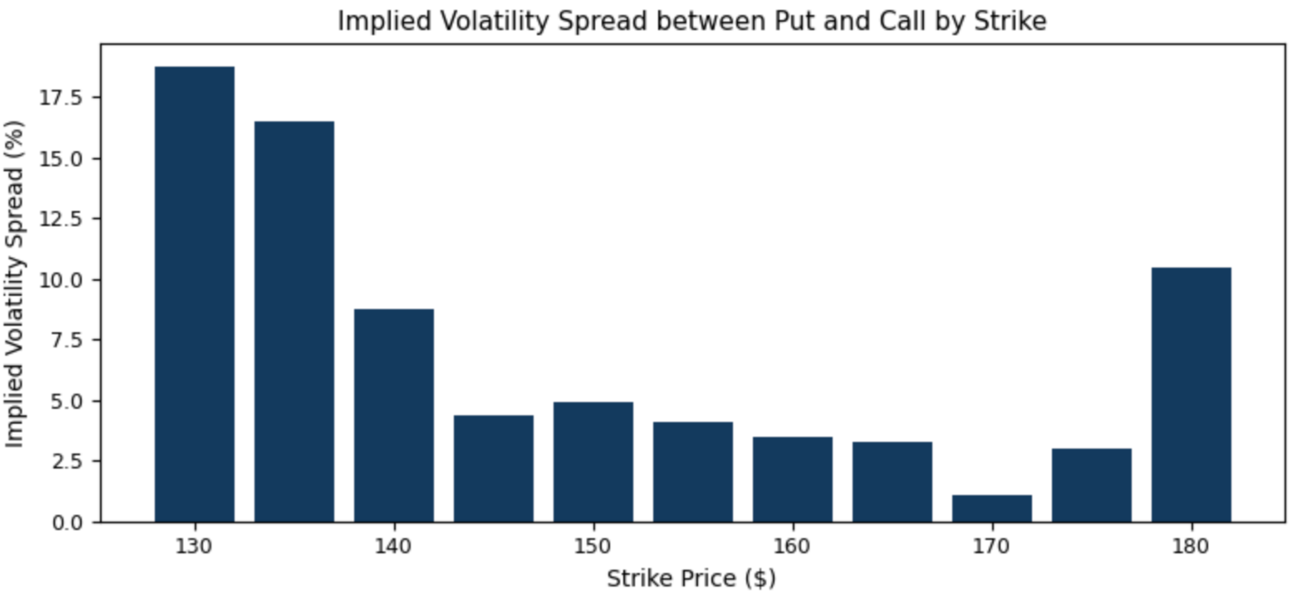

Figure 3.3: The volatility spread is highest at low strikes where put demand elevates implied volatility and narrows toward the money before rising again in the illiquid far wing.

4 Delta Hedging

4.1 Delta Hedging Theory

Delta hedging is a method used to neutralise the directional risk of an option position. By holding a quantity of the underlying asset equal to the option's delta, the combined position becomes locally insensitive to small movements in the underlying price. As market conditions change, delta must be adjusted over time, leading to a dynamic rebalancing process that illustrates how option risk evolves through maturity (Hull, 2014).

4.2 Option Delta

An option's delta is the proportion of the underlying required to neutralise directional risk. A positive delta indicates the option's value increases as the underlying's value increases. Writing a call requires a positive delta.

Under the Black-Scholes framework, European calls have a delta of 0.5. However, the call we are writing has an early exercise right. These traditionally trade at a premium; the BSM interprets this as increased implied volatility. Since delta-hedging is expected to be profitable when the implied volatility is greater than the realised volatility over the hedge period, this simplification is reasonable for our purposes.

4.3 P&L Analysis

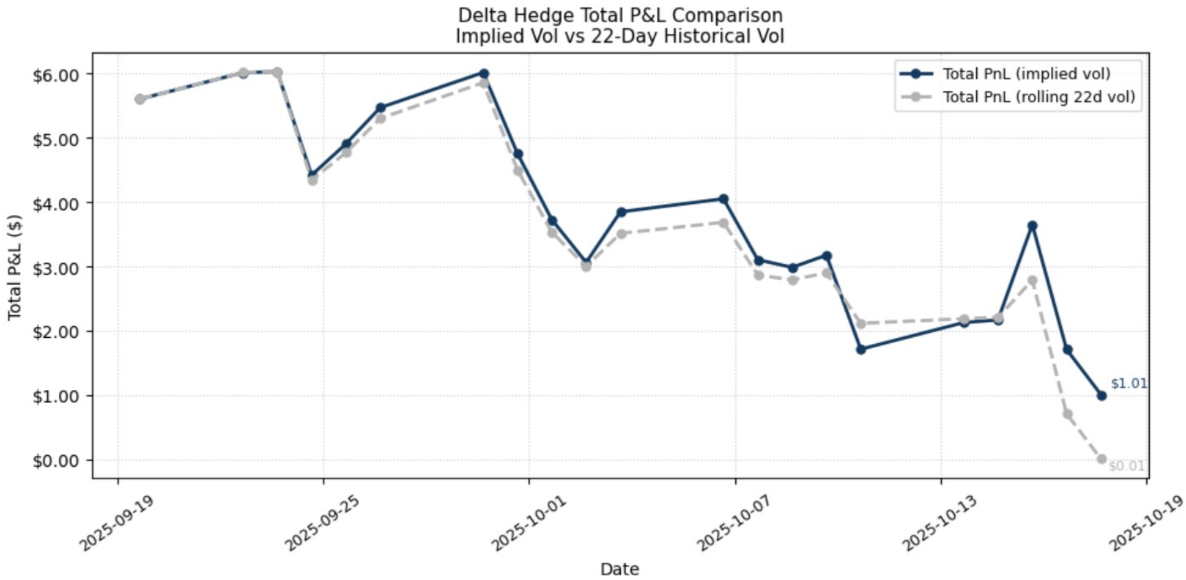

Figure 4.3: Total delta hedge P&L declines steadily through the hedging period with implied and historical volatility producing similar paths, diverging only near expiry where realised volatility increases.

A premium of $5.60 was received for writing the call option. The total P&L depletes over the course of the trade, but maintains a final profitability of ~18%, a result of implied volatility being greater than realised volatility over the hedging period (31.4% vs ~25%).

Rerunning the hedge with 22-day rolling volatility, the strategy's profitability depletes faster, approaching zero at expiration. The backwards-looking nature of rolling volatility does not account for future price moves, leading to increased delta-sensitivity, in turn, increasing the chances we buy high and sell low.

4.4 The Hedge Path

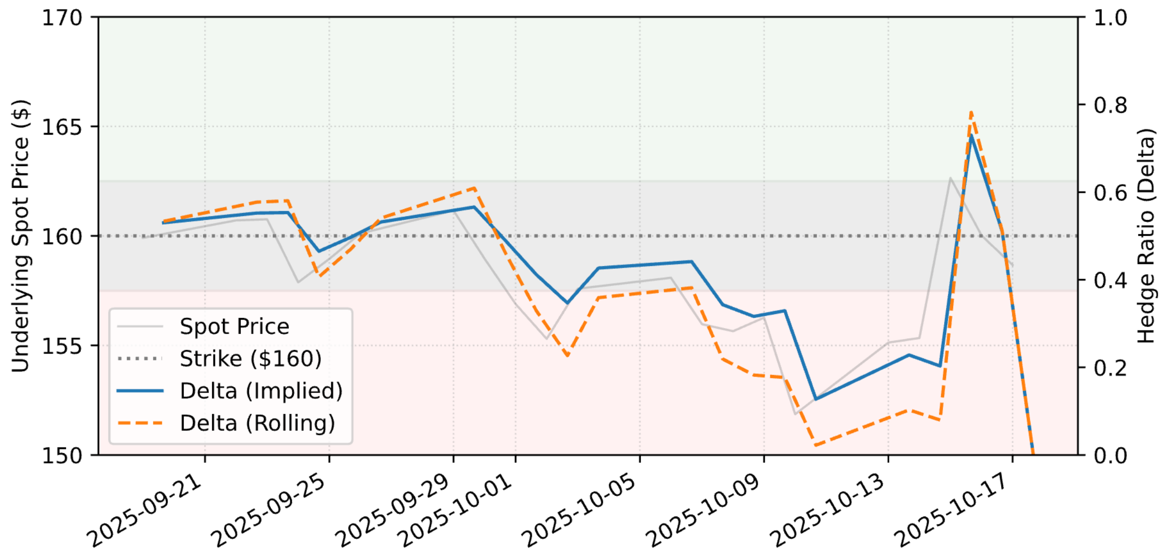

Figure 4.4: Implied vs rolling volatility hedge path. Decreasing moneyness decreases delta requirements.

Comparing the implied vs rolling hedge paths, the shortcomings of using historic volatility are apparent. Delta hedges lose money when the implied volatility is lower than realised volatility. Since rolling volatility is inherently backwards-looking, any price change that would increase the realised volatility cannot be accounted for. This is reminiscent of Peso Risk, events that can happen but have not yet. Historic volatility is likely to undershoot realised volatility; delta hedging is not profitable in this environment (Figure 4.2).

4.5 Delta Sensitivity

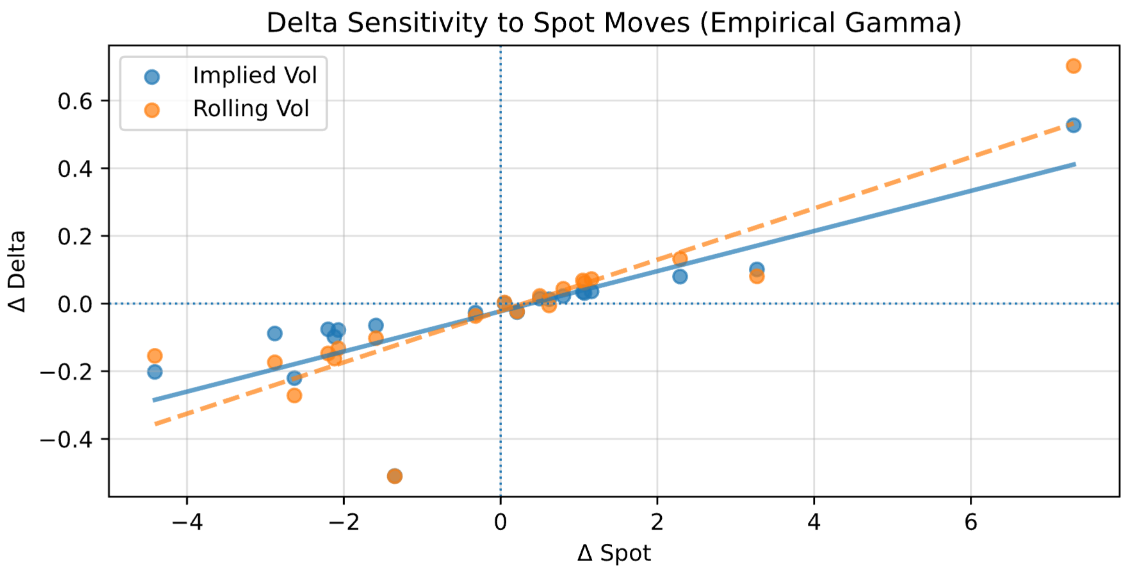

Figure 4.5: Rolling volatility has higher delta sensitivity compared to implied volatility.

While successful delta hedges protect against the directional risk of the underlying, a single delta hedge leaves us with convexity exposure. Written calls are short gamma; higher gamma has a greater risk of buying high and selling low when rebalancing our hedge. This provides a structural reason why implied volatility is often greater than realised volatility, it increases delta hedge profits and reduces gamma exposure.

5 Volatility Trade

5.1 Volatility Analysis

Morgan Stanley options are currently subject to a significant volatility discrepancy:

Metric	Value	Meaning
Historic Volatility (22-day)	16.04%	Realised Movement
ATM Implied Volatility (Average Call and Put)	29.67%	Market Pricing
IV/HV Ratio	**1.85x**	**Overpriced**
Expected HV Range (1σ)	\$153.01 - \$167.99	68% Probability Zone

Table 5.1: Volatility comparison and expected price range as of September 19th, 2025.

Driver: October 15th earnings (2 days prior to expiry) increased amount of crash hedging demand. Historical MS post-earnings move: 1.7% average (Market Chameleon, 2025).

Opportunity: Profit from volatility that has been overpriced, while having a defined risk structure.

5.2 Strategy Construction

As the implied volatility is higher than the historic, the position we want to take is to short Vega and profit on the volatility reducing. To do this we have constructed three trades using calls and puts below (Table 5.2, Table 5.3 and Table 5.4):

Short Call Butterfly (Recommend)

Position	Strike	Quantity	Price	Premium
Sell	\$160	2	\$5.60 bid	\$11.20
Buy	\$150	1	\$12.90 ask	(\$12.90)
Buy	\$170	1	\$1.89 ask	(\$1.89)
			Net	**(\$3.59)**

Table 5.2: Construction of short call butterfly.

Short Iron Butterfly

Position	Strike	Quantity	Price	Premium
Sell	\$160C	1	\$5.60 bid	\$5.60
Sell	\$160P	1	\$4.60 bid	\$4.60
Buy	\$150P	1	\$12.90 ask	(\$1.99)
Buy	\$170C	1	\$1.89 ask	(\$1.89)
			Net	**\$6.32**

Table 5.3: Construction of short iron butterfly.

Short Put Butterfly

Position	Strike	Quantity	Price	Premium
Sell	$160	2	$4.60 bid	$9.20
Buy	$150	1	$1.99 ask	($1.99)
Buy	$170	1	$11.65 ask	($11.65)
			Net	**($4.44)**

Table 5.4: Construction of short put butterfly

5.3 Strategy Comparison

Metric	Call Butterfly	Iron Butterfly	Put Butterfly
Entry Cost	($3.59)	**$6.32**	($4.44)
Max Profit	**$6.41**	$6.32	$5.56
Max Loss	**$3.59**	$3.68	$4.44
Break-Even Points	**$153.59 | $166.41**	$153.68 | $166.32	$154.44 | $165.56
Risk/Reward	**1.79:1**	1.72:1	1.25:1

Table 5.5: Comparison of each strategy using different metrics.

We can see that the short call butterfly call beats the other two strategies in almost every metric (Table 5.3), therefore it is the strategy that we recommend implementing, this is mainly due to the better risk/reward metric (1.79:1) and lower entry cost.

5.4 Payoff Function and Expiry Payoff Short Call Butterfly

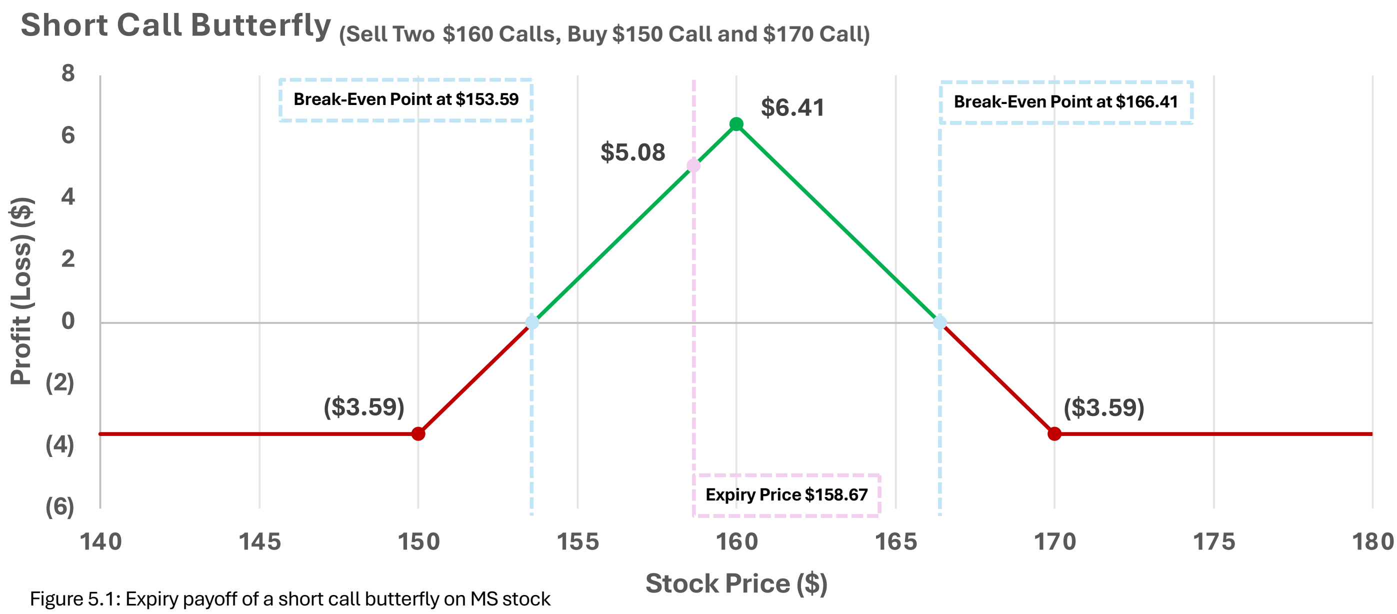

Figure 5.1: Expiry payoff of a short call butterfly on MS stock (4 Calls).

Stock Price	$150 Call	$160 Call x2	$170 Call	Gross Value	Net P&L
$150.00	$0.00	$0.00	$0.00	$0.00	($3.59)
$153.59	$3.59	$0.00	$0.00	$3.59	$0.00
$155.00	$5.00	$0.00	$0.00	$5.00	$1.41
$158.67	**$8.67**	**$0.00**	**$0.00**	**$8.67**	**$5.08**
$160.00	$10.00	$0.00	$0.00	$10.00	$6.41
$165.00	$15.00	($10.00)	$0.00	$5.00	$1.41
$166.41	$16.41	($12.82)	$0.00	$3.59	$0.00
$170.00	$20.00	($20.00)	$0.00	$0.00	($3.59)

Table 5.6: Payoff at key strike prices for the short call butterfly.

We've constructed a payoff chart (Figure 5.1) and a payoff table (Table 5.6) showing the outcome of the short call butterfly across different stock prices, using the bid/ask prices from Table 5.2.

On expiry, the underlying stock price remained within our expected range (Table 5.1), meaning that the trade was profitable. The underlying finished at $158.67, close to the max profit, successfully profiting from our Vega short (Merril Edge, 2025), generating a profit of $508 per contract.

5.5 Payoff Function and Expiry Payoff Short Iron Butterfly

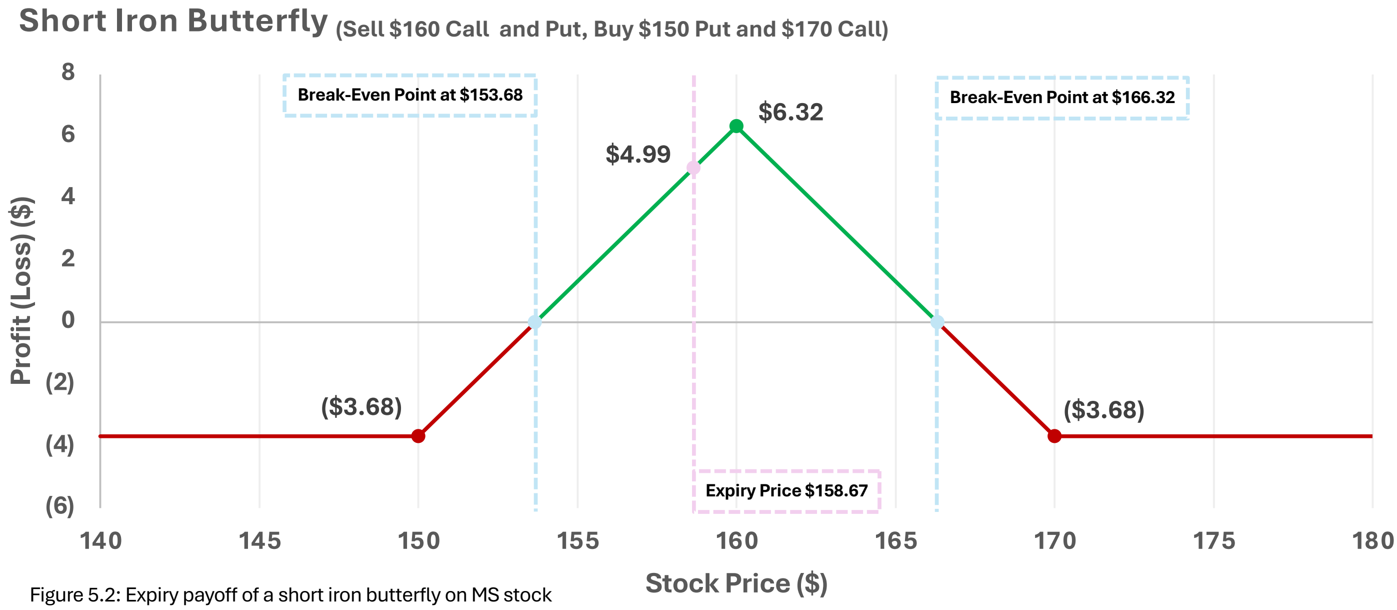

Figure 5.2: Expiry payoff of a short iron butterfly on MS stock (2 Calls and 2 Puts).

Stock Price	$150 Put	$160 Call	$160 Put	$170 Call	Gross Value	Net P&L
$150.00	$0.00	$0.00	($10.00)	$0.00	($10.00)	($3.68)
$153.68	$0.00	$0.00	($6.32)	$0.00	($6.32)	$0.00
$155.00	$0.00	$0.00	($5.00)	$0.00	$5.00	$1.32
$158.67	**$0.00**	**$0.00**	**($1.33)**	**$0.00**	**($1.33)**	**$4.99**
$160.00	$0.00	$0.00	$0.00	$0.00	$10.00	$6.32
$165.00	$0.00	($5.00)	$0.00	$0.00	$5.00	$1.32
$166.32	$0.00	($6.32)	$0.00	$0.00	$3.59	$0.00
$170.00	$0.00	($10.00)	$0.00	$0.00	($10.00)	($3.68)

Table 5.7: Payoff at key strike prices for the short iron butterfly.

We've constructed a payoff chart (Figure 5.2) and a payoff table (Table 5.7) showing the outcome of the short call butterfly across different stock prices, using the bid/ask prices from Table 5.2.

While the short iron butterfly was also profitable, it had a lower absolute P&L and a lower return on capital compared to the call only strategy. Generating $499 per contract, the strategy generated 2% less profit ($4.99 vs $5.08).

5.6 Payoff Function and Expiry Payoff Short Put Butterfly

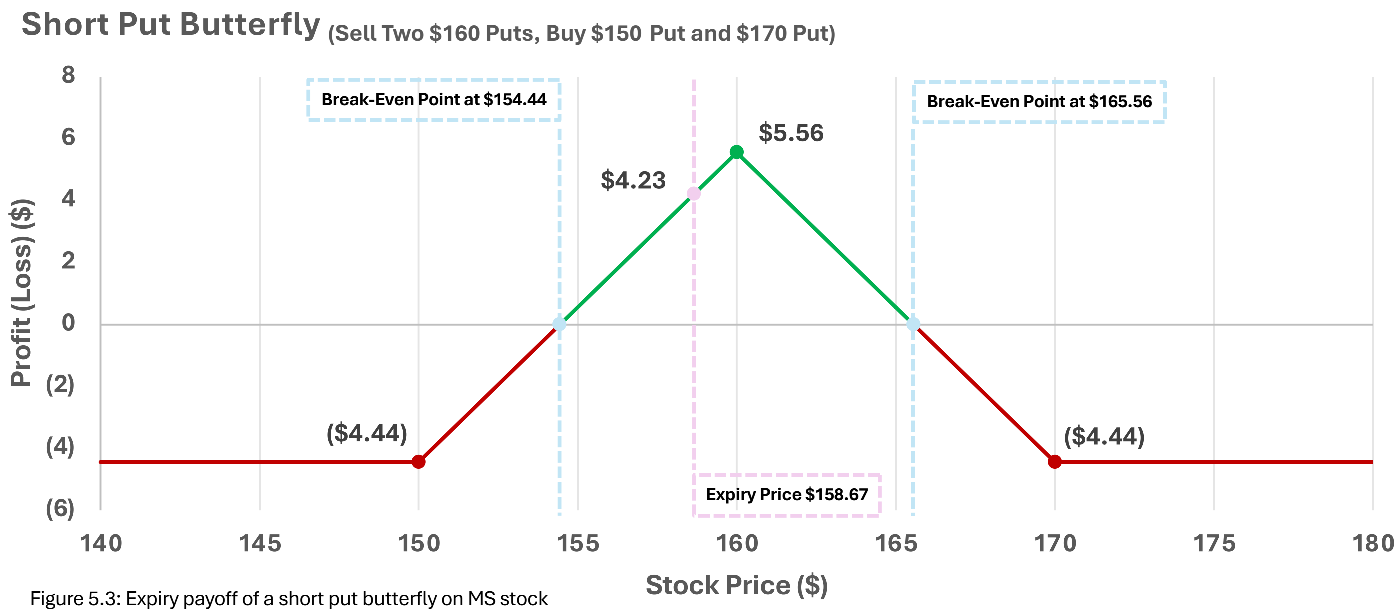

Figure 5.3: Expiry payoff of a short put butterfly on MS stock (4 Puts).

Stock Price	$150 Put	$160 Put x2	$170 Put	Gross Value	Net P&L
$150.00	$0.00	($20.00)	$20.00	($4.44)	($4.44)
$154.44	$0.00	($11.12)	$15.56	$4.44	$0.00
$155.00	$0.00	($10.00)	$15.00	$5.00	$0.56
$158.67	**$0.00**	**($2.66)**	**$11.33**	**$8.67**	**$4.23**
$160.00	$0.00	$0.00	$0.00	$10.00	$5.56
$165.00	$0.00	$0.00	$0.00	$5.00	$0.56
$165.56	$0.00	$0.00	$0.00	$4.44	$0.00
$170.00	$0.00	$0.00	$0.00	($4.44)	($4.44)

Table 5.8: Payoff at key strike prices for the short put butterfly.

We've constructed a payoff chart (Figure 5.3) and a payoff table (Table 5.8) showing the outcome of the short call butterfly across different stock prices, using the bid/ask prices from Table 5.2.

The short put butterfly is more expensive to enter ($4.44 vs $3.59) with an inferior risk/reward (1.25:1 vs 1.79:1), making it the least attractive of the three strategies. The short call butterfly provides the identical exposure with 24% lower capital requirement and more attractive return characteristics.

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