Options, Futures & Risk Management

Group assignment

Strategic equity price risk management for IBG clients

Implementing advanced derivatives strategies in volatile markets

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Table of Contents:

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The word count excludes the appendix, bibliography, table of contents, tables, charts and graphs (and their captions), and all footnotes.

Introduction

All calculations and Python functions used in this report are available in the open-access Google Collab at [LINK].

1.1 Analysis of NST.AX Share Price Behaviour (Mar 2023 - Mar 2025)

Over the period from March 2023 to March 2025, NST (NST.AX) underwent significant price fluctuations (from A$10.66 on 1/03/2023 to A$18.32 on 31/03/2025). Driven by company news and macro factors.

1.1.1 Major Price Movements and Catalysts

NST (NST.AX) experienced several notable price and volume events between March 2023 and March 2025:

- **March 2023 (23/03/2023):** The first significant price spike (+5.02%) corresponded to an operational update at the Pogo mine. Despite a six-week outage that threatened output[1], the management reaffirmed FY23 production guidance, boosting confidence and triggering a price/volume reaction. (Figure_1.2).
- **July 2023 (19-20/07/2023):** Consecutive sharp declines (-5.83% and -6.59%) aligned with the release of the June quarterly report. Despite meeting FY23 guidance with sales of 426koz gold at an AISC of A$1,700/oz, the market focused on cost pressures, sparking a double volume and price spike.
- **August 2023 (24/08/2023):** FY23 financial results prompted a +5.18% rally, following a 29% YoY net profit increase and a 15.5¢ final dividend. Due to the extension of a A$300m buyback.
- **January 2024:** Another upward price spike (+6.04%) occurred on strong quarterly results and the announcement of a fully undrawn A$1.5bn credit facility.

[1] *Risked a 20-40k ounce reduction in gold output*

- **October 2024 (25/10/2024):** The September quarter update triggered a +5.05% surge, with reaffirmed FY25 production guidance (1.65-1.80Moz at an AISC of A$1,850-2,100/oz).[2]
- **December 2024 (02/12/2024):** The most notable negative reaction followed the A$5 billion all-share acquisition of De Grey Mining, causing a -5.25% fall on 6.6 million shares traded. The decline extended to the next day (-2.77%, 8.7 million shares) as the market absorbed the implications.

Spike Methodology:

A Price Spike is identified when the daily simple return exceeds ±5%. A Volume Spike is flagged when trading volume exceeds the mean by at least two standard deviations:

$$Volume > Mean + 2 \cdot Std\ Dev$$

Both price and volume spikes are shown in Figures_1.1 **and** Figure_1.2.[3]

1.1.2 Volatility and Liquidity Patterns

The technical evolution of NST.AX's share price over the past two years can be divided into two phases: Correction (H1 2023 - Q3 2023), marked by a persistent downtrend amid mixed earnings and operational uncertainty, and Recovery and Expansion (Late 2023 - 2025), with a strong uptrend peaking above A$18.

Volatility and volumes spiked during earnings and major events like the December 2024 acquisition. Volatility ranged from 21% to 44%, while extreme liquidity events frequently coincided with fundamental news, reflecting intense market activity and institutional flows. (See Figure_1.3**)**

1.1.3 Comparative Performance and Sector Dynamics

Between March 2023 and March 2025, NST.AX gained ~65%, though it lagged key peers GMD.AX and EVN.AX Figure_1.4. While GMD tripled and EVN doubled, NST's return was a more modest +65%. This relative underperformance is further highlighted in Figure_1.5 and Figure_1.6, where NST is persistently below its peers from mid-2023 onward.

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[2] *High volume (6.5m shares) indicated market confidence despite sector-wide cost pressures.*
[3] *This approach (see code:* Spike Classification and Event Table*) captures statistically significant trading surges often associated with institutional flows or news-driven activity.*

Nevertheless, NST outperformed the S&P/ASX 200 Figure_1.7, supported by stronger fundamentals. Notably, NST's gold-focused portfolio provided partial downside protection during periods of inflation and macroeconomic uncertainty, especially in early 2024.

Overall, NST's conservative growth may reflect investor confidence in its stability and disciplined capital management. This divergence reflects preference for higher-beta stocks during expansion.

1.2 ESG Initiatives and Their Impact on Stock Price Performance

Over the period from March 2023 to March 2025, NST (NST.AX) made substantial progress in its environmental, social, and governance (ESG) practices. These improvements enhanced the company's ESG score and transparency, and in several instances had clear, short-term impacts on the stock price.

1.2.1 ESG Strategy and Disclosure

According to LSEG ESG data (2025), NST's overall ESG score rose to **72.41 (B+)** from **64.18** the prior year. Governance (A+) led, followed by Social (A-) and Environmental (B-); controversy score: 100.

1.2.2 Market Reactions to ESG Events

ESG market reactions were assessed over a ±3-day window. Key findings:

- **Environmental initiatives** (*Table_1.1*) caused the largest swings, especially tied to resource-use and green-energy projects.
- **Social initiatives (*Table_1.2*)** led to smaller, positive impacts linked to workforce diversity and safety.
- **Governance and mixed-ESG initiatives** (*Table_1.3*) sometimes caused spikes, especially on transparency-related news.

The immediate price reactions to these ESG events are visualized in *Figure_1.8*, *Figure_1.9* show price/volume effects by ESG type, confirming that well-communicated ESG actions can move markets.

1.2.3 Long-Term ESG Performance and Sector Positioning

While not every ESG initiative resulted in an immediate revaluation, the overall improvements contributed to enhanced investor confidence, especially among institutions with sustainability mandates. Compared to peers, NST ranked:

- **7th out of 82** by ESG score.
- **1st in Governance**, reflecting its leadership in transparency and shareholder alignment

In summary, Northern Star's ESG efforts not only supported a stronger sustainability profile but also contributed to short-term volatility around key announcements. These developments strengthened NST's ESG positioning

2.1 Methodological Assumptions and Computational Approach

2.1.1 Data and Computational Assumptions

For all option pricing and volatility analysis, we assume **no dividends** on NST during the relevant period, as per assignment guidelines. (Task 4) This enables direct application of the standard Black-Scholes model for both option pricing and implied volatility extraction, with no dividend adjustment (i.e., dividend yield $q = 0$). All calculations were performed using the mid-point between bid and ask prices, unless otherwise stated.

2.1.2 Implied Volatility

Starting from option market data, we computed implied volatility (IV) by inverting the Black-Scholes formula, using market prices (bid/ask) through a root-finding algorithm. The implied volatility curve shows a volatility skew, which is quite common in equity options (see *Figure_2.1*). This volatility skew is generally interpreted as a correction to the assumptions of the Black-Scholes model. It reflects the fact that many market participants are structurally long equity and hedge their positions using out-of-the-money (OTM) puts.

2.1.3 Greeks Computation

We calculated the Greeks using the Black-Scholes formulas, with implied volatility as the volatility input.

2.2 Volatility Strategy Design and Selection Criteria

Our goal is to profit from increased volatility without taking a directional view on NST. Accordingly, Strategies with high Vega and low Delta were preferred.[4]

The **long straddle** and the **long strangle** are the two most common strategies used in such scenarios. In both cases, the **maximum loss** is equal to the **sum of the premiums** paid for the options.

- **Long Straddle:**
  Buy ATM call and put with same strike and expiry. Loss equals total premiums paid; gain is unlimited with large moves. If price stays near strike, loss occurs.
- **Long Strangle:**
  Buy OTM call and put with different strikes. Requires a bigger move to profit, but costs less than a straddle. Wider strikes reduce cost but raise the required move.

Efficiency Metric: Cost per Vega

We used "Cost per Vega" metrics: absolute strategy cost divided by Vega exposure.

This metric quantifies how much volatility exposure is gained for every dollar invested see Table_2.1 and Table_2.2).

2.3 Strategy Results and Comparative Analysis

The June 18.01 strike represents the most effective straddle option. The June expiry provides the best combination of affordable premium costs and sufficient time value which makes it the preferred choice when expecting elevated volatility during the first half of the year.

The most efficient strangle option exists in the May expiry with 17.01 put and 19.01 call strikes.

- The strangle configuration produces lower costs than straddle alternatives which validates its effectiveness for volatility-based trading. The unlimited potential profit of this strangle remains theoretical while its breakeven range remains narrower than deeper OTM strangles because it offers lower costs at the expense of higher movement probability within the range.

See Figure_2.2 and Figure_2.3 for payoff diagrams.

4 *We sought strategies with: High Vega (to benefit from higher volatility) ; Low Delta (to minimize directional exposure)*

2.4 Comparison with Strategies and Possible Alternatives

The straddles provide higher Vega sensitivity, but they are more expensive. The selected strangle provides a more cost-effective volatility exposure, suitable for investors expecting a moderate, but sudden move in either direction, possibly triggered by commodity-related news or earnings releases.

Short butterfly spreads (reverse butterfly, long volatility) were also tested. However, under current market conditions, they produced negative payoffs and unattractive reward profiles, multiple commissions and narrow spreads made opening and closing these positions inefficient. (*see Table_2.3 and Figure_2.4*).[5]

3.1 Strategic Selection and Rationale

The investor's modestly bullish outlook on the S&P/ASX 200 calls for a strategy balancing directional exposure with prudent risk control. Among the various directional trading strategies suited for such conditions, the covered call and the bull spread emerge as the most coherent choices.

Covered Call:

It involves writing a call on stock already held or being acquired. OTM calls should be selected when the market view ranges from neutral to bullish. The maximum profit is equal to the difference between the strike price and the current stock price, plus the premium earned from the call. Downside is limited only by the premium buffer. Suited to moderate medium-term gains.

Note: Selected, given the current modestly bullish outlook and the absence of significant downside concerns.

Metrics in Table_3.1; Payoff in Figure_3.1.

Bull Spread (Call or Put):

The bull spread, is constructed using either calls or puts, involving the simultaneous purchase and sale of options with different strike prices. The spread is the distance between strike prices. In the case of a bull call spread, the maximum profit is the spread minus the net premium paid. For the bull

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[5] *Finally, we excluded also the iron condor because it has low Vega, high cost per Vega, and its payoff diagram clearly shows that even with significant price moves upward, the strategy does not generate sufficient profit compared to the better alternatives. (see Table_2.4 and Figure_2.5)*

put spread, the maximum profit is the net credit received upfront, the difference between the premium collected from the short put and the premium paid for the long put. The maximum loss corresponds to the spread minus the premium received. This strategy suits investors wanting bullish exposure without full downside risk. [6]

Metrics in [Table_3.2](), [Table_3.3](), [Table_3.4](), [Table_3.5]()

Payoff in [Figure_3.2](), [Figure_3.3](), [Figure_3.4](), [Figure_3.5]()

3.2 Comparative Analysis of Bullish Option Strategies

The bull call spread requires less capital than buying the asset outright, thereby reducing exposure, while the bull put spread involves no initial capital outlay and instead generates a net cash inflow, though it does imply contingent liabilities. The appeal of both strategies lies in their fixed risk-reward profiles, which allow for a controlled expression of directional views. Covered calls require more capital and offer limited downside protection, making the bull spread a more suitable and capital-efficient alternative.

See Figure_3.6, Figure_3.7, and Figure_3.8.

3.3 Results: Strategy Selection and Outcomes

Focusing solely on the covered call strategy, it becomes immediately apparent that the most attractive choice is the July expiry with the most OTM call. Premiums for July are higher due to time decay, favouring the writer.

However, for the reasons outlined above, it is more appropriate to shift focus toward bull spread strategies. To compare the alternatives, we introduced a parameter called the Profit and Loss Ratio, defined as the ratio between the maximum potential profit and the absolute value of the maximum potential loss.

Based on the Profit and Loss Ratio, the most effective bull call spread analysed involves May expiry with strikes at 7950 (long call) and 8050 (short call). This structure requires an upfront premium of 67, offers a maximum profit of 33, has a breakeven point at 8017, and exhibits a delta of 0.13. The resulting Profit and Loss Ratio is approximately 0.49. By comparison, the most favourable bull put spread uses May expiry with strikes at 7900 (short put) and 8050 (long put). It earns 47 upfront, with

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[6] *The collar was excluded as it's protective, not suited for this directional outlook.*

a max loss of 103, and sets a breakeven point at 8003, producing a Profit and Loss Ratio of 0.44. While the bull call spread provides a slightly higher return relative to its risk, the bull put spread offers distinct structural advantages. It requires no initial capital outlay, allowing the investor to enter the position with a positive cash inflow, and its breakeven level is more favourable, occurring earlier within the expected price range. Given the current modestly bullish outlook and the investor's preference for capital efficiency and early breakeven potential, the bull put spread with May expiry and strikes 7900/8050 is ultimately considered the more suitable and strategically efficient choice.

4.1 Option Pricing Using the Binomial Model

We use a 3-step binomial tree to price European and American options on NST. [7]

From these, we compute: *(Table_4.1)*

- Step size: $dt = \frac{T}{3}$
- Up/down factors: $u = e^{\sigma\sqrt{dt}}$, $d = \frac{1}{d}$
- Risk-neutral probability: $p = \frac{(R-d)}{(u-d)}$
- Discount factor per step: $R = (1+r)^{dt}$

4.1.1 Binomial Tree Construction:

Stock Price Tree: (*Figure_4.1*) (*Table_4.2*)

Each node at step i, node j of the tree corresponds to: $S_{i,j} = S_0 * u^j * d^{i-j}$

Option Payoffs at Maturity: (*Table_4.3*)

At the final time step (i=3), option payoffs are:

- European Call: $C_{3,j} = Max(0, S_{3,j} - K)$
- European/American Put: $P_{3,j} = Max(0, K - S_{3,j})$

Backward Induction: (*Table_4.4*) (*Figures_4.2*) (*Figures_4.3*) (*Figures_4.4*)

The value of the option at any earlier node (i,j) is computed recursively:

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[7] Inputs: S_0 = \$17.90, K = \$19.00, T = 0.312 years, σ = 28.73%, r = 4.0563% (annual).

- For European options: $V_{i,j} = \frac{p * V_{i+1,j+1} + (1-p)V_{i+1,j}}{R}$
- For American put: $V_{i,j} = \max\left(K - S_{i,j}\ ;\ \frac{p * V_{i+1,j+1} + (1-p)V_{i+1,j}}{R}\right)$

  At each node, choose the higher between intrinsic and continuation value.

4.1.2 Results

The model yields the following theoretical prices at $t = 0$. *Results in:Table_4.5*

4.2 Replicating Hedge Portfolio - Binomial Model

In this section, we explore two complementary approaches to constructing a replicating hedge portfolio for a European call option using the 3-step binomial model on NST.AX. Each method demonstrates how the risk-neutral pricing principle is maintained.

4.2.1 Method 1: Delta-Hedged Stock Portfolio (Δ×S − C) *(Table_4.6)*

This method interprets the hedge portfolio as the initial cost required to replicate a long call position. At each node, we:

- Compute Δ (the hedge ratio)
- Multiply by the current stock price: Δ×S
- Subtract the call value to find the net investment: Δ×S - C

Risk-Neutral Pricing Check (Δ×S − C)

- Initial hedge portfolio value (V_0): 6.2244
  - Portfolio value after one step if UP: 10.9636
  - Portfolio value after one step if DOWN: 1.5522
- Risk-neutral probability (p): 0.4990
- Risk-free growth factor (R): 1.0040
- Expected value (risk-neutral): 6.2485
- Grown value ($V_0 \times R$): 6.2493

The replicating portfolio exhibits growth consistent with the risk-free rate, confirming its value matches the options under the risk-neutral measure. This validates the no-arbitrage condition and core pricing principles.

4.2.2 Method 2: Delta + Risk-Free Asset (Δ×S + B) *(Table 4.7)*

In this approach, we replicate the option payoff using a portfolio of:

- Δ shares
- B risk-free asset

$$B = \frac{(u \cdot C_d) - (d \cdot C_u)}{\left((u - d) \cdot R\right)}$$

At each node:

- Compute Δ and B
- Portfolio value = Δ×S + B

Risk-Neutral Pricing Check (Δ×S + B)

- Initial portfolio value (V_0): 0.8061
  - Portfolio value after one step if UP: 1.4632
  - Portfolio value after one step if DOWN: 0.1578
- Risk-neutral probability (p): 0.4992
- Risk-free growth factor (R): 1.0040
- Expected value (risk-neutral): 0.8094
- Grown value ($V_0 \times R$): 0.8093

The results confirm that the hedge portfolio, under the risk-neutral measure, grows at the risk-free rate and accurately replicates the option's value, ensuring consistency with no-arbitrage pricing principles.

Both hedging approaches demonstrate consistency with the risk-neutral valuation framework and confirm the absence of arbitrage in the binomial pricing setup.

- The Δ×S − C method offers a trader-oriented perspective by quantifying the upfront net cost to replicate the option payoff, making it practical for interpreting real trading positions.
- The Δ×S + B approach. It is more suitable for illustrating the completeness of the market and validating the theoretical underpinnings of no-arbitrage pricing.

Both methods yield the same value; one aids trading intuition, the other supports theoretical rigor.

4.3 Comparison of Black-Scholes-Merton and Binomial Models

4.3.1 Black-Scholes-Merton (BSM) Model:

BSM offers a closed-form solution for European options, assuming lognormal prices, constant volatility/rates, and no dividends. The pricing formula are:

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right)+\left(r+\frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \; ; d_2 = d_1 - \sigma\sqrt{T}$$

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

$$P = Ke^{-rT}N(-d_2) - S_0 N(-d_1)$$

where N(x) is the cumulative normal distribution function.

4.3.2 Binomial Model (3-Step Tree)

The binomial approach discretizes the time to maturity into three steps, building a tree of possible asset prices with each period allowing for an up or down movement. It discounts path payoffs using risk-neutral probabilities

- The binomial model can **price both European and American options**.
- It easily incorporates **early exercise** and **discrete dividends**.
- As the number of steps increases, the model converges to the BSM value by the Central Limit Theorem.

Comparison table: *Table_4.8*

4.4 Discussion: Model Strengths and Practical Implications

The binomial model and the Black-Scholes-Merton (BSM) model are widely used tools for option pricing, but they differ substantially in assumptions, computational methods, and flexibility**.**

The binomial model is a discrete-time framework that builds a tree of possible future asset prices, assuming the price can move up or down in each period. It is particularly versatile: it can price both European and American options, and it naturally incorporates early exercise features by comparing the intrinsic value and continuation value at each node. It also accommodates dividends by adjusting the stock price path or incorporating discrete cash flows. The model becomes more accurate as the number of time steps increases, ultimately converging to the BSM value.

The Black-Scholes model, in contrast, assumes continuous time, constant volatility and interest rates, no dividends, and assumes European-style options. It provides a closed-form solution, which is computationally efficient but less flexible. The model is not directly applicable to American options or those with discrete dividends unless modified.

In terms of volatility, both models show that option prices increase as volatility rises. In the BSM model, volatility directly increases the value due to the convexity of payoffs. In the binomial model, higher volatility increases the distance between up and down movements, broadening the price tree and leading to higher option values. In short, BSM is faster, but binomial suits complex or early-exercise cases.

Table of contents, tables, charts and graphs*:*

Figure 1.1: Liquidity Analysis - Volume Histogram

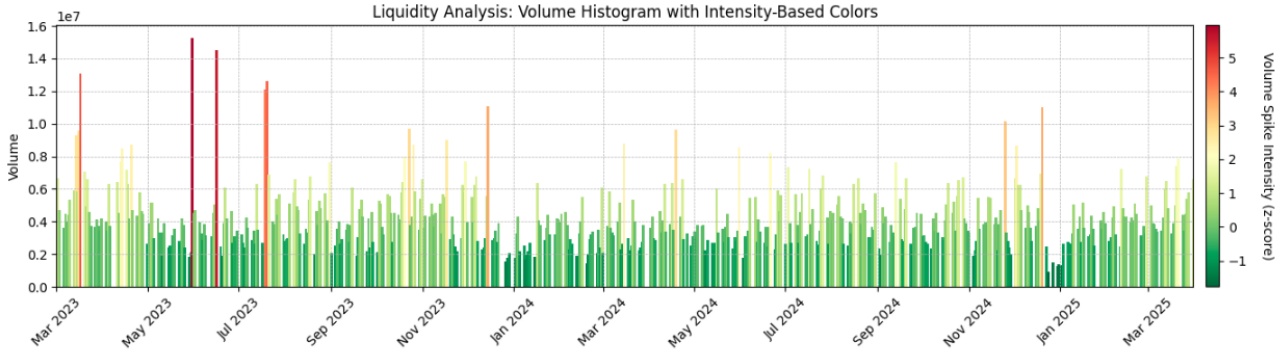

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Figure 1.2: Event Sensitivity Study - Price and Volume Spikes

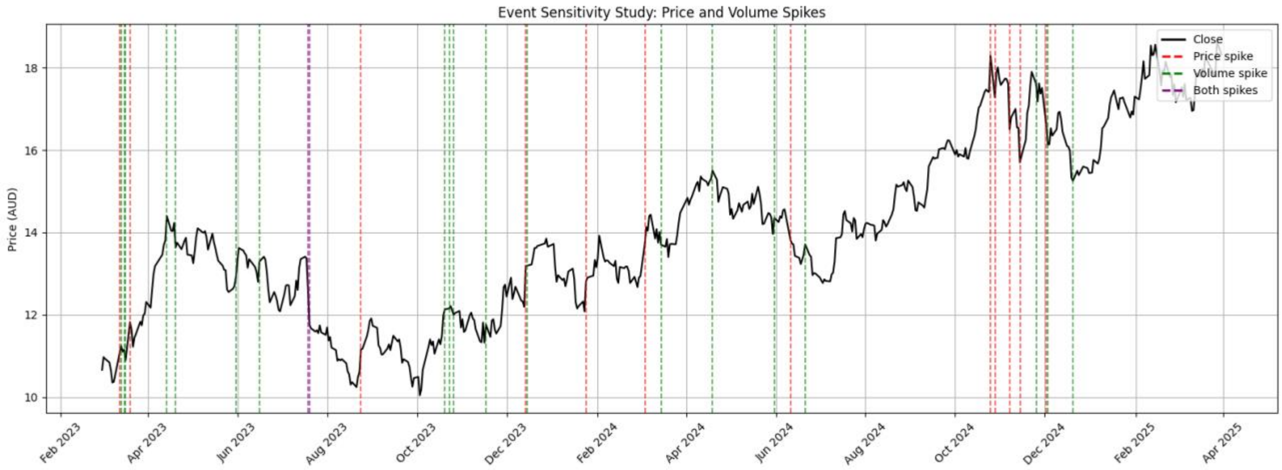

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Figure 1.3: NST.AX - 30-Day Rolling Volatility (2024-2025)

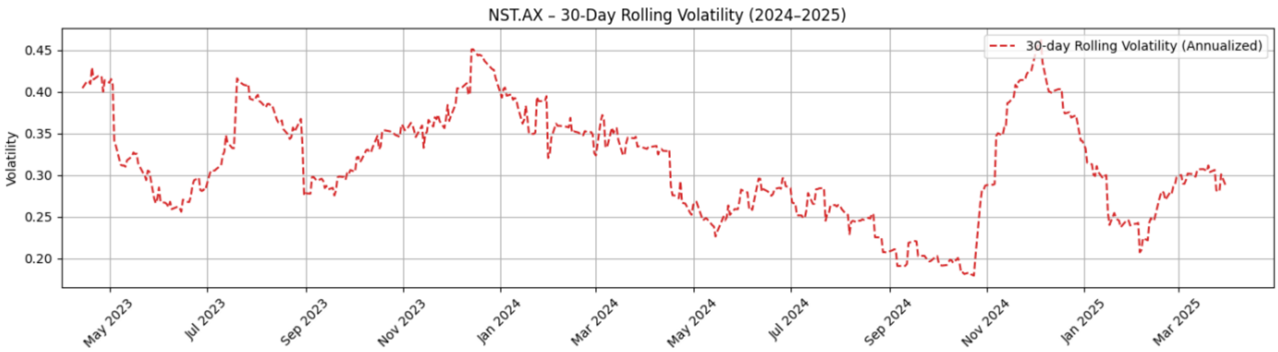

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Figure 1.4: Cumulative Return Comparison - NST vs Peers and Benchmark

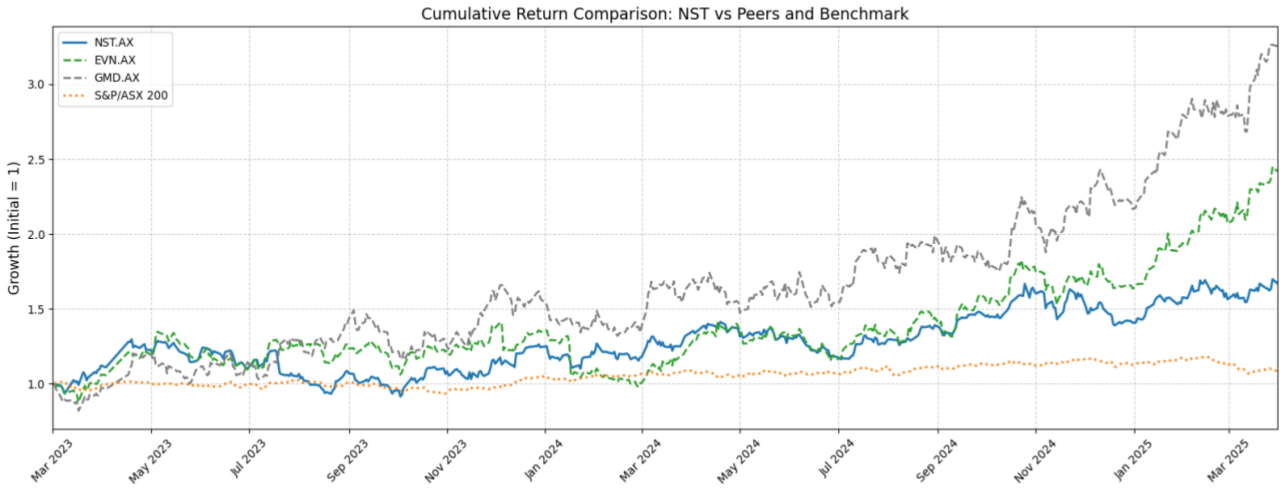

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Figure 1.5: NST vs EVN - Over/Underperformance

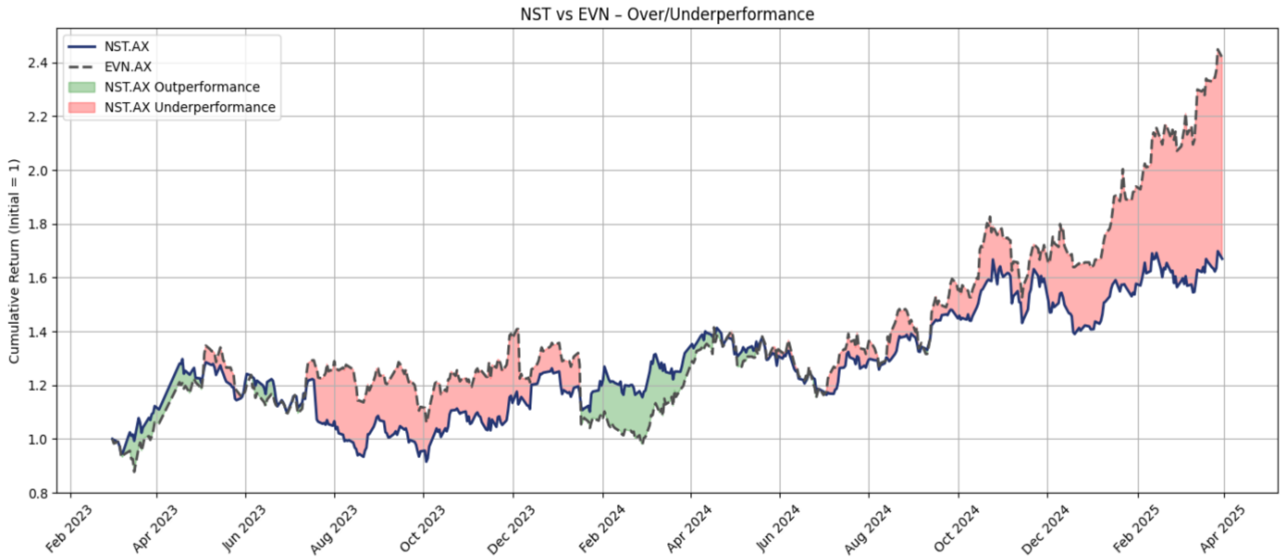

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Figure 1.6: NST vs GMD - Over/Underperformance

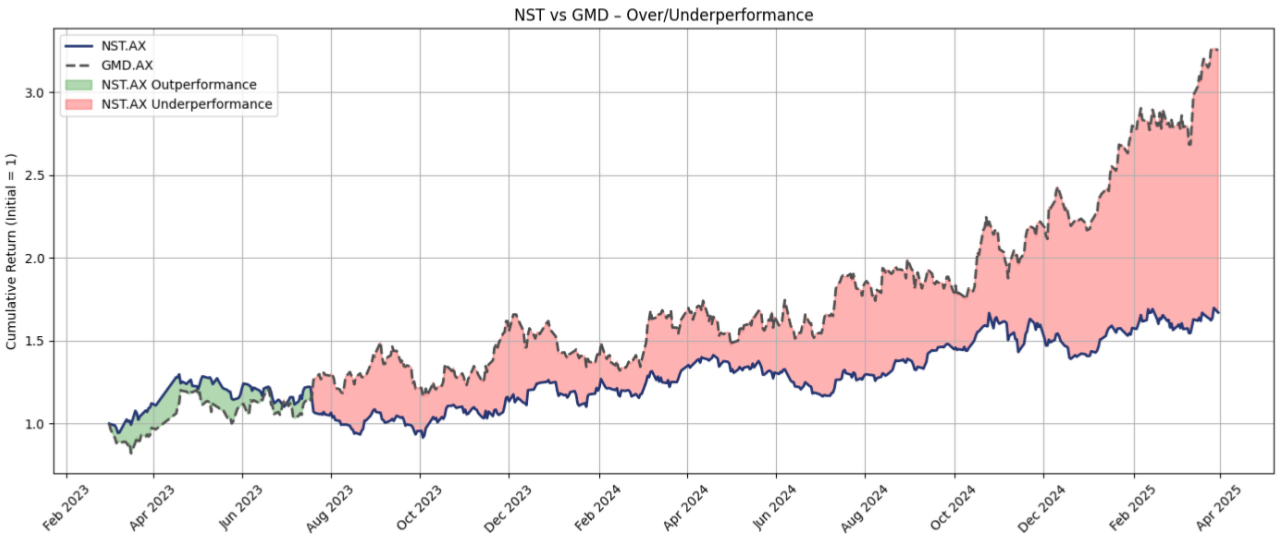

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Figure 1.7: NST vs S&P/ASX 200 - Over/Underperformance

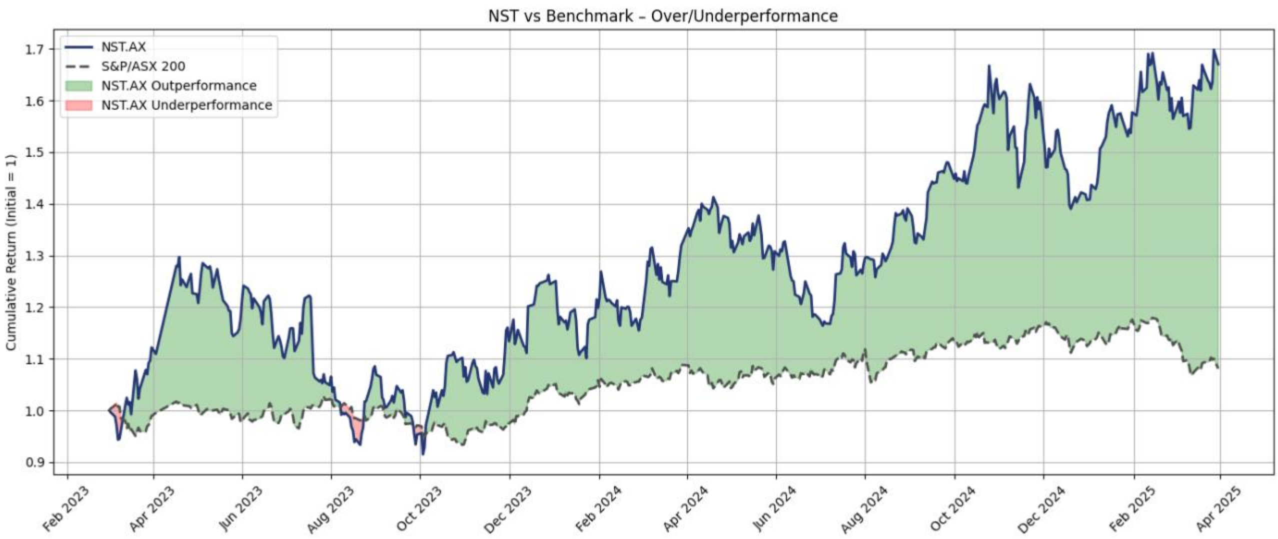

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Figure 1.8: NST.AX - ESG Events: Price Change from t to t+3 (Directional Bands). The chart displays the immediate price reaction to major ESG announcements, with each event window color-coded by ESG pillar.

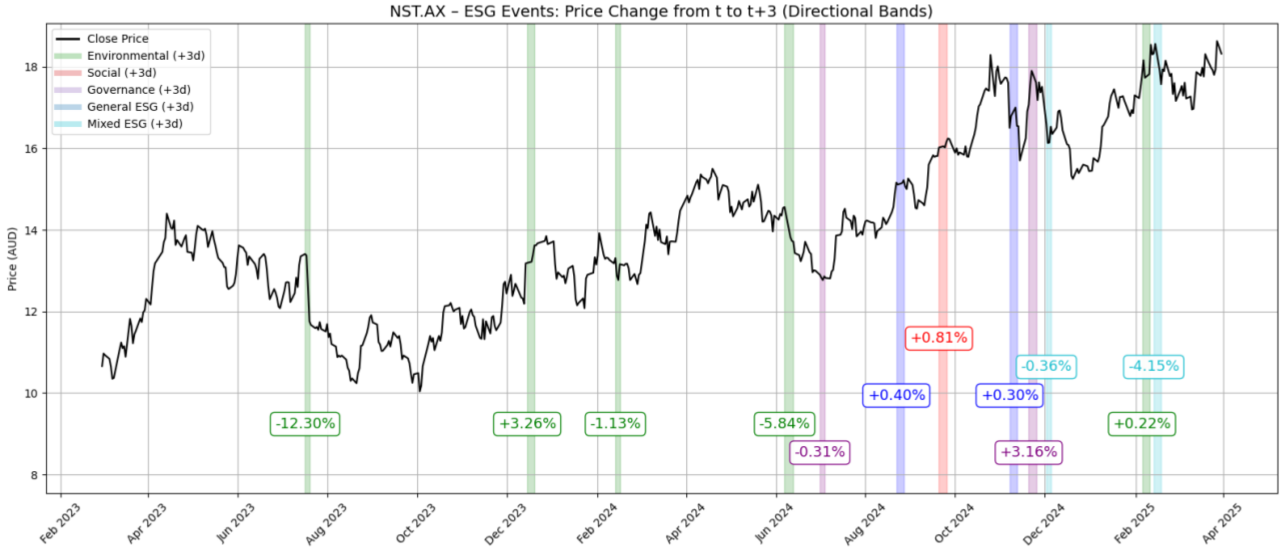

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Figure 1.9: NST.AX - ESG Events with Confirmed Spikes (t → t+3). Only ESG announcements that led to statistically significant price or volume spikes are shown, highlighting the direct market impact of key sustainability disclosures.

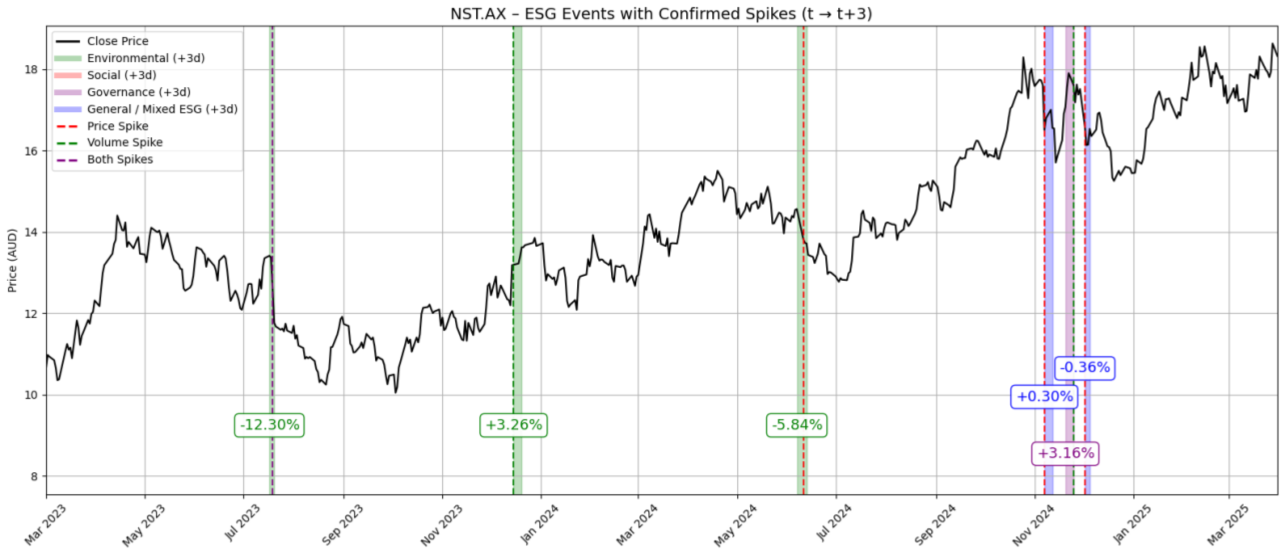

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Table 1.1: ESG Environmental Events - Market Reactions and Spikes

Date	Initiative	Δ Price (t → t+3)	Spike Type
17/07/2023	Announced East Wall remediation at KCGM (enabling Golden Pike access)	–12.30 %	Both spikes
15/12/2023	Published FY23 “Resource Use” improvements: >80 % environmental-sourcing scores	3.26%	Volume spike
13/02/2024	Released Scope 1–3 emissions data under SFDR (no material change)	– 1.13 %	-
07/06/2024	Funded Pogo solar–wind hybrid power at Thunderbox	– 5.84 %	Price spike
05/02/2025	Upgrade water-recycling targets (24.6 %) in SFDR report	0.22%	None

Table 1.2: ESG Social Events - Market Reactions and Spikes

Date	Initiative	Δ Price (t → t+3)	Spike Type
22/08/2024	Disclosure of new “Diversity & Opportunity” targets (86.9 %)	0.004	-
20/09/2024	Published enhanced whistleblower-protection and health-&-safety policies	0.81%	-

*Table 1.3**:** ESG Governance & Mixed Events - Market Reactions and Spikes*

Date	Initiative	Δ Price (t → t+3)	Spike Type
07/06/2024	Updated Board-tenure & non-audit/audit fee policies (93 % score)	– 0.31 %	-
07/11/2024	Announced enhanced ESG-linked executive-compensation framework	0.30%	Price spike
20/11/2024	Published new “Whistleblower” & “Supply-chain” compliance metrics	0.0316	Volume spike
02/12/2024	Released first “Mixed ESG” climate & community-engagement report	– 0.36 %	Price spike

Figure 2.1: Implied Volatility skew for NST.AX Options (Calls and Puts, All Expiries)

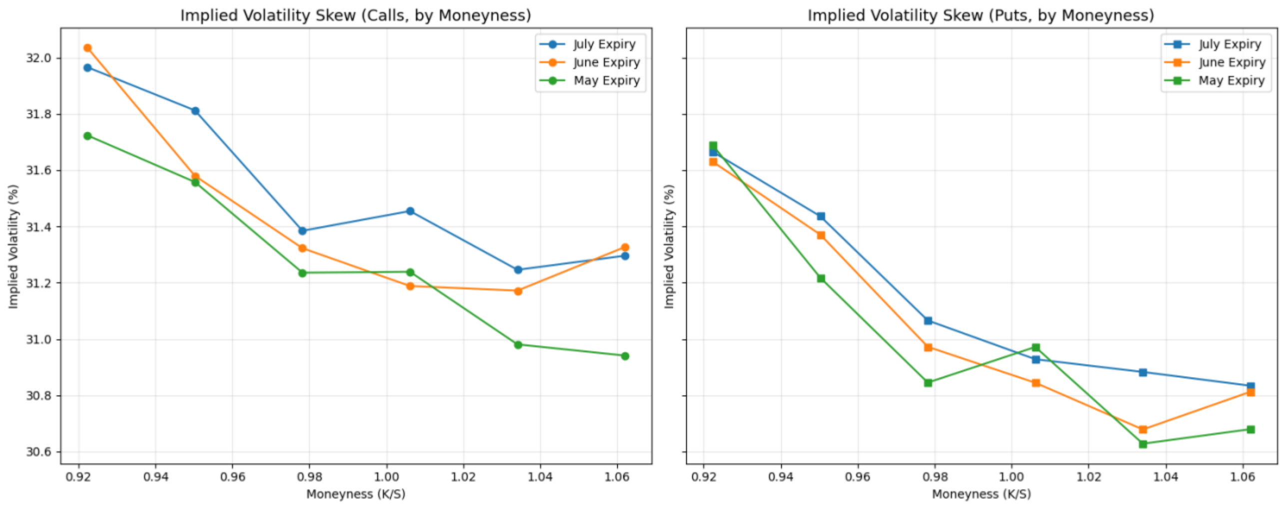

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Table 2.1: Long Straddle Strategy Metrics (Top 5 by Cost per Vega)

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Cost per Vega
Straddle	June	18.01	-2.270000	Unlimited	2.270000	(15.74, 20.28)	0.080000	0.290000	0.070000	-0.010000	32.90
Straddle	July	18.01	-2.640000	Unlimited	2.640000	(15.37, 20.65)	0.100000	0.250000	0.080000	-0.010000	33.34
Straddle	May	18.01	-1.780000	Unlimited	1.780000	(16.23, 19.79)	0.040000	0.380000	0.050000	-0.020000	33.39
Straddle	July	18.51	-2.680000	Unlimited	2.680000	(15.83, 21.19)	-0.030000	0.260000	0.080000	-0.010000	33.59
Straddle	June	18.51	-2.330000	Unlimited	2.330000	(16.18, 20.84)	-0.070000	0.300000	0.070000	-0.010000	33.73

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Table 2.2: Long Strangle Strategy Metrics (Top 5 by Cost per Vega)

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Cost per Vega
Strangle	May	(16.51, 19.01)	-0.790000	Unlimited	0.790000	(15.72, 19.80)	0.130000	0.310000	0.040000	-0.010000	17.93
Strangle	May	(17.01, 19.01)	-0.930000	Unlimited	0.930000	(16.08, 19.94)	0.050000	0.340000	0.050000	-0.010000	19.57
Strangle	June	(16.51, 19.01)	-1.270000	Unlimited	1.270000	(15.24, 20.28)	0.150000	0.260000	0.060000	-0.010000	20.71
Strangle	May	(16.51, 18.51)	-0.980000	Unlimited	0.980000	(15.53, 19.49)	0.210000	0.330000	0.050000	-0.010000	21.40
Strangle	July	(16.51, 19.01)	-1.590000	Unlimited	1.590000	(14.92, 20.60)	0.160000	0.230000	0.070000	-0.010000	22.02

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Figure 2.2: Payoff of Top 3 Long Straddle Strategies (lowest Cost per Vega)

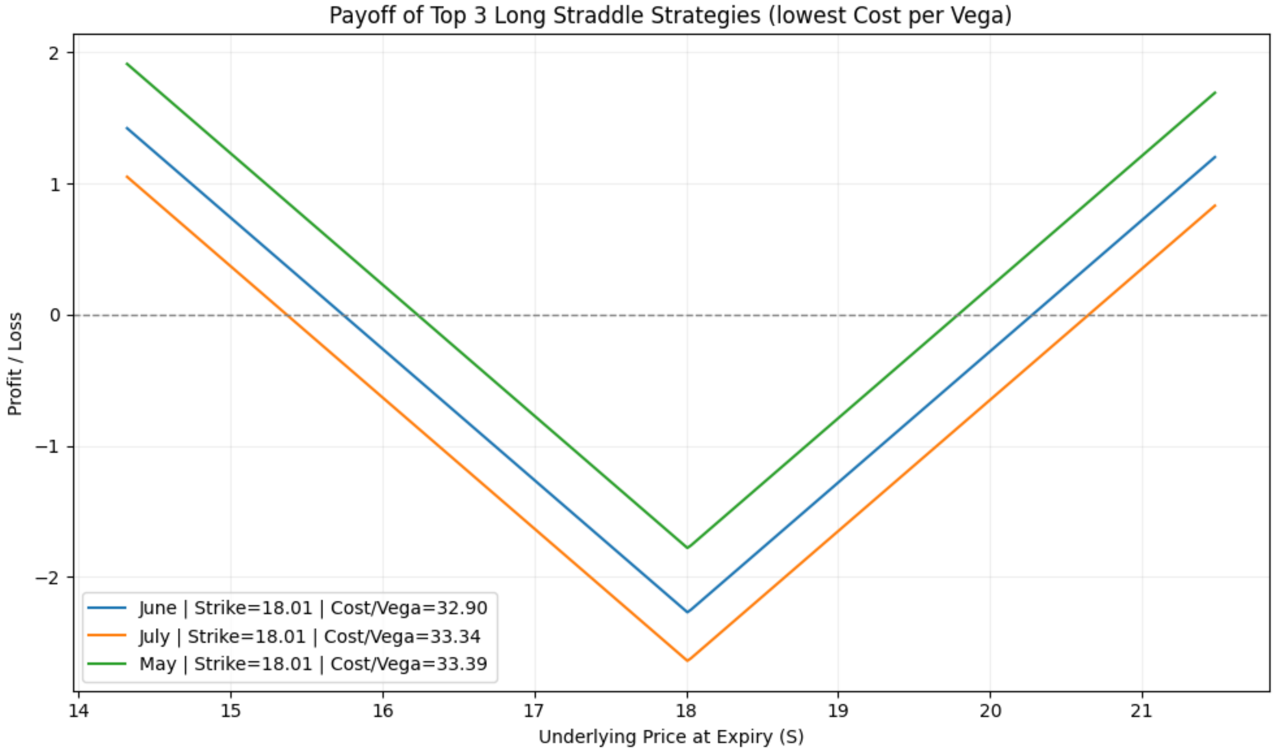

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Figure 2.3: Payoff of Top 3 Long Strangle Strategies (lowest Cost per Vega)

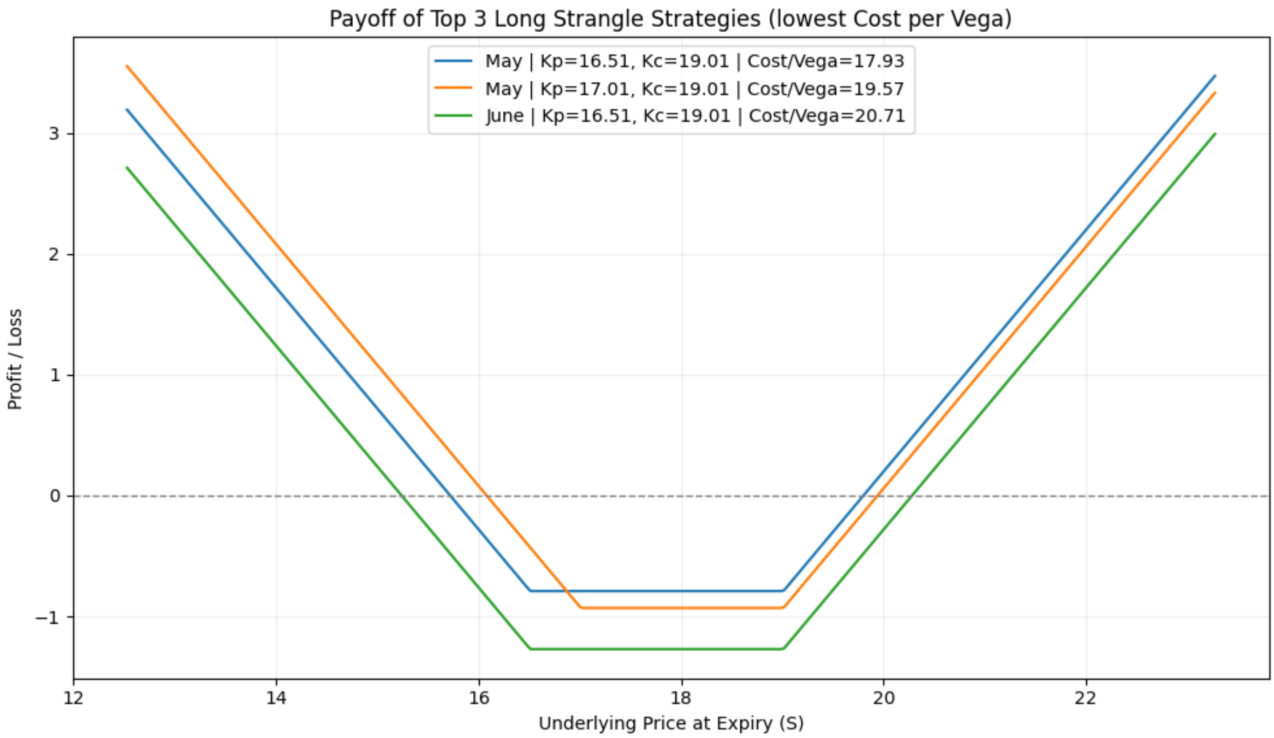

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Table 2.3: Top 3 Short Butterfly (Reverse Butterfly) Strategies - Key Metrics

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Cost per Vega
Short Butterfly	May	17.01, 18.01, 19.01	-0.030000	-0.970000	0.030000	(17.04, 18.98)	-0.000000	0.050000	0.010000	-0.000000	4.80
Short Butterfly	May	16.51, 17.51, 18.51	-0.050000	-0.950000	0.050000	(16.56, 18.46)	0.020000	0.040000	0.010000	-0.000000	8.48
Short Butterfly	June	17.01, 18.01, 19.01	-0.090000	-0.910000	0.090000	(17.10, 18.92)	-0.000000	0.020000	0.000000	-0.000000	18.27
Short Butterfly	June	16.51, 17.51, 18.51	-0.110000	-0.890000	0.110000	(16.62, 18.40)	0.010000	0.020000	0.000000	-0.000000	23.11
Short Butterfly	July	17.01, 18.01, 19.01	-0.210000	-0.790000	0.210000	(17.22, 18.80)	-0.000000	0.010000	0.000000	-0.000000	48.76

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Figure 2.4: Payoff of Top 3 Short Butterfly (Reverse Butterfly) Strategies (optional/Appendix)

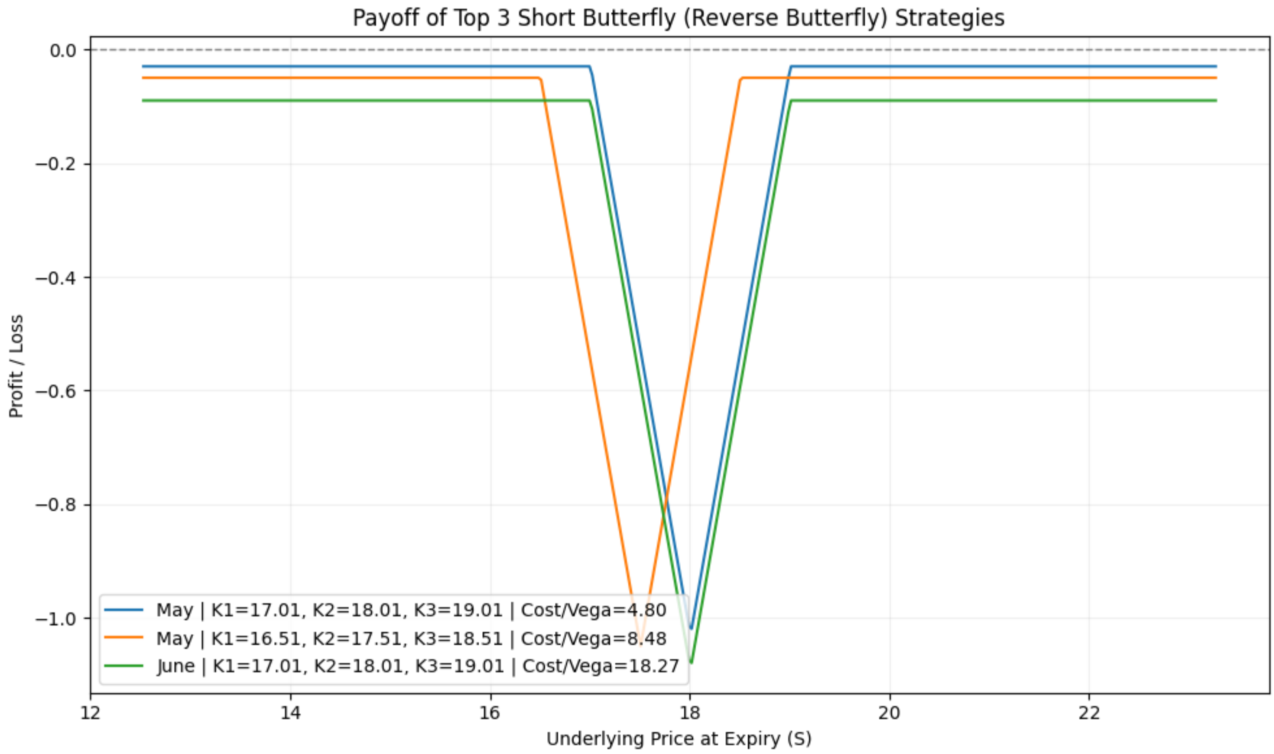

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Table 2.4: Top 3 Reverse Iron Condor (Long Volatility) Strategies - Key Metrics

	Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Cost per Vega
0	Reverse Iron Condor	May	16.51, 17.51, 18.51, 19.01	-0.660000	0.340000	-0.160000	(15.85, 19.67)	-0.080000	0.060000	0.010000	-0.000000	85.32
1	Reverse Iron Condor	May	16.51, 17.01, 18.51, 19.01	-0.480000	0.020000	0.020000	(16.03, 19.49)	0.010000	0.040000	0.010000	-0.000000	91.95
2	Reverse Iron Condor	May	16.51, 18.01, 18.51, 19.01	-0.910000	0.590000	-0.410000	(15.60, 19.92)	-0.180000	0.070000	0.010000	-0.000000	102.73
3	Reverse Iron Condor	May	16.51, 17.51, 18.01, 19.01	-0.890000	0.110000	0.110000	(15.62, 19.90)	0.010000	0.060000	0.010000	-0.000000	109.42
4	Reverse Iron Condor	May	16.51, 17.51, 18.01, 18.51	-0.740000	0.260000	-0.240000	(15.77, 19.25)	-0.070000	0.050000	0.010000	-0.000000	115.78

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Figure 2.5: Payoff of Top 3 Reverse Iron Condor (Long Volatility) Strategies (optional/Appendix)

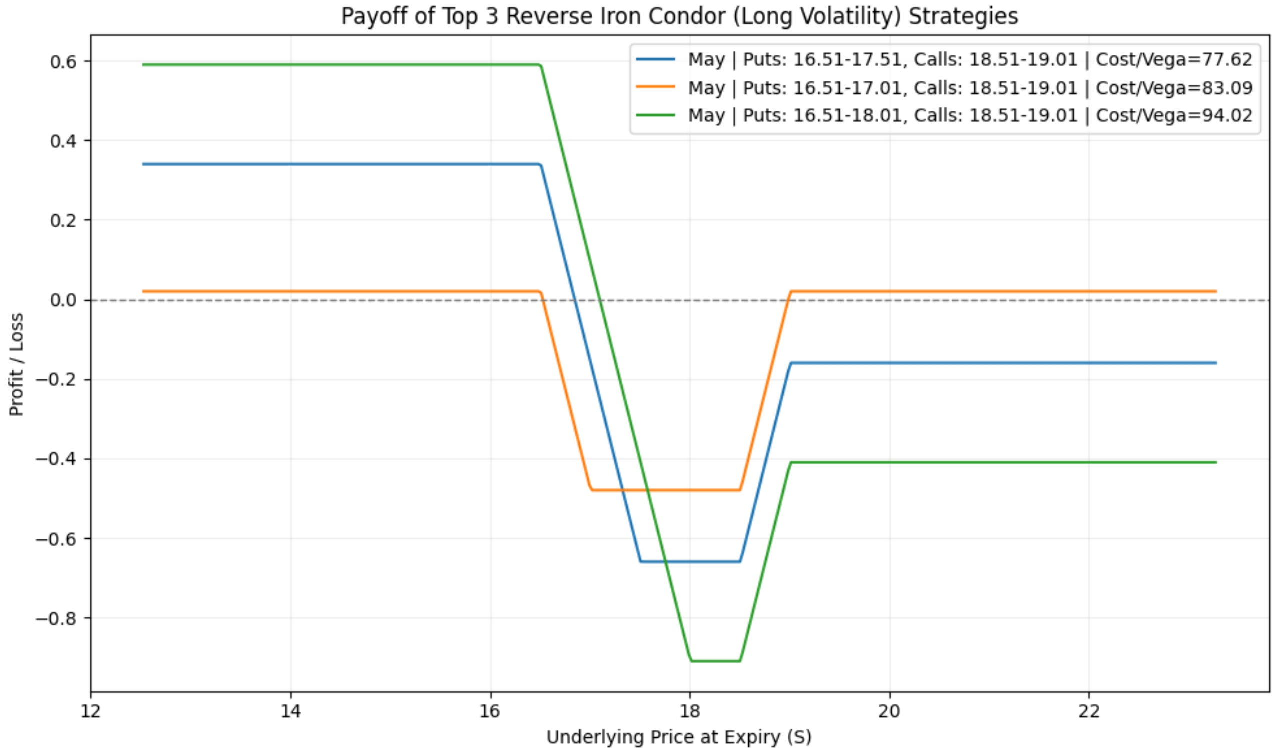

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Table 3.1: Top 5 Covered Call Strategies on S&P/ASX 200 (Ranked by Profit/Loss Ratio)

Strategy	Expiry	Strike	Call_Bid (Sell)	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Profit/Loss Ratio
Covered Call	July	8050	202.000000	-7779.900000	270.100000	7779.900000	7779.900000	0.459594	-0.000821	-17.704641	1.302182	0.03
Covered Call	July	8025	216.000000	-7765.900000	259.100000	7765.900000	7765.900000	0.439456	-0.000812	-17.590668	1.317652	0.03
Covered Call	July	8000	231.000000	-7750.900000	249.100000	7750.900000	7750.900000	0.419911	-0.000796	-17.436174	1.334868	0.03
Covered Call	July	7975	247.000000	-7734.900000	240.100000	7734.900000	7734.900000	0.400723	-0.000781	-17.242089	1.347681	0.03
Covered Call	June	8050	164.000000	-7817.900000	232.100000	7817.900000	7817.900000	0.480701	-0.000961	-15.438695	1.407171	0.03

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Figure 3.1: Payoff of Best Covered Call per Expiry

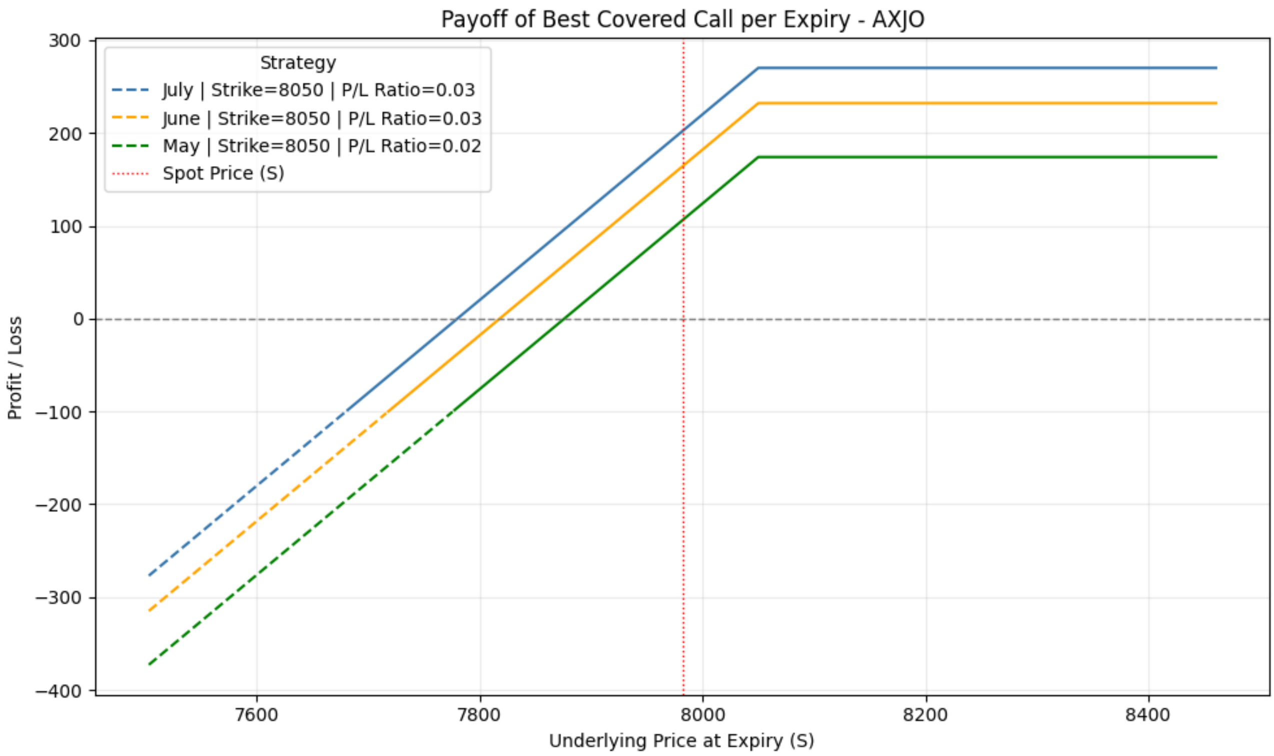

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Table 3.2: Top 5 Bull Call Spread Strategies on S&P/ASX 200 (Ranked by Profit/Loss Ratio)

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Profit/Loss Ratio
Bull Call Spread	May	(7950.00, 8050.00)	-67.000000	33.000000	67.000000	8017.000000	0.130000	-0.000000	-0.400000	-0.110000	0.49
Bull Call Spread	May	(7925.00, 8050.00)	-84.000000	41.000000	84.000000	8009.000000	0.160000	-0.000000	-0.670000	-0.120000	0.49
Bull Call Spread	May	(7900.00, 8050.00)	-103.000000	47.000000	103.000000	8003.000000	0.180000	-0.000000	-0.980000	-0.120000	0.46
Bull Call Spread	May	(7975.00, 8050.00)	-52.000000	23.000000	52.000000	8027.000000	0.100000	-0.000000	-0.190000	-0.100000	0.44
Bull Call Spread	May	(7925.00, 8025.00)	-71.000000	29.000000	71.000000	7996.000000	0.120000	-0.000000	-0.680000	-0.080000	0.41

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Table 3.4: Best Bull Call Spread by Expiry (May, June, July)

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Profit/Loss Ratio
Bull Call Spread	May	(7950, 8050)	-67.000000	33.000000	67.000000	8017.000000	0.130000	-0.000000	-0.400000	-0.110000	0.49
Bull Call Spread	June	(7925, 8050)	-91.000000	34.000000	91.000000	8016.000000	0.110000	-0.000000	-0.830000	-0.080000	0.37
Bull Call Spread	July	(7925, 8050)	-99.000000	26.000000	99.000000	8024.000000	0.100000	-0.000000	-0.960000	-0.060000	0.26

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Figure 3.2: Payoff of Top 3 Bull Call Spreads (Highest Profit/Loss Ratio) - AXJO

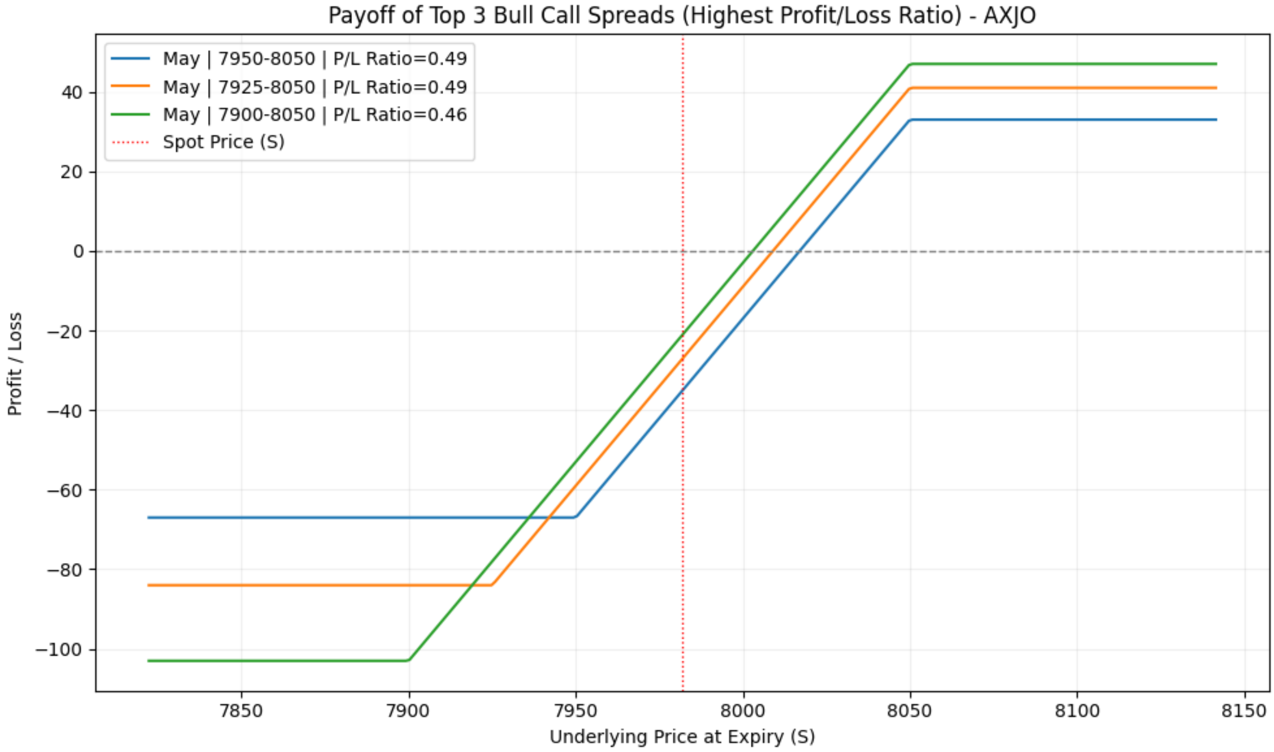

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Figure 3.4: Payoff of Best Bull Call Spread for Each Expiry (AXJO)

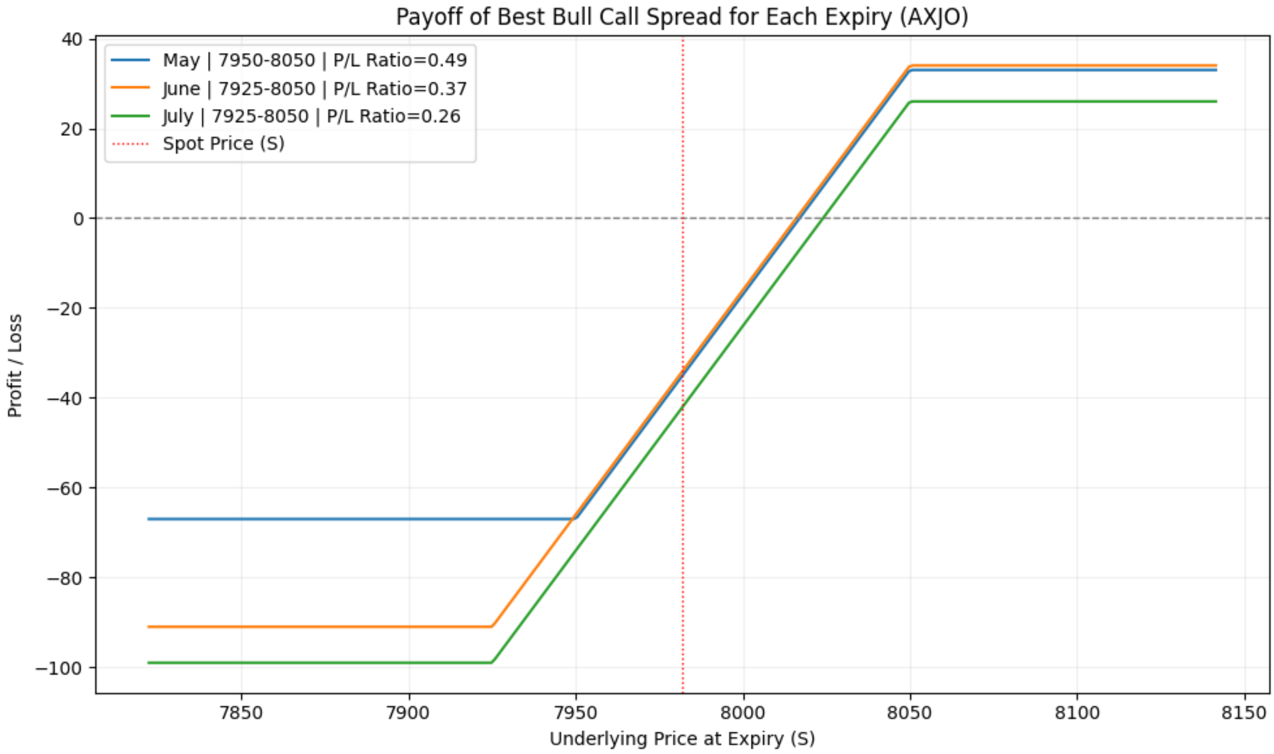

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Table 3.3: Top 5 Bull Put Spread Strategies on S&P/ASX 200 (Ranked by Profit/Loss Ratio)

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Profit/Loss Ratio
Bull Put Spread	May	(7900, 8050)	47.000000	47.000000	103.000000	8003.000000	0.150000	-0.000000	-0.720000	-0.150000	0.46
Bull Put Spread	May	(7925, 8050)	39.000000	39.000000	86.000000	8011.000000	0.130000	-0.000000	-0.490000	-0.140000	0.45
Bull Put Spread	May	(7950, 8050)	31.000000	31.000000	69.000000	8019.000000	0.110000	-0.000000	-0.300000	-0.120000	0.45
Bull Put Spread	May	(7975, 8050)	22.000000	22.000000	53.000000	8028.000000	0.080000	-0.000000	-0.150000	-0.100000	0.42
Bull Put Spread	May	(7900, 8025)	35.000000	35.000000	90.000000	7990.000000	0.130000	-0.000000	-0.730000	-0.120000	0.39

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Table 3.5: Best Bull Put Spread by Expiry (May, June, July)

Strategy	Expiry	Strikes	Entry	Max Profit	Max Loss	Break Even	Delta	Gamma	Vega	Theta	Profit/Loss Ratio
Bull Put Spread	May	(7900, 8050)	47.000000	47.000000	103.000000	8003.000000	0.150000	-0.000000	-0.720000	-0.150000	0.46
Bull Put Spread	June	(7900, 8050)	40.000000	40.000000	110.000000	8010.000000	0.110000	-0.000000	-0.850000	-0.110000	0.36
Bull Put Spread	July	(7900, 8050)	39.000000	39.000000	111.000000	8011.000000	0.090000	-0.000000	-0.910000	-0.090000	0.35

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Figure 3.3: Payoff of Top 3 Bull Put Spreads (Highest Profit/Loss Ratio) - AXJO

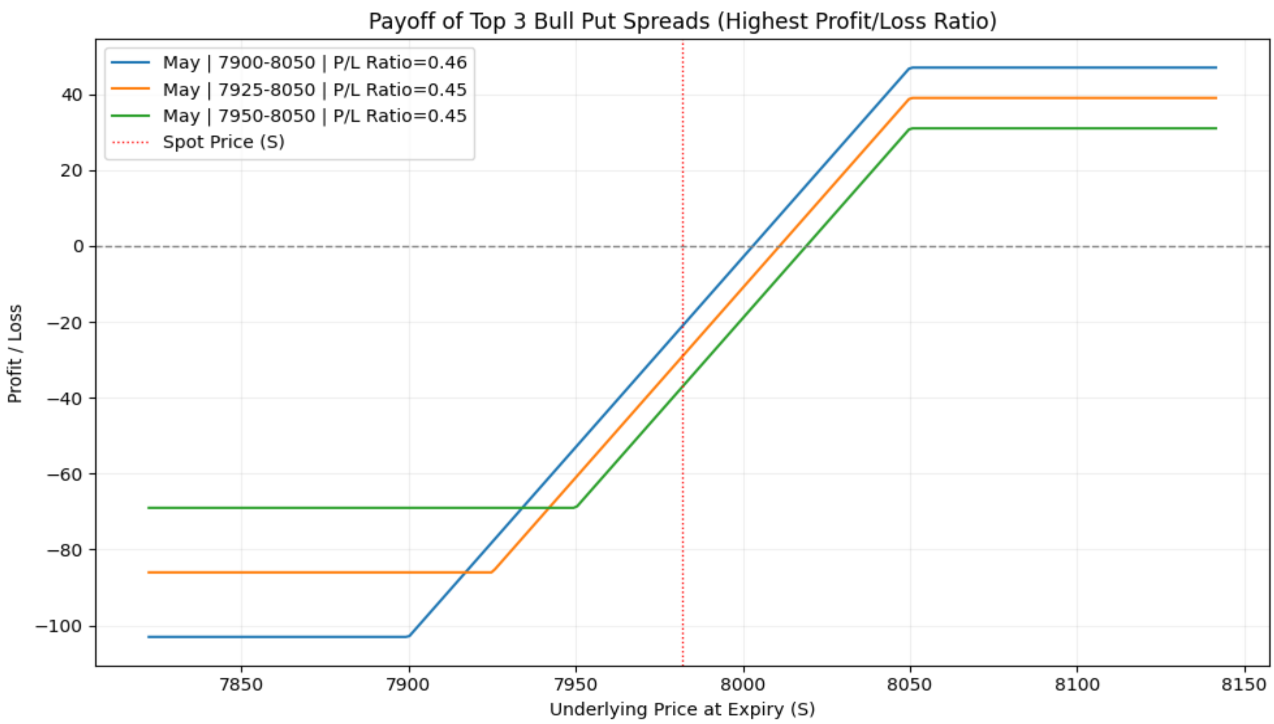

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Figure 3.5: Payoff of Best Bull Put Spread for Each Expiry (AXJO)

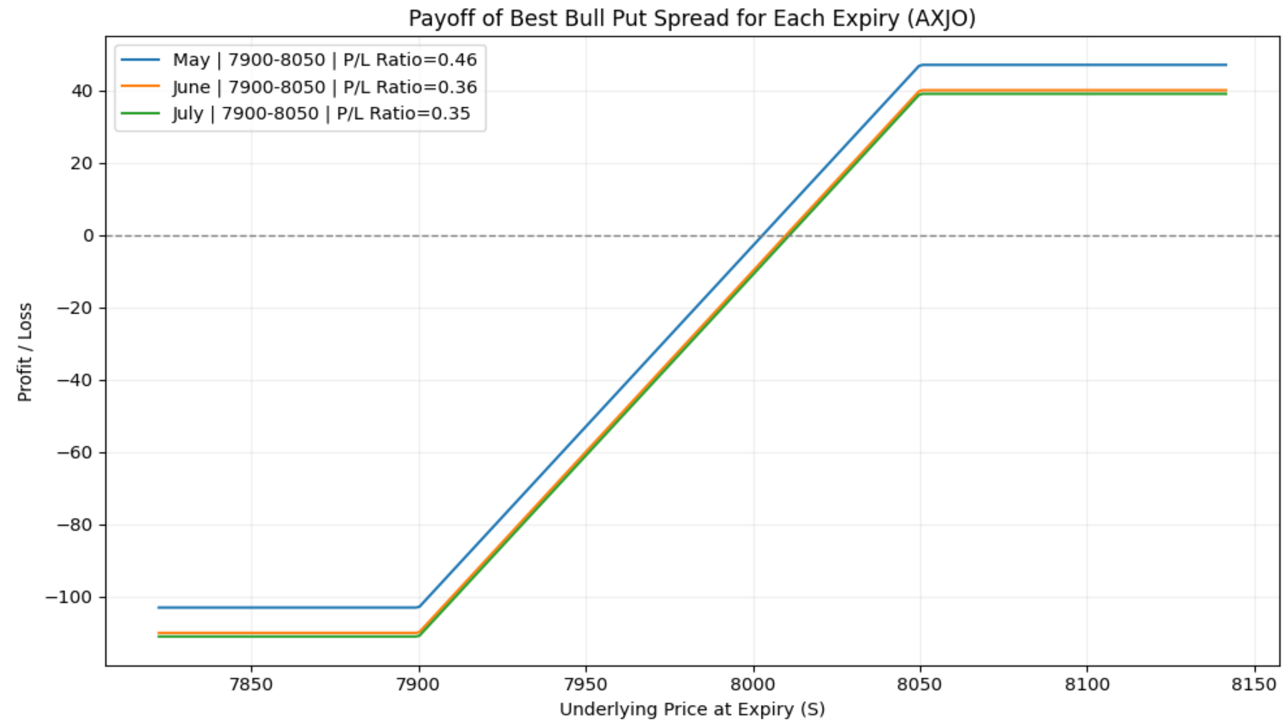

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Figure 3.6: Payoff Comparison of Best Strategies — May Expiry

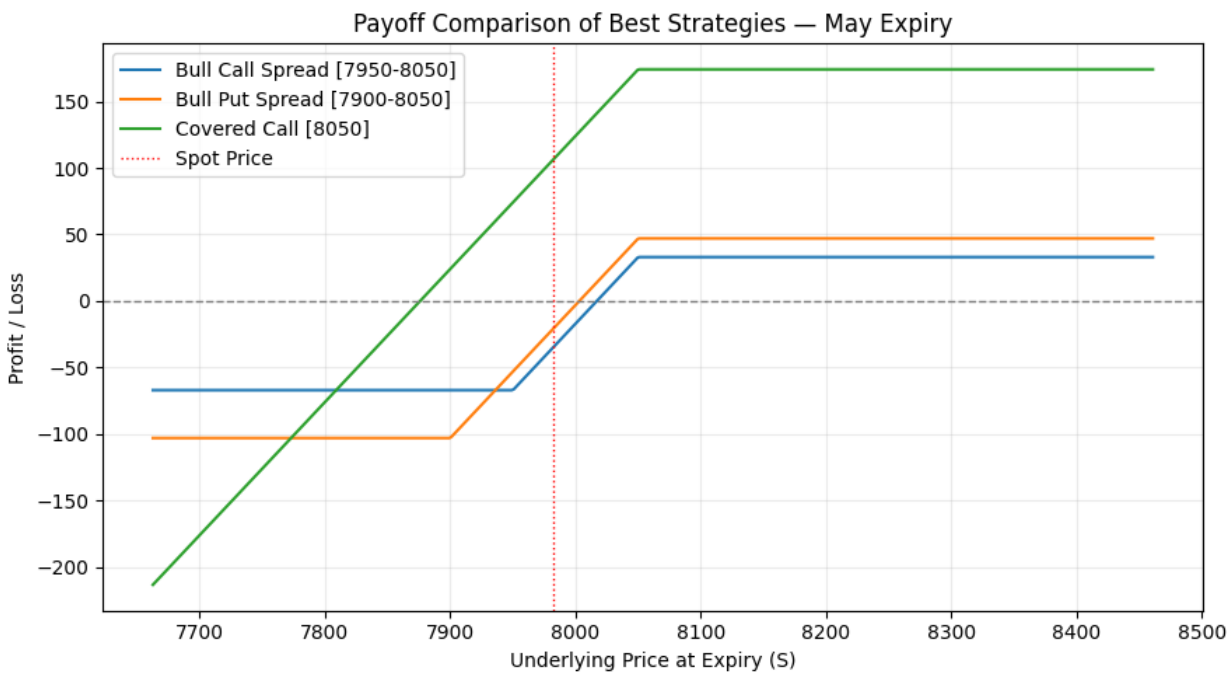

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Figure 3.7: Payoff Comparison of Best Strategies — June Expiry

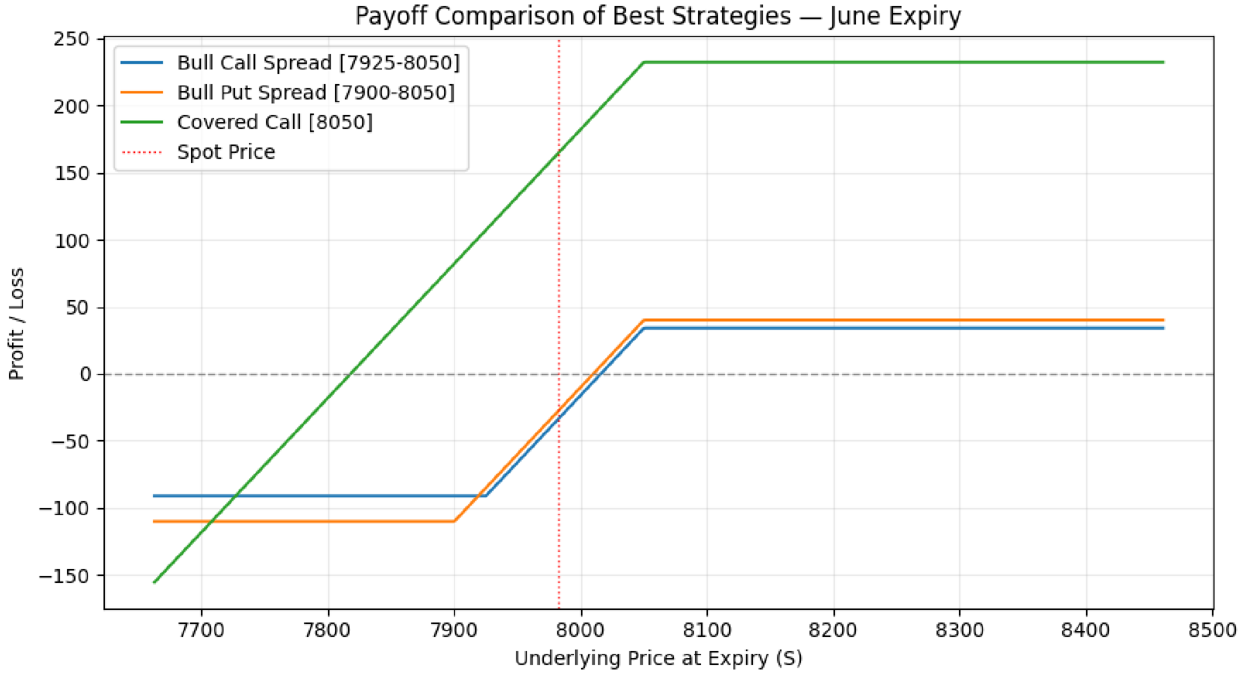

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Figure 3.8: Payoff Comparison of Best Strategies — July Expiry

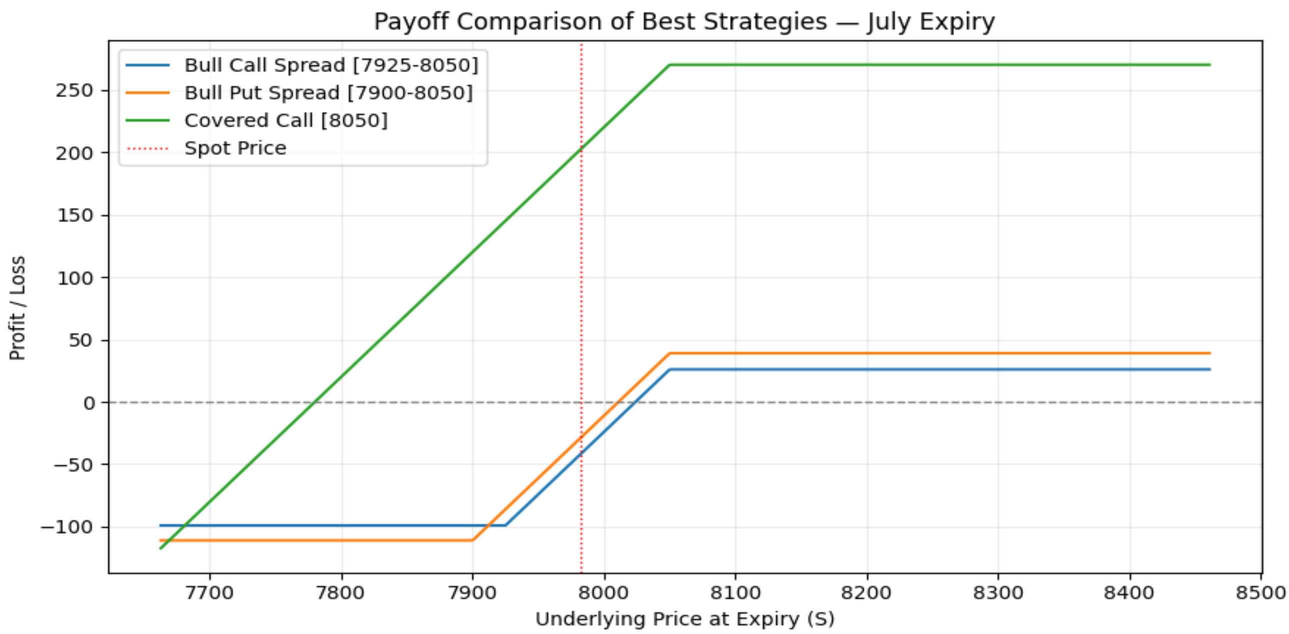

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Table 4.1: Binomial Model Parameters

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Binomial Model Parameters:
  Time step (dt): 0.10411
  Up factor (u): 1.09713
  Down factor (d): 0.91147
  Per-period risk-free factor (R): 1.00415
  Risk-neutral probability (p): 0.49918

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Table 4.2: Stock Price Tree Node Values

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Stock Price Tree (node values):
  Step 0, Node 0: 17.900 * (1.0971^0) * (0.9115^0) = 17.9000
  Step 1, Node 0: 17.900 * (1.0971^0) * (0.9115^1) = 16.3153
  Step 1, Node 1: 17.900 * (1.0971^1) * (0.9115^0) = 19.6387
  Step 2, Node 0: 17.900 * (1.0971^0) * (0.9115^2) = 14.8708
  Step 2, Node 1: 17.900 * (1.0971^1) * (0.9115^1) = 17.9000
  Step 2, Node 2: 17.900 * (1.0971^2) * (0.9115^0) = 21.5462
  Step 3, Node 0: 17.900 * (1.0971^0) * (0.9115^3) = 13.5542
  Step 3, Node 1: 17.900 * (1.0971^1) * (0.9115^2) = 16.3153
  Step 3, Node 2: 17.900 * (1.0971^2) * (0.9115^1) = 19.6387
  Step 3, Node 3: 17.900 * (1.0971^3) * (0.9115^0) = 23.6391

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Table 4.3: Option Payoff at Maturity

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Option Payoff at Final Step (Maturity):
  Call Payoff: max(0, 13.5542 - 19.0) = 0.0000
  Put Payoff:  max(0, 19.0 - 13.5542) = 5.4458
  Call Payoff: max(0, 16.3153 - 19.0) = 0.0000
  Put Payoff:  max(0, 19.0 - 16.3153) = 2.6847
  Call Payoff: max(0, 19.6387 - 19.0) = 0.6387
  Put Payoff:  max(0, 19.0 - 19.6387) = 0.0000
  Call Payoff: max(0, 23.6391 - 19.0) = 4.6391
  Put Payoff:  max(0, 19.0 - 23.6391) = 0.0000

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Table 4.4: Backward Induction Calculation Steps

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Backward Induction Calculation Steps:
Step 2, Node 0:
  European Call: (0.4992 * 0.0000 + 0.5008 * 0.0000) / 1.0041 = 0.0000
  European Put:  (0.4992 * 2.6847 + 0.5008 * 5.4458) / 1.0041 = 4.0507
  American Put:  max(hold=4.0507, exercise=4.1292) = 4.1292
Step 2, Node 1:
  European Call: (0.4992 * 0.6387 + 0.5008 * 0.0000) / 1.0041 = 0.3175
  European Put:  (0.4992 * 0.0000 + 0.5008 * 2.6847) / 1.0041 = 1.3390
  American Put:  max(hold=1.3390, exercise=1.1000) = 1.3390
Step 2, Node 2:
  European Call: (0.4992 * 4.6391 + 0.5008 * 0.6387) / 1.0041 = 2.6247
  European Put:  (0.4992 * 0.0000 + 0.5008 * 0.0000) / 1.0041 = 0.0000
  American Put:  max(hold=0.0000, exercise=-2.5462) = 0.0000
Step 1, Node 0:
  European Call: (0.4992 * 0.3175 + 0.5008 * 0.0000) / 1.0041 = 0.1578
  European Put:  (0.4992 * 1.3390 + 0.5008 * 4.0507) / 1.0041 = 2.6859
  American Put:  max(hold=2.7251, exercise=2.6847) = 2.7251
Step 1, Node 1:
  European Call: (0.4992 * 2.6247 + 0.5008 * 0.3175) / 1.0041 = 1.4632
  European Put:  (0.4992 * 0.0000 + 0.5008 * 1.3390) / 1.0041 = 0.6678
  American Put:  max(hold=0.6678, exercise=-0.6387) = 0.6678
Step 0, Node 0:
  European Call: (0.4992 * 1.4632 + 0.5008 * 0.1578) / 1.0041 = 0.8061
  European Put:  (0.4992 * 0.6678 + 0.5008 * 2.6859) / 1.0041 = 1.6716
  American Put:  max(hold=1.6911, exercise=1.1000) = 1.6911

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Table 4.5: Option Prices at t=0

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Theoretical option prices at t=0:
  European Call Option:   0.8061
  European Put Option:    1.6716
  American Put Option:    1.6911

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Figure 4.1: Stock Price Binomial Tree

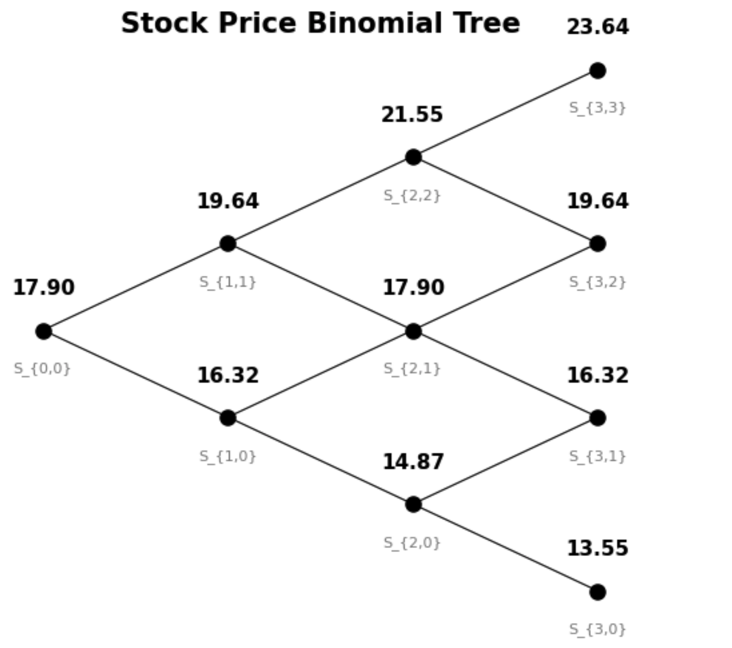

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Figure 4.2: European Call Value Tree

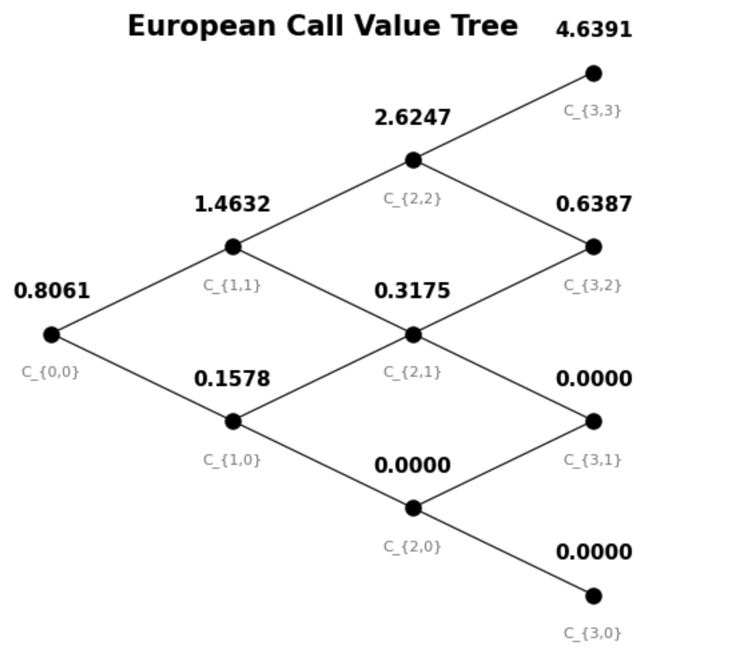

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Figure 4.3: European Put Value Tree

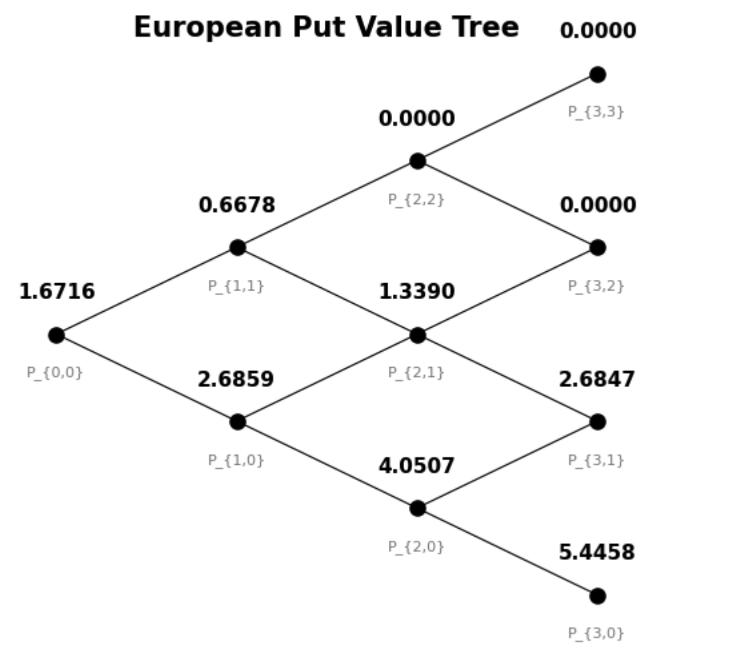

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Figure 4.4: American Put Value Tree

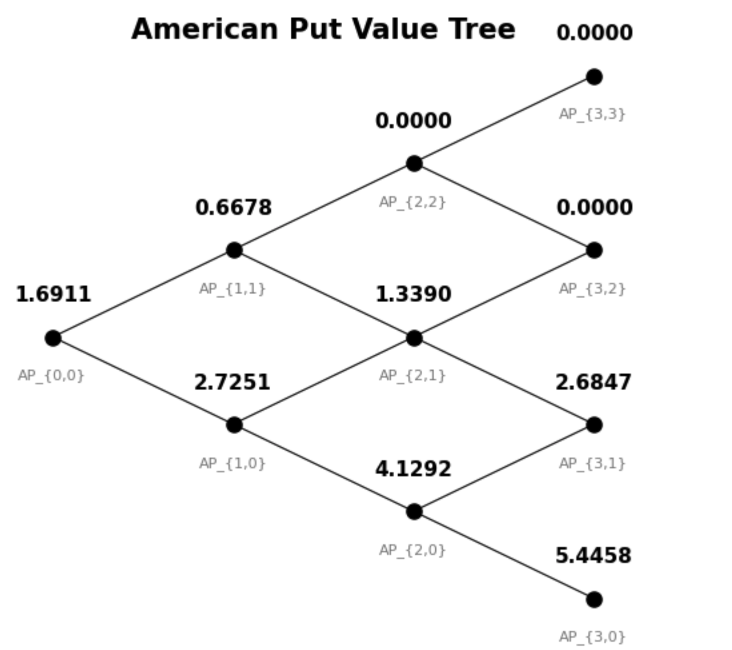

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Table 4.6: Delta-Hedged Portfolio Evolution (Δ×S − C)

Step, Node, Stock Price, Call Value, Delta (hedge ratio), Hedge Portfolio Value (Δ×S − C)

Step	Node	Stock Price	Call Value	Delta (hedge ratio)	Hedge Portfolio Value (Δ×S − C)
0	0	17.9000	0.8061	0.3928	6.2244
1	0	16.3153	0.1578	0.1048	1.5522
1	1	19.6387	1.4632	0.6328	10.9636
2	0	14.8708	0.0000	0.0000	0.0000
2	1	17.9000	0.3175	0.1922	3.1224
2	2	21.5462	2.6247	1.0000	18.9215

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Table 4.7: Delta + Risk-Free Asset Portfolio (Δ×S + B)

Step, Node, Stock Price, Call Value, Delta (hedge ratio), Hedge Portfolio Value (Δ×S + B)

Step	Node	Stock Price	Call Value	Delta (hedge ratio)	Hedge Portfolio Value (Δ×S + B)
0	0	17.9000	0.8061	0.3928	0.8061
1	0	16.3153	0.1578	0.1048	0.1578
1	1	19.6387	1.4632	0.6328	1.4632
2	0	14.8708	0.0000	0.0000	0.0000
2	1	17.9000	0.3175	0.1922	0.3175
2	2	21.5462	2.6247	1.0000	2.6247

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Table 4.8: Comparison table BSM and Binomial model

Option Type	BSM Price	Binomial (3 Steps)	Difference
European Call Option	0.8173	0.8061	0.0112
European Put Option	0.3268	0.3175	0.0093

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