Analysis of the Effectiveness of the Call Ratio Backspread Strategy Using Vanilla and Cap Options on Stock Price Movement Risk

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Abstract

Stock price volatility exposes short sellers to potentially unlimited losses, making effective hedging strategies essential for risk management. This study compares the performance of Vanilla Call Ratio Backspread and Capped Call Ratio Backspread stratefies in hedging short stock positions. The analysis utilizes Advanced Micro Devices (AMD) and Johnson & Johnson (JNJ) as representatives of high and low volatility stocks, respectively. Option premiums are determined using the Black-Scholes-Merton framework, while future stock price movements are simulated using Geometric Brownian Motion model through Monte Carlo simulation. The efffectiveness of each stratefy is evaluated based on expected return, portofolio volatility, probability of loss, and Value at Risk. The empirical results reveal that capped call options significantly reduce premium costs compared with vanilla call options. Moreover, the capped call ratio backspread strategy outperforms both the vanilla call ratio backspread and the unhedged position by generating higher expected profits and lower risk measures across both volatility scenarios. These results indicate that the cost savings associated with capped options outweigh the disadvantages of their limited payoff structure. Consequently, the capped call ratio backspread strategy represents a practical and efficient alternative for investors seeking to hedge stock price movement risk while minimizing hedging costs.

Keywords: hedging strategy, vanilla option, capped option, call ratio backspread

1. Introduction

A stock is a financial security that represents a proportional ownership claim on a corporation, granting the holder residual rights to the firm's cash flows (Ross et al., 2024). As financial markets become increasingly complex, stock investments are highly vulnerable to price dynamics. This study utilizes two underlying assets representing contrasting volatility spectrums to examine hedging strategies. To test the effectiveness of hedging strategies under contrasting volatility conditions, this study deliberately selected two contrasting stocks: Advanced Micro Devices (AMD) and Johnson & Johnson (JNJ). The first asset is Advanced Micro Devices, Inc.

(AMD) stock, representing high-volatility market conditions (historical volatility exceeding 50%). As a prominent entity in the semiconductor industry, AMD's price movements are highly sensitive to technological trends and global supply chain disruptions. The second asset is Johnson & Johnson (JNJ) stock, representing low-volatility market conditions (historical volatility below 30%), as the healthcare sector tends to be more defensive and stable in the face of macroeconomic fluctuations.

For investors holding a short position, this exposure to volatility presents a unique and severe threat. Unlike long positions, short sellers face theoretically unlimited losses if the stock price surges due to systematic macroeconomic factors or unexpected positive technological trends. Consequently, active risk management through hedging strategies is not just an option, but a necessity to protect against sudden upward price spikes (Bodie et al., 2021).

In the effort to minimize systematic risk, derivative instruments such as options play a crucial role. Jarrow & Chatterjea (2024) define an option as a contract that grants the holder the right, but not the obligation, to buy or sell an underlying asset at a specified strike price within a predetermined timeframe. This research specifically examines and compares the application of vanilla call and capped call options within a call ratio backspread strategy, designed to protect a short stock position against the catastrophic risk of extreme upward price movements. Vanilla options are standard derivative forms where the payoff is a continuous linear function of the difference between the underlying asset's price and the strike price at expiration. In contrast, capped options are instruments that modify this linear structure by imposing a predetermined upper boundary (cap) on the maximum possible payoff (Hull & Basu, 2022).By sacrificing unlimited upside potential, the option buyer benefits from a significantly lower initial premium. However, this mathematical constraint creates a unique risk paradox when utilized as an insurance mechanism against unlimited losses.

The primary objective of this study is to evaluate and compare the effectiveness of vanilla and capped options in hedging strategies. By applying both instruments to stocks with contrasting volatility characteristics (AMD and JNJ), this research aims to identify the critical trade-off between the reduction of initial hedging costs (net premium) and the structural vulnerability of a capped payoff when offsetting unlimited short risks. Furthermore, by employing Monte Carlo simulations, this study analyzes the expected value, portfolio volatility, and maximum loss limits to determine the most robust risk management approach across different market environments.

1.1 Literature Review

In capital markets, options serve as fundamental derivative instruments primarily utilized for hedging and speculation (Jarrow & Chatterjea, 2024). Options are widely used for hedging and speculative purposes (Hull & Basu, 2022). Among various option-based strategies, the Call Ratio Backspread is particularly effective for hedging short stock positions, as it provides protection against substantial upward price movements while maintaining limited downside risk. Traditionally, this strategy is constructed using Vanilla call options. However, the use of Capped call options may provide a lower-cost alternative by limiting the upside payoff through a predetermined cap. Since a Capped call can be replicated using a Bull Call Spread, replacing Vanilla calls with Capped calls in a Call Ratio Backspread may significantly alter both the payoff profile and the hedging effectiveness of the strategy (Hull & Basu, 2022).

Furthermore, options are indispensable for portfolio optimization, particularly in the context of mitigating systematic risk. According to Bodie et al. (2021), systematic risk represents market-wide vulnerabilities that cannot be neutralized through simple asset diversification. Consequently, implementing a robust hedging strategy using options is critical to insulating investments from adverse price fluctuations. In the context of short selling, the primary objective of a hedging mechanism is to constrain upside price risk and minimize the overall variance of the portfolio's returns. The introduction of capped options into a ratio backspread introduces a complex dynamic: while it significantly lowers the initial cost of building the hedge, its inherent upper limit restricts the strategy's ability to perfectly offset extreme, unconstrained stock price surges, presenting a vital area of analysis for optimal risk management (Hull & Basu, 2022).

1.2 Volatility and option pricing

Volatility is a primary measure of risk in financial markets, reflecting the degree of price fluctuations of an asset. According to Hull & Basu (2022), volatility is measured by the standard deviation of returns and represents the level of uncertainty regarding future price movements. In the context of options, volatility is a crucial factor because it determines the probability of an option ending up in-the-money. Higher volatility increases the likelihood of significant price movements, thereby raising the value of options.

In the Black–Scholes–Merton model developed by Fischer Black, Myron Scholes, and Robert C. Merton, volatility is a key parameter in determining the price of European options. The model assumes constant volatility and shows that the option value is positively related to volatility. According to Rathgeber et al. (2021), volatility is still one of the most important aspects in options pricing since changes in implied volatility can result in significant changes in option prices.

In this study, differences in volatility across stocks are an important aspect of the analysis. AMD, with high volatility (52%), tends to have higher option premiums and more extreme price movements, which may enhance the effectiveness of strategies such as the call ratio backspread. In contrast, Johnson & Johnson, with lower volatility (16%), exhibits more stable price movements, which may lead to different strategy performance. Therefore, understanding volatility is essential for evaluating the effectiveness of option strategies under varying market conditions

1.3 Spread Strategies

This study focuses on a specific options strategy designed to manage asset price movement risks from the perspective of a stock seller:

- Call Ratio Backspread: This strategy is constructed by selling a smaller number of lower-strike call options and buying a larger number of higher-strike call options (Kakushadze & Serur, 2018). Specifically, this study utilizes a 1:2 ratio configuration, which involves selling 1 lower-strike call option and simultaneously buying 2 higher-strike call options. The main goal of this setup is to capture unlimited profits if the stock price skyrockets, while limiting potential losses if the price drops sharply (Natenberg, 2015)

1.4 Previous Studies

Previous research have mainly analyzed the effectiveness of stock hedging using the strangle strategy on both vanilla options and capped options (Citra Lesmana et al., 2025). The study applied the Black-Scholes Merton Model and Monte Carlo Simulation to estimate option prices and evaluate hedging performance MU stock. The results indicated that vanilla options provide unlimited profit potential as stock prices increase, whereas capped options limit the maximum payoff through a predetermined cap level. However, cappped options were found to generate lower potential losses, making them more appropriate for investors who prioritize controlled risk exposure and more stable hedging outcomes. This comparison establishes a baseline for understanding how structural constraints within options can be utilized to optimize portfolio protection.

This previous body of literature is closely related to the present research, as both domains examine stock price risk management and contrast the payoff profiles of vanilla and capped options. Nevertheless, while previous capped option research focused on non-directional frameworks like the strangle, this study investigates the call ratio backspread strategy. This shifts the focus toward capturing directional price jumps and asymmetric volatility risks, building upon ratio-based derivative frameworks (Lopez-Díaz et al., 2025) and the foundational mechanics of volatile, non-linear option strategies detailed in standard financial theory (Hull & Basu, 2022). Therefore, this research extends the existing financial literature by shifting the capped option performance analysis into a ratio-based, asymmetric strategy framework.

1.5 Research Framework

The research model is developed using a quantitative comparative approach to evaluate the effectiveness of hedging strategies involving call ratio backspread with vanilla and cap options under different volatility conditions. The study utilizes stock data from high-volatility and low-volatility assets to assess risk reduction and payoff performance. The stages include:

1. Data Collection: Stock price data of Advanced Micro Devices (AMD) and Johnson & Johnson (JNJ) are collected from financial data platforms. A risk-free interest rate is obtained from relevant financial sources. Logarithmic returns are computed, and statistical analysis, including normality testing (e.g., Shapiro-Wilk test), is conducted to ensure suitability for option pricing models.
2. Parameter Estimation: Key parameters such as historical volatility, risk-free rate, expected return, and time to maturity are estimated. These parameters serve as inputs for stock price simulation and option pricing.
3. Option Pricing: European call option prices are calculated using the Black–Scholes–Merton

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(BSM) model for vanilla options. For cap options, pricing is performed by incorporating the capped payoff structure and cap level into the option valuation process.

4. Strategy Simulation: The call ratio backspread strategy is implemented using both vanilla call ratio backspread and cap call ratio backspread structures. Future stock prices at maturity are generated through Monte Carlo simulation under different volatility conditions represented by AMD and JNJ stocks.
5. Profit and Risk Analysis: The performance of each strategy is evaluated using expected profit, payoff structure, standard deviation, Value at Risk (VaR), loss probability, and hedging effectiveness. Risk characteristics and profit distributions are analyzed to determine the protective capability of each strategy.
6. Strategy Evaluation: A comparative analysis is conducted to assess the effectiveness of vanilla options and cap options when applied to the call ratio backspread strategy under different volatility conditions represented by AMD and JNJ stocks. The analysis focuses on profit distribution, risk reduction, and hedging effectiveness to identify which option type provides better performance within the call ratio backspread framework.

1.6 Hedging

Hedging is a financial risk management strategy used by corporations and investors to offset or mitigate the risk of adverse price movements in an asset. Essentially, it acts as an insurance policy for investments; by taking an opposite position in a related security (usually using financial derivatives like forwards, futures, options, or swaps), any loss in the primary asset can be balanced out by a gain in the hedging instrument (Butnariu et al., 2018).

1.7 Vanilla Option

Vanilla option refers to a standard financial instrument that provides the holder with the right, but not the obligation, to buy or sell an underlying asset at a predetermined strike price within a specific period of time. Vanilla option exists in the form of either a call or a put option without the additional features present in more complex derivatives. Exotic options such as capped option can be combined with vanilla options for more customized financial strategies.

1.8 Capped Option

A capped option is defined as a derivative contract that establishes a fixed upper limit on the maximum realizable payoff (Hull & Basu, 2022). Within the structure of a capped call option, the instrument is automatically exercised once the underlying asset's market price reaches the predetermined cap level, after which the terminal payoff remains constant regardless of further price appreciation. In financial engineering, these instruments are integrated into hedging frameworks to insulate portfolios against adverse price dynamics at maturity (S_T).

At maturity (T), the terminal payoff functions for a capped call option and a capped put option are expressed as follows:

$$\bar{C}(S,T) = \min\{\max(S_T - K, 0), x\} \tag{1}$$

$$\bar{P}(S,T) = \min\{\max(S_T - K, 0), x\} \quad (2)$$

where
$\bar{C}$ = capped call option payoff
$\bar{P}$ = capped call put option payoff
S_T = underlying asset market price at maturity
K = strike price
x = call/put option upper cap (profit ceiling)

1.9 Call Option
A call option is a financial derivative granting the buyer the right, but not the obligation, to purchase an underlying asset at a predetermined strike price in exchange for an upfront premium (Hull & Basu, 2022). Mathematically, the terminal payoff for a long vanilla call option position at expiration is expressed as:

$$Payoff\ Call = \max(S_T - K, 0) \quad (3)$$

1.10 Option Position

Option positions are fundamentally divided into long and short standings. A long position provides the holder the right to buy or sell an asset at a set strike price, with risk limited to the premium paid (Hull & Basu, 2022). In contrast, a short position involves writing an option, obligating the seller to fulfill the contract in exchange for a premium, which entails higher risk (Bodie et al., 2021).

These basic positions can be combined to form complex derivatives, such as the call ratio backspread. In this strategy, a trader sells one call option at a lower strike price (K_1) and buys two call options at a higher strike price (K_2), where $(K_1 < K_2)$ using the same underlying asset and expiration date. This setup allows investors to profit from high volatility within a defined risk profile

1.11 Black-Scholes Merton Model

This study employs the Black-Scholes-Merton (BSM) model as the primary framework for pricing European call options in the context of vanilla options. The model is widely recognized for providing a closed-form analytical solution under a set of simplifying assumptions, making it one of the most fundamental approaches in option pricing theory.

According to Hull & Basu (2022), the model assumes that stock prices follow a Geometric Brownian Motion with constant drift and volatility.

$$dS = \mu S\, dt + \sigma S\, dz \quad (4)$$

where

μ = drift rate,
σ = volatility,
dz = Wiener process.

In addition, markets are considered frictionless, implying no transaction costs or taxes, while securities are perfectly divisible and short selling is allowed. The model also assumes the absence of arbitrage opportunities, continuous trading, a constant risk-free interest rate, and no dividend payments during the option's life.

Under these assumptions, the value of a European call option can be expressed as:

$$C = S_0 N(d_1) - Ke^{-rT} N(d_2) \quad (5)$$

where:

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \quad (6)$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad (7)$$

In this formulation, S_0 denotes the current stock price, K represents the strike price, T is the time to maturity, r is the risk-free interest rate, and σ denotes the volatility of the underlying asset. The function $N(\cdot)$ represents the cumulative distribution function of the standard normal distribution. The model is used to obtain option prices that will be utilized in the subsequent analysis.

1.12 Call Ratio Backspread

The call ratio backspread is an options strategy designed to capitalize on significant upward price movements and increasing market volatility. In modern financial literature, option-based strategies such as spreads are used to construct nonlinear payoff profiles that aim to manage risk while maximizing return potential (Hull & Basu, 2022). This strategy typically involves selling a smaller number of call options at a lower strike price and buying a larger number of call options at a higher strike price, resulting in relatively limited downside risk and potentially unlimited upside profit when the underlying asset price rises substantially. In this study, two variants of the strategy are examined from the seller's perspective:

1. Vanilla Call Ratio Backspread
   The vanilla variant employs standard European call options for both legs of the strategy. The profit function is defined as:

$$\pi_v(S_T) = \begin{cases} S_0 - S_T - NP, & S_T \le K_1 \\ S_0 - S_T - (S_T - K_1) - NP, & K_1 < S_T \le K_2 \\ S_0 - S_T + 2(S_T - K_2) - (S_T - K_1) - NP, & S_T > K\_2 \end{cases} \quad (8)$$

   where
   π_v = profit for vanilla call ratio backspread,
   S_T = underlying asset market price at time T,
   S_0 = initial stock price at time 0,

K_1 = lower strike price, set at-the-money ($K_1 = S_0$),
K_2 = upper strike price, set 30% out-of-the-money ($K_2 = 1.30 \times S_0$),
NP = net premium, defined as $NP = 2C(K_2) - C(K_1)$, where $C(K)$ denotes the Black-Scholes call option price at strike K.

2. Capped Call Ratio Backspread
The cap variant incorporates a knock-out barrier $C = 1.05 \times K_2$, where the hedging payoff is automatically deactivated once the stock price reaches or exceeds the barrier level. The profit function is defined as:

$$\pi_c(S_T) = \begin{cases} S_0 - S_T - NP, & S_T \leq K_1 \\ S_0 - S_T - (S_T - K_1) - NP, & K_1 < S_T \leq K_2 \\ S_0 - S_T + (S_T - K_2) - (S_T - K_1) - NP, & K_2 < S_T < C \\ S_0 - S_T - NP, & S_T \geq C \end{cases} \quad (9)$$

where
π_c = profit for capped call ratio backspread
S_T = underlying asset market price at time T,
S_0 = initial stock price at time 0,
K_1 = lower strike price, set at-the-money ($K_1 = S_0$),
K_2 = upper strike price, set 30% out-of-the-money ($K_2 = 1.30 \times S_0$),
C = knock-out barrier level ($C = 1.05 \times K_2$),
NP = net premium, defined as $NP = 2C(K_2) - C(K_1)$, where $C(K)$ denotes the Black-Scholes call option price at strike K.

2. Method

This study adopts a quantitative descriptive research design to assess the effectiveness of call ratio backspread strategies using vanilla and cap (knock-out) options for hedging stock positions under contrasting volatility conditions. The focus is on providing empirical comparisons of the risk-return profiles of each strategy using historical stock data and Monte Carlo simulations.

The population in this study comprises option strategies applied to equities in the U.S. stock market. A purposive sampling technique is used to select two stocks with contrasting volatility profiles: Advanced Micro Devices (AMD) as a high-volatility asset and Johnson & Johnson (JNJ) as a low-volatility asset, both of which are relevant for evaluating hedging strategy effectiveness across different market conditions.

This research utilizes secondary data in the form of weekly stock prices of AMD and JNJ spanning 260 weekly observations, obtained from investing.com. The U.S. risk-free interest rate used in the calculation is 5%, sourced from Trading Economics (2025).

The primary instrument in this study is a computational model based on the Black-Scholes model, used to price European vanilla and cap call options. All calculations are performed using RStudio. The research process follows these steps:

1. Log Return Calculation
   Weekly logarithmic returns are calculated by taking the natural logarithm of the ratio between the current and previous period's stock price:
   $$r_t = \ln\left(\frac{S_t}{S_{t-1}}\right) \tag{10}$$
   Descriptive statistics including mean, standard deviation, skewness, and kurtosis are computed for each stock's return series.
2. Normality Testing
   The distribution characteristics of stock returns were examined using histograms, Q-Qplots, and the Shapiro–Wilk normality test to evaluate whether the return data followed a normal distribution.
   $$W = \frac{\left(\sum_{i=1}^{n} a_i y_i\right)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{11}$$
3. Volatility Estimation
   Stock volatility was estimated using the standard deviation of weekly returns. Since the study employed weekly stock price data, the annual volatility was obtained by annualizing weekly volatility using:
   $$\sigma = \sigma_{\text{weekly}} \times \sqrt{52} \tag{12}$$
   The resulting volatility values were then used as input parameters in the Monte Carlo simulation process.
4. Parameter Determination
   The model parameters including the initial stock price (S_0), expected return (μ), volatility (σ), maturity period (T), strike prices (K_1, K_2), and cap level (C) were determined.
5. Future stock prices at maturity are generated using the Monte Carlo simulation method based on the Geometric Brownian Motion (GBM) model:
   $$S_T = S_0 \cdot \exp\left[\left(\mu - \frac{1}{2}\sigma^2\right)T + \sigma\sqrt{T}Z\right] \tag{13}$$
   where:
   S_T = stock price at maturity,
   S_0 = initial stock price,
   μ = expected return,
   σ = annual volatility,
   T = time to maturity,
   $Z \sim N(0,1)$ is a standard normal random variable.

   The stock prices at maturity were simulated using the Monte Carlo method with 100,000 iterations to obtain a large number of possible future stock price scenarios. The resulting simulated prices were then used as inputs to calculate option payoffs and profit distributions, and to evaluate the effectiveness of the hedging strategies.
6. European call option prices for both vanilla, $C(K)$, and capped variant, $C_{\text{cap}}(K)$, are calculated using the Black-Scholes model using Equation (6), Equation (6), and Equation (7). For the capped variant, the option price is using a cap level C, which

conceptually follows a knock-out barrier mechanism, as discussed in (Hull & Basu, 2022). Therefore, the capped call option price is expressed as follows:

$$C_{\text{cap}}(K) = C(K) - C(C) \quad (14)$$

7. The profit for each strategy is computed using the simulated terminal stock prices S_T obtained from Equation (11). For the unhedged position, the profit is defined as:

$$\pi_{\text{unhedged}} = S_0 - S_T \quad (15)$$

For the vanilla and capped variants, the profit functions defined in Equation $(8)$and Equation (9) are applied respectively.

8. Profit Distribution Analysis
The profit distribution of each strategy is evaluated and compared using mean, standard deviation, minimum, maximum, probability of negative profit, and Value at Risk at the 95% confidence level (VaR 95%).
9. Payoff Diagram
A payoff diagram is constructed across a range of simulated stock prices $(0.5 \times S_0 \; to \; 2 \times S_0)$ to visually compare the profit profiles of the unhedged position, vanilla backspread, and cap backspread strategies for both AMD and JNJ.

3. Results

3.1 Descriptive Statistics and Normality Assessment of Log Returns

Before executing the options pricing valuation using the Black-Scholes framework and simulating future prices via Geometric Brownian Motion (GBM), it is a prerequisite to examine the distributional properties of the underlying assets' logarithmic returns. The assumption of constant volatility and normally distributed returns is central to the validity of the models employed in this study.

Table 1. Descriptive Statistics and Shapiro-Wilk Normality Test of Logarithmic Returns

Parameter	**AMD**	**JNJ**
Skewness	0.15429	0.22314
Kurtosis	0.51315	0.19159
Shapiro-Wilk (W)	0.99335	0.99499
P-value	0.3056	0.5607

The descriptive statistics, as summarized in Table 1, reveal that the logarithmic returns of both AMD and JNJ closely align with the characteristics of a theoretical normal distribution. Analyzing the higher moments of the distribution, AMD exhibits a near-zero skewness of 0.15429, and JNJ demonstrates a slight skewness of 0.22314. Furthermore, the excess kurtosis values for both assets are remarkably close to the standard normal baseline of 0, with AMD recording an excess kurtosis of 0.51315 and JNJ at 0.19159. These low positive excess kurtosis values indicate that the empirical distributions do not suffer from severe leptokurtic anomalies or heavy-tailed distortions, which are typically prevalent in financial time series.

To provide a rigorous statistical confirmation, a formal normality test using the Shapiro-Wilk method was conducted. The statistical results yield a Shapiro-Wilk (W) metric of 0.9934 for AMD and 0.9950 for JNJ. Crucially, the corresponding p-values for AMD $(p = 0.3056)$ and JNJ $(p = 0.5607)$ are both significantly greater than the standard $\alpha = 0.005$ significance level. Therefore, the null hypothesis (H_0), which posits that the data is normally distributed, cannot be rejected.

Consequently, the logarithmic returns of AMD and JNJ can be considered sufficiently consistent with the normality assumption. Therefore, the return distributions are regarded as appropriate for the application of the Black–Scholes model and Geometric Brownian Motion (GBM) simulations in this study.

3.2 Vanilla Call Option Price Calculation

The Black-Scholes Merton model is employed to determine the vanilla call option prices based on Equations (5), (6), and (7), using the input parameters summarized in Table 2 for AMD stock and Table 3 for JNJ stock. By utilizing RStudio, the computations were conducted with these specific inputs, and the resulting option prices across different strike prices are detailed in Table 4 and Table 5, respectively.

Tabel 2. Input Parameters for Black-Scholes Merton Model for AMD Stock

Parameter	**Value**
Initial Stock Price (S_0)	\$347.81
Expiration Date (T)	3 months
Risk-free Rate (r)	5%
Volatility (σ)	52.2%

Table 3. Input Parameters for Black-Scholes Merton Model for JNJ Stock

Parameter	**Value**
Initial Stock Price (S_0)	\$227.5
Expiration Date (T)	3 months
Risk-free Rate (r)	5%
Volatility (σ)	16.52%

Table 4. Price of Vanilla Call Options for AMD Stock

Strike Price (K)	**Vanilla Call Option Price (C)**
347.81	\$38.10
452.153	\$9.24

Table 5. Price of Vanilla Call Options for JNJ Stock

Strike Price (K)	**Vanilla Call Option Price (C)**
227.5	\$8.95
295.75	\$0.0074

Tables 3 and 4 present the vanilla call option prices computed using the Black-Scholes Merton model for both AMD and JNJ stocks across their respective strike price variations. In accordance with option pricing theory, a consistent decrease in the call option value is observed as the strike price increases from K_1 to K_2. This inverse relationship aligns with the fundamental concept that the intrinsic value of a call option diminishes when the right to purchase the underlying asset is set at a higher predetermined price.

3.3 Capped Call Option Price Calculation

The Black-Scholes Merton model is modified and employed to determine the capped call option price based on Equation (5), (6), and (7), where the cap level C is determined as $1.05 \times K_2$. This specialized framework utilizes the operational input parameters summarized in Table 5 for AMD and Table 6 for JNJ. Through computational execution in RStudio, the pricing model yields the final adjusted contract values, which are subsequently detailed in Table 7 and Table 8.

Table 6. Input Parameters for Black-Scholes Merton Model for AMD Stock

Parameter	**Value**
Initial Stock Price (S_0)	\$347.81
Expiration Date (T)	3 months
Risk-free Rate (r)	5%
Volatility (σ)	52.2%
Barrier Level (C)	474.76

Tabel 7. Input Parameters for Black-Scholes Merton Model for JNJ Stock

Parameter	**Value**
Initial Stock Price (S_0)	\$227.5

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Expiration Date (T)	3 months
Risk-free Rate (r)	5%
Volatility (σ)	16.52%
Barrier Level (C)	310.54

Table 8. Price of Capped Call Options for AMD Stock

Strike Price (K)	**Capped Call Option Price (C)**
347.81	$31.51
452.153	$2.66

Table 9. Price of Cappped Call Options for JNJ Stock

Strike Price (K)	**Capped Call Option Price (C)**
227.5	$8.94
295.75	$0.00664

Tables 7 and 8 present the capped call option prices adjusted for the knock-out barrier $C = 1.05 \times K_2$. In the Black-Scholes framework, the capped premium decreases as the strike price increases, dropping to zero at the barrier because the knock-out component is subtracted from the vanilla price.

3.3 Application of Call Ratio Backspread Using Vanilla and Cap Options

Call Ratio Backspread is an options strategy that involves a short position in 1 call option (lower strike, K_1) and a long position in 2 call options (higher strike, K_2). In this study, the perspective taken is that of the option seller who wants to protect a short stock position from extreme stock price increases. The vanilla call ratio backspread and the cap call ratio backspread options are used to implement the call ratio backspread strategy on AMD and JNJ equities. High volatility equities are represented by AMD stock, and low volatility stocks are represented by JNJ. The outcomes of the simulation demonstrate that the two approaches behave differently under various volatility scenarios.

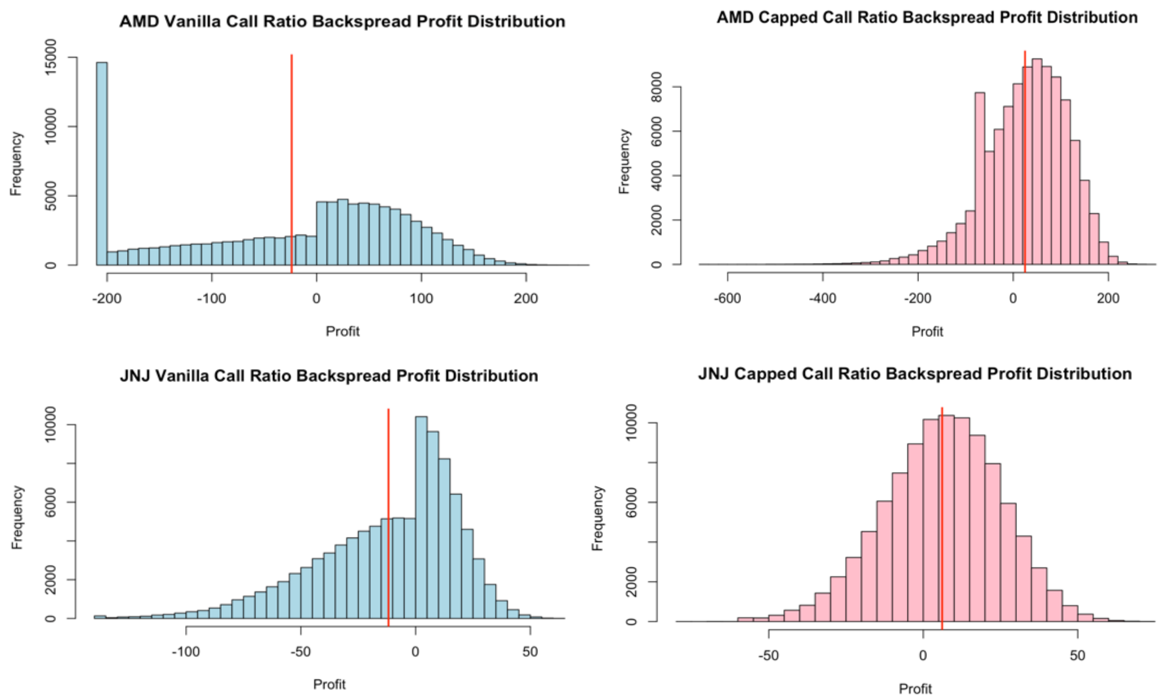

Figure 1. Profit Distribution Comparison of Vanilla and Capped Call Ratio Backspread Strategies under High- and Low-Volatility Stocks.

Table 9. AMD stock profit distribution

Strategy	**Mean**	**SD**	**Min**	**Max**	**Prob (Negative)**	**VaR_95**
Unhedged	-4.308287	93.67192	-665.7417	237.0001	0.46694	-175.1450
Vanilla	-24.095460	111.28411	-208.6860	237.0001	0.46694	-208.6860
Cap	24.579188	88.69697	-616.9408	263.1933	0.35863	-126.3441

For AMD stock, the unhedged position produced a mean profit of -4.30, a standard deviation of 93.67, a loss probability of 46.69%, and a VaR value of -175.14. The vanilla call ratio backspread strategy showed weaker performance with a mean profit of -24.09, an increased standard deviation of 111.28, and a lower VaR value of -208.68, indicating higher risk compared with the unhedged position. In contrast, the cap call ratio backspread strategy generated the best performance with a positive mean profit of 24.57, a lower standard deviation of 88.69, a reduced loss probability of 35.86%, and an improved VaR value of -126.34. These results indicate that the cap strategy provided better hedging performance than both the vanilla strategy and the unhedged position for AMD stock.

Table 10. JNJ stock profit distribution

Strategy	Mean	SD	Min	Max	Prob (Negative)	VaR_95
Unhedged	-2.796225	19.02750	-105.72588	74.02651	0.54162	-35.42671
Vanilla	-11.782623	30.74768	-136.50000	74.02651	0.54162	-70.85342
Cap	6.131903	18.99649	-82.01836	82.94653	0.35861	-26.50670

For JNJ stock, the unhedged position resulted in a mean profit of -2.80, a standard deviation of 19.03, a loss probability of 54.16%, and a VaR value of -35.43. The vanilla call ratio backspread strategy again showed poorer performance with a mean profit of -11.78, a standard deviation of 30.75, and a VaR value of -70.85, indicating greater downside risk. Meanwhile, the cap call ratio backspread strategy achieved better results with a positive mean profit of 6.13, a standard deviation of 19.00, a lower loss probability of 35.86%, and an improved VaR value of -26.50. Therefore, the cap strategy demonstrated better risk control performance for low-volatility stocks.

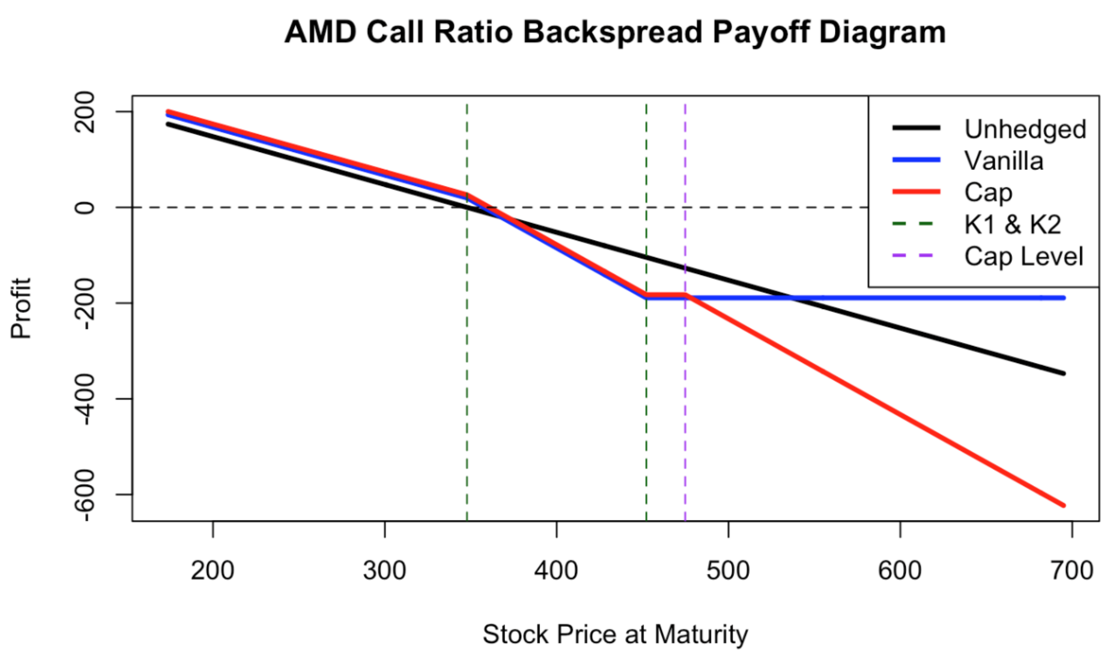

Figure 2. Payoff comparison of unhedged, vanilla call ratio backspread, and capped call ratio backspread for AMD stock

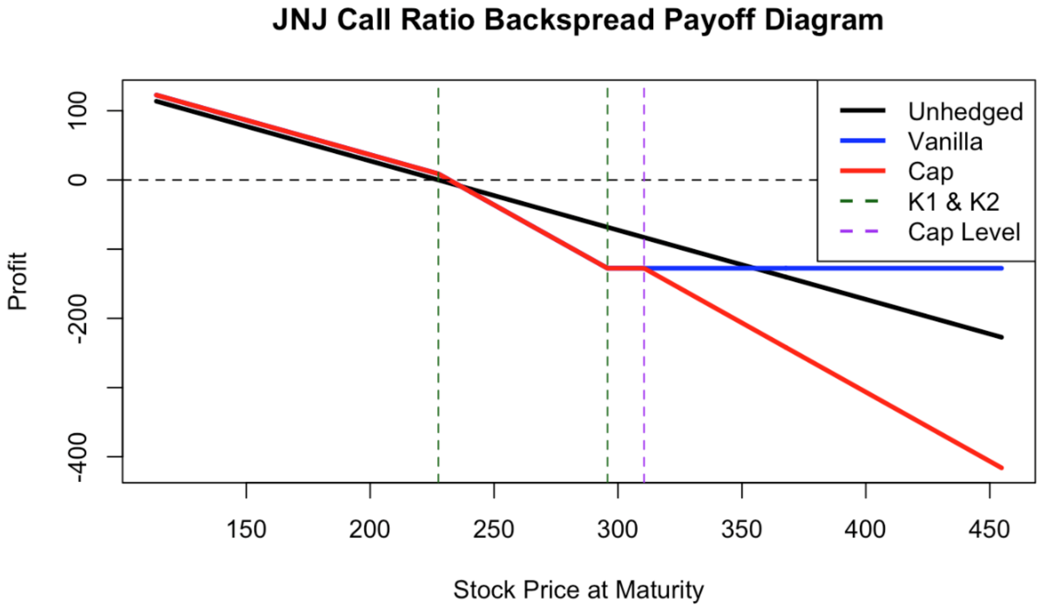

Figure 3. Payoff comparison of unhedged, vanilla call ratio backspread, and capped call ratio backspread for JNJ stock

Overall, the findings indicate that the unhedged position still exhibited relatively high risk due to the absence of hedging protection. The vanilla call ratio backspread strategy did not provide optimal risk reduction in this study and even produced higher risk compared with the unhedged position. On the other hand, the cap call ratio backspread strategy outperformed both alternatives by generating higher expected profit, lower volatility, smaller loss probability, and better Value at Risk performance. Therefore, the cap call ratio backspread strategy can be considered the most effective hedging strategy within the simulation setting and market conditions evaluated in this study.

In addition to the numerical results, the payoff diagrams in Figure 2 and Figure 3 illustrate the behavior of the unhedged, vanilla call ratio backspread, and cap call ratio backspread strategies under different stock price scenarios at maturity for AMD and JNJ stock. The unhedged position shows a continuously decreasing payoff as stock prices increase, indicating greater exposure to market risk. Meanwhile, the vanilla call ratio backspread reduces the rate of loss after exceeding K_2; however, numerical results indicate that its overall hedging performance remained weaker than the cap strategy. The cap call ratio backspread initially follows the same pattern as the vanilla strategy, but the hedging effect becomes inactive after the cap level is reached, causing the payoff to decline again. Therefore, the payoff diagrams demonstrate the differences in risk behavior among the three strategies and supports the comparative analysis of hedging performance.

4. Conclusion

This study evaluated the effectiveness of Vanilla Call Ratio Backspread and Capped Call Ratio Backspread strategies in hedging short stock positions under different volatility conditions represented by AMD and JNJ stocks. Option prices were determined using the Black–Scholes–Merton model, while portfolio performance was analyzed through Monte Carlo simulation.

The option pricing results showed that capped call options consistently had lower premiums than vanilla call options. For AMD stock, the vanilla call option prices were $\$38.10$ and $\$9.24$, while the corresponding capped call option prices were $\$31.51$ and $\$2.66$. Similarly, for JNJ stock, the vanilla call option prices were $\$8.95$ and $\$0.0074$, whereas the capped call option prices were slightly lower at $\$8.94$ and $\$0.00664$. This difference occurred because the capped option limits the maximum payoff through a predetermined barrier level, resulting in a lower premium.

Based on the simulation results, the vanilla call ratio backspread strategy did not improve portfolio performance for either AMD or JNJ stock. For AMD, the strategy produced a mean profit of -24.10 and a standard deviation of 111.28, compared with -4.31 and 93.67 for the unhedged position. Similar results were obtained for JNJ, where the mean profit decreased from -2.80 to -11.78 and the standard deviation increased from 19.03 to 30.75. These results indicate that the vanilla call ratio backspread strategy was not effective in reducing portfolio risk within the simulation setting of this study.

In contrast, the capped call ratio backspread strategy generated better results for both stocks. For AMD, the strategy produced a positive mean profit of 24.58, reduced the standard deviation to 88.70, lowered the probability of loss from 46.69% to 35.86%, and improved the VaR95 from -175.15 to -126.34. For JNJ, the strategy generated a mean profit of 6.13, reduced the probability of loss from 54.16% to 35.86%, and improved the VaR95 from -35.43 to -26.51. These findings indicate that the lower premium cost of capped call options contributed to better overall portfolio performance despite the payoff limitation imposed by the cap level.

Therefore, it can be concluded that the capped call ratio backspread strategy was more effective than the vanilla call ratio backspread strategy for both high-volatility and low-volatility stocks in this study. The strategy was able to provide better risk reduction while maintaining a more favorable profit performance, making it a potential alternative for investors seeking a cost-efficient hedging strategy.

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