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The Strategies of Butterfly Spread and Broken Wing Condor Spread in Managing Investment Risks in Gold Futures Contracts

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Abstract

This study examines option-based hedging strategies, Butterfly Spread and Broken Wing Condor Spread, for managing risk in gold futures contracts during 2024. Although gold futures are widely used for hedging, holding them without protection (unsecured) exposes investors to significant price risk. The research addresses this gap by evaluating both strategies through simulation using historical gold futures data and the Black-76 option pricing model. Results show that both strategies effectively limit potential losses compared to unsecured positions. The Broken Wing Condor Spread offers a higher probability of profit and greater flexibility under market uncertainty, despite a slightly lower maximum return than the Butterfly Spread. These findings provide a quantitative basis for selecting hedging strategies based on market expectations and individual risk tolerance. This study contributes to the existing literature by providing a probability-based comparison of option hedging strategies for gold futures using the Black-76 framework, offering practical insights for investors operating in low-to-moderate volatility environments.

Keywords: hedging, gold futures, butterfly spread, broken wing condor spread, risk management

1. Introduction

Gold has long been recognized as a strategic asset due to its role as a store of value and a hedge against economic uncertainty. As a precious metal, gold is widely used in investment portfolios, particularly during periods of inflationary pressure, financial instability, and geopolitical tension (Kumar et al., 2025). In modern financial markets, exposure to gold price movements is commonly obtained through gold futures contracts, which offer liquidity and price transparency but also expose investors to substantial market risk.

Gold futures prices are influenced by a complex interaction of macroeconomic factors, including inflation expectations, monetary policy, exchange rate dynamics, and global geopolitical conditions. As a result, gold futures often experience non-trivial price fluctuations, even during periods of relatively stable market conditions. While futures contracts are traditionally employed as hedging instruments, holding an unprotected or unsecured futures position exposes investors to potentially significant losses when price movements deviate from expectations.

In 2024, the price of gold futures showed an overall up-and-down trend during specific periods, marked by changing patterns and several small price fluctuations throughout the year. These fluctuations were largely influenced by global economic factors such as high inflation (Le Thi Thuy et al., 2024). For investors, such relatively stable price movements can be used as opportunities for hedging (Zai & Mansur, 2024). Perfect hedging means eliminating all risk, but such conditions are rarely achieved. By utilizing derivative contracts, it is expected that investors can approximate ideal hedging conditions, aiming to produce returns that align with expected outcomes (Hull, 2021). To achieve this, investors can apply more advanced risk management strategies, including the Butterfly Spread and the Broken Wing Condor Spread.

The Butterfly Spread and the Broken Wing Condor Spread can serve as alternative approaches to risk management, as both offer measurable risk profiles and the potential for optimal profits under certain market conditions. The Butterfly Spread is a portfolio consisting of three options (either calls or puts) with different strike prices arranged symmetrically (Lesmana & Wang, 2013). The Broken Wing Condor Spread on the other hand, combines elements of a traditional Condor strategy, but with asymmetrical strike distances, offering greater flexibility in managing risk. This strategy is suitable when a trader has a directional bias and aims to gain more on one side while limiting risks on the other. Research focusing on hedging gold futures using the Broken Wing Condor Spread strategy remains limited. Therefore, this study aims to expand and complement existing literature by exploring other relevant and effective hedging strategies, particularly those that can be applied in low-volatility economic environments. Two strategies examined in this research are the Butterfly Spread and the Broken Wing Condor Spread.

Despite extensive studies on futures hedging and classical option spreads, empirical research comparing probability-based performance metrics of Butterfly Spread and Broken Wing Condor Spread strategies in gold futures markets remains limited. In particular, studies integrating payoff analysis with profit probability under realistic volatility conditions are scarce. This study aims to fill this gap by conducting a simulation-based comparative analysis of the Butterfly Spread and the Broken Wing Condor Spread strategies applied to gold futures contracts. Using historical gold futures data for 2024 and the Black-76 option pricing model, this research evaluates not only payoff and profit structures but also the Probability of Profit (POP) associated with each strategy. By integrating payoff analysis with probability-based metrics, this study provides a more comprehensive assessment of risk management performance. The findings offer practical insights for investors and risk managers in selecting appropriate hedging strategies based on market expectations and individual risk tolerance.

2. Method

2.1 Data and Sample

The data used in this study consist of daily closing prices of gold futures contracts traded on international commodity markets for the period from January 1, 2024, to December 31, 2024. The selected contract represents the most actively traded gold futures during the observation period, ensuring sufficient liquidity and price reliability. The data were obtained from Yahoo Finance. In this analysis, we employ a quantitative method based on simulation, using an experimental approach aimed at comparing the potential profitability of both strategies under different volatility scenarios.

2.2 Research Process

The steps involved in determining the price of a futures contract based on an exchange value include:

1. Collecting historical data of gold futures prices, specifically daily closing prices.
2. Calculating the log return from the closing prices of gold futures contracts using the following formula.

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{1}$$

   where
   R_t refer to return at time *t*, P_t is the closing price at time *t*, and P_t is the closing price at time *t* – 1, where *t* is measured in days.

3. Calculating the daily and annual volatility of gold futures prices.

$$\sigma_{\text{daily}} = \sqrt{Var(R_t)} \tag{2}$$

$$\sigma_{\text{annual}} = \sigma_{\text{daily}} \times \sqrt{252} \tag{3}$$

4. Determining the option prices using the Black-76 model.
5. Calculating the payoff and profit values of the Butterfly Spread and Broken Wing Condor Spread strategies.
6. Visualizing the payoff and profit graphs of the Butterfly Spread and Broken Wing Condor Spread strategies.
7. Identifying the unsecured positions based on relevant values.
8. Estimating the probability distribution of gold futures prices at expiration and calculating the Probability of Profit (POP) for each strategy based on the defined breakeven intervals.

2.3 Gold Futures Contract

To minimize adverse impacts from exchange rate fluctuations and protect shareholder interests, multinational corporations implement hedging policies through the use of derivative instruments. A derivative is a financial instrument whose value derives from the value of one or more underlying assets. In Indonesia, derivatives that have been introduced and widely adopted include futures contracts, both financial (such as stocks) and commodity-based (Ulfa et al., 2024). This study focuses on futures contracts as the chosen derivative instrument.

A futures contract is an agreement to buy or sell an asset at a fixed price on a specific date in the future (Hull, 2021). Utilizing futures contracts provides price certainty, which helps investors and companies mitigate potential losses caused by unexpected price fluctuations. One of the commodities traded in futures markets is gold. Gold is a precious metal widely favored as an investment and store of value. In addition to being used as a means of payment and a reserve asset, gold prices typically move in tandem with inflation and currency values, especially the US Dollar (Beckmann & Czudaj, 2013).

2.4 Unsecured Position

An unsecured position, also known as an uncovered or naked position, in derivatives or options trading refers to an open position where the trader does not hold the underlying asset or a hedging position to offset the potential obligations of the derivative contract (Tian & Wu, 2023). Based on previous research, the risk of loss in an unsecured position is significantly high and can theoretically be unlimited in certain cases. Because the seller of a naked option lacks any protective asset, the profit-loss profile is highly asymmetric: the maximum potential profit is limited to the premium initially received, whereas the potential loss can far exceed that amount.

2.5 Hedging

Hedging through gold futures contracts has proven to be highly significant due to their tendency to move in line with currency values. From an investment perspective, derivative transactions serve as tools to protect against various types of risks, including fluctuations in interest rates, exchange rates, stock prices, bond yields, indexes, and commodities (Beckmann & Czudaj, 2013). Derivative transactions represent a hedging strategy, which refers to methods or techniques used to reduce risks arising from price volatility in financial markets (Aretz et al., 2007). Therefore, to minimize market risk, hedging is required to stabilize returns. One effective way to achieve this is by using derivatives as hedging instruments.

2.6 Black-76 Model

The Black-76 Model is an extension of the Black-Scholes model, in which the underlying asset is the futures price rather than the forward or spot price (Bramante et al., 2022). The Black-76 Model, which was developed by Black in 1976, is used not only to price options but also to express market-quoted swap prices in terms of volatility. Since forward rates are known from the market, the only unknown input is volatility, creating a direct link between option prices and volatility (Gunnarsson et al., 2024). The formula for the Black-76 Model is as follows:

$$dF_t = \sigma F_t dW_t \tag{4}$$

$$C = e^{-rT}(F_0 N(d_1) - KN(d_2)) \tag{5}$$

$$P = e^{-rT}(KN(-d_2) - F_0 N(-d_1)) \tag{6}$$

where C refers to the call option price, P refers to the put option price, r denotes the risk-free interest rate, and T indicates the time to maturity. F_0 is the current futures price of the underlying asset. $N(.)$ represents the cumulative distribution function (CDF) of the standard normal distribution. The terms d_1 and d_2 are calculated parameters that depend on the asset's volatility and time to maturity.

The application of the Black-76 model in this study assumes constant volatility, a frictionless market environment, no arbitrage opportunities, and log-normally distributed futures prices. While these assumptions simplify real market dynamics, they provide a widely accepted and analytically tractable framework for option valuation on futures contracts.

2.7 Butterfly Spread

Let K_1, K_2, and K_3 denote the lower, middle, and upper strike prices, respectively, with K_2 set close to the initial futures price F_0. Butterfly Spread is designed for a neutral market outlook. This strategy involves three strike prices: K_1, K_2, and K_3, where the following conditions must be satisfied:

1. K_2 is set near the current stock price,
2. The strike prices are symmetrically spaced: $K_2 - K_1 = K_3 - K_2$.

Thus, $K_2 = 0.5(K_1 + K_3)$. The strategy generates profit when the stock price remains close to K_2, but incurs limited losses if the stock experiences a significant movement upward or downward. This strategy yields a profit if the stock price remains close to its initial level but results in a modest loss if the stock price moves significantly in either direction (Hull, 2021).

2.8 Broken Wing Condor Spread

The Broken Wing Condor Spread is an options strategy used when anticipating a market price movement within a certain range (i.e., not too bullish or bearish/neutral). This strategy is a variation of the standard iron condor, where the risk distribution is intentionally shifted toward one side rather than being balanced symmetrically. The Broken Wing Condor Spread achieves this by creating a non-symmetrical spread between strike prices, where one "wing" is wider than the other. A Broken Wing Condor Spread for call position shifts risk toward the upside, thereby offering more protection on the downside. This is done by purchasing a further out-of-the-money call option rather than using an equally spaced call strike, as typically done in standard iron condors.

For the Broken Wing Condor Spread, $K_1 < K_2 < K_3 < K_4$ denote the ordered strike prices, where the distances between strikes are intentionally asymmetric.

2.9 Payoff

Payoff refers to the amount of profit or loss realized at the expiration of an option, defined as the difference between the underlying asset's final price and the strike price. According to Hull (2012), the payoff for a long position in a futures contract is expressed as:

$$\max(F_T - K, 0) \tag{7}$$

where F_T is the futures price at expiration (T) and K is the strike price. Similarly, the payoff for a short position is represented as:

$$\max(K - F_T, 0) \tag{8}$$

The payoff structure of the Butterfly Spread for call options is expressed as follows (Hull, 2021).

Table 1. Payoff Structure of Butterfly Spread

Strategies	$F_T \leq K_1$	$K_1 < F_T \leq K_2$	$K_2 < F_T \leq K_3$	$F_T \geq K_3$
Long 1 call option (K_1)	0	$F_T - K_1$	$F_T - K_1$	$F_T - K_1$
Short 2 call options (K_2)	0	0	$2(K_2 - F_T)$	$2(K_2 - F_T)$
Long 1 call option (K_3)	0	0	0	$F_T - K_3$
Total payoff	0	$F_T - K_1$	$K_3 - F_T$	0

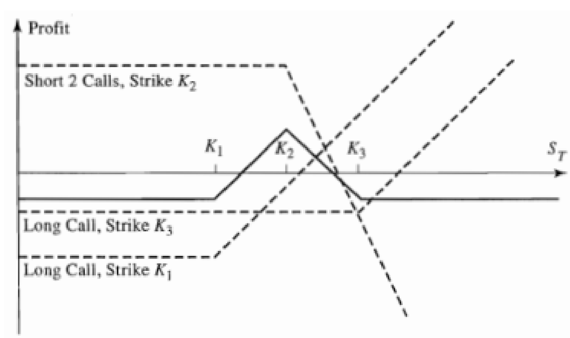

Figure 1. Long 1 Call (ITM) − Short 2 Call (ATM) + Long 1 Call (OTM)

The payoff structure of the Broken Wing Condor Spread for call options is expressed as follows

Table 2. Payoff Structure of Broken Wing Condor Spread

Strategies	$F_T \leq K_1$	$K_1 < F_T \leq K_2$	$K_2 < F_T \leq K_3$	$K_3 < F_T \leq K_4$	$F_T \geq K_4$
Long 1 call (K_1)	0	$F_T - K_1$	$F_T - K_1$	$F_T - K_1$	$F_T - K_1$
Short 1 call (K_2)	0	0	$K_2 - F_T$	$K_2 - F_T$	$K_2 - F_T$
Short 1 call (K_3)	0	0	0	$K_3 - F_T$	$K_3 - F_T$
Long 1 call (K_4)	0	0	0	0	$F_T - K_4$
Total payoff	0	$F_T - K_1$	$-K_1 + K_2$	$-K_1 + K_2 + K_3 - F_T$	$-K_1 + K_2 + K_3 - K_4$

2.10 Asset Price Distribution Modeling

Quantitative analysis of option strategies requires a model for the probability distribution of the future price of the underlying asset (F_T). Asset prices are commonly assumed to follow a log-normal distribution, implying that the logarithm of asset returns (log-returns) is normally distributed. This assumption underpins many option pricing frameworks, including the foundational Black-Scholes model (Nwobi et al., 2021). Under the log-normal assumption, future asset prices are modeled using parameters such as current price, time to maturity, and return volatility.

Despite its practicality and mathematical tractability, empirical studies have shown that real-world asset return distributions often deviate from log-normality by exhibiting features like skewness and fat tails. These deviations can lead to systematic mispricing in options markets when log-normality is strictly assumed (Tegnér & Poulsen, 2018). Nonetheless, the log-normal model remains widely adopted due to its closed-form analytical solutions and computational efficiency, especially in standardized markets such as equities and currencies (Nwobi et al., 2021).

2.11 Volatility Estimation

Volatility refers to the variation in index prices over a specific unit of time. These changes are measured consistently within defined time intervals and are regularly evaluated. Volatility is calculated by determining the standard deviation of the price changes occurring within those time units (Li et al., 2022). One of the methods for estimating volatility is historical volatility, calculated using past asset price data. This method involves computing the standard deviation of a series of asset log-returns over a certain time period, which is often annualized for consistency (Hull, 2021). The calculation of daily and annual volatility adopted in this study, as explained before, follows this standard approach. The resulting historical volatility serves as a key input in projecting the probability distribution of future asset prices.

2.12 Breakeven Point Calculation

The breakeven point in an options strategy represents the level of the underlying asset price at which the strategy yields neither a profit nor a loss at expiration. Identifying the breakeven point is crucial for understanding the profitability range of a given strategy.

Butterfly Spread

The long call Butterfly Spread strategy is typically constructed by buying one call option at a lower strike price (K_1), selling two call options at a middle strike price (K_2), and buying one call option at a higher strike price (K_3), where $K_1 < K_2 < K_3$ and the strike prices are symmetrically spaced (Hull, 2021). This strategy results in a net initial debit. The two breakeven points for a long call butterfly spread are:

- Lower Breakeven Point

$$LBEP = K_1 + \text{intial net debit} \tag{9}$$

- Upper Breakeven Point

$$UBEP = K_3 - \text{intial net debit} \tag{10}$$

Broken Wing Condor Spread

The long call Broken Wing Condor Spread strategy involves four strike prices: buying one call at K_1 (lowest), selling one call at K_2, selling one call at K_3, and buying one call at K_4 (highest), where $K_1 < K_2 < K_3 < K_4$ (Royal, 2025). The "broken wing" variant refers to a modification in which the strike prices are not symmetrically spaced. For a long call Broken Wing Condor Spread strategy that is structured as a debit spread, the breakeven points are calculated as:

- Lower Breakeven Point

$$UBEP = K_1 + intial\ net\ debit \tag{11}$$

- Upper Breakeven Point

$$UBEP = K_4 - intial\ net\ debit \tag{12}$$

2.13 Profit Probability Analysis

The Probability of Profit (POP) is an essential metric in the analysis of option strategies that provides a quantitative estimate of the likelihood that a strategy will generate a profit at expiration. This metric allows investors to evaluate the attractiveness of a strategy not only by its maximum profit potential but also by its probability of success. The calculation of POP is based on a series of mathematical steps, beginning with the modeling of the future asset price distribution.

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Future Price Distribution Modeling

The fundamental step in this analysis is the assumption that the future asset price (F_T) follows a log-normal distribution. This assumption is a standard in many option pricing models because it inherently prevents prices from being negative and is capable of reflecting observed market characteristics (Nwobi et al., 2021). The main implication of this assumption is that the natural logarithm of the price will be normally distributed. The parameters for the normal distribution of log price are estimated as follows:

$$\mu_{\ln(F_T)} = \ln(F_0) + \left(\mu_{daily} \times N_{days}\right) \quad (13)$$

$$\sigma_{\ln(F_T)} = \sigma_{daily} \times \sqrt{N_{days}} \quad (14)$$

Probability of Profit (POP) Calculation

Once the future price distribution model is defined, the POP is calculated by defining the price range in which a strategy will be profitable. This range is bounded by the Lower Breakeven Point (LBEP) and the Upper Breakeven Point (UBEP), whose values are specific to each strategy. The conceptual definition of POP is the probability of the expiration price (FT) falling within that range. This calculation is performed using the Cumulative Distribution Function (CDF) of the standard normal distribution, denoted by Φ. The computational formula is as follows:

$$POP = \Phi\left(\frac{\ln(UBEP) - \mu_{\ln(F_T)}}{\sigma_{\ln(F_T)}}\right) - \Phi\left(\frac{\ln(LBEP) - \mu_{\ln(F_T)}}{\sigma_{\ln(F_T)}}\right) \quad (15)$$

Accordingly, POP analysis, together with other risk and reward metrics, aids investors in making more informed investment decisions by providing insight not only into the magnitude of potential gains or losses but also the likelihood of those outcomes occurring (Cohen et al., 2017).

3. Results and Discussion

Data Processing

In the initial stage of the research, the value of gold futures contracts was calculated using simulations based on the Black-76 model under the options strategies of Butterfly Spread and Broken Wing Condor Spread.

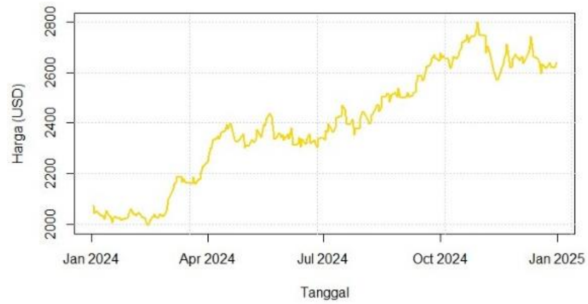

Figure 2. Daily Closing Prices of Gold Futures Contracts in 2024.

Figure 2 illustrates the daily closing prices of gold futures from January 1 to December 31, 2024, which serve as the underlying data for volatility estimation and option strategy simulations. The risk-free interest rate used is 5.39%, chosen as it is the most relevant rate for the contract's maturity period and reflects prevailing market conditions during the time frame.

Analysis of Gold Futures Price Movement and Risk

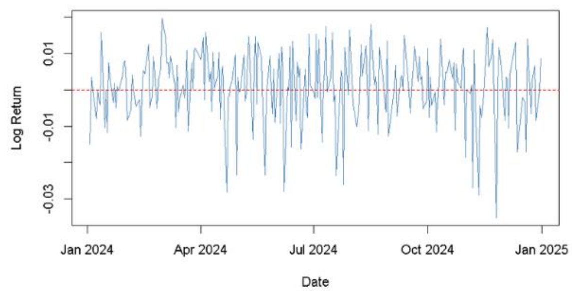

Figure 3. Daily Log Returns of Gold Futures Prices in 2024.

Figure 3 presents the daily log return chart of gold prices, which fluctuates around zero, indicating daily price volatility. The red dashed horizontal line represents the average daily log return, which is approximately 0.0997% per day, which is very close to zero. This suggests that on average, gold prices neither increased nor decreased significantly, but exhibited relatively high volatility.

Table 3. Summary Statistics of Daily Log Returns of Gold Futures Prices in 2024.

Statistics	**Value**
p-Value	0.208593
Average log return	0.000945
Annual volatility	0.151377

Table 3 presents the summary statistics of gold futures price data for the year 2024. In this study, the Kolmogorov–Smirnov test was employed to assess whether the daily log returns follow a normal distribution. This test was selected due to its suitability for continuous data and the fact that it does not assume any specific initial distribution parameters. The test yielded a p-value of

0.208593, which exceeds the 0.05 significance threshold. This result leads to a failure to reject the null hypothesis, indicating that the daily log return data can be considered normally distributed. Statistically, this suggests that the daily log returns of gold prices follow a normal distribution at the 95% confidence level.

Additionally, the annualized volatility was calculated to be 0.151377. This value implies that the gold futures prices fluctuated by approximately $\pm 15.14\%$ from the mean over the course of one year. Assuming the log returns are normally distributed, this level of volatility reflects the degree of market uncertainty or the inherent risk associated with gold futures contracts during the 2024 observation period.

Determining Option Parameters and Strike Prices Using the Black-76 Model

At this stage, a set of key parameters is established for the analysis and evaluation of option strategies on gold futures contracts. Since the underlying asset is a futures contract, the theoretical valuation of options and strategic analysis is carried out using the Black-76 model. This process includes identifying market parameters and the characteristics of the underlying asset, as well as determining strike prices that are consistent with the structure of the analyzed option strategies.

Market and Underlying Asset Parameters for the Black-76 Model
Initial Gold Futures Contract Price (F_0)

The initial price of the gold futures contract (F_0) serves as the primary reference point for determining the strike prices of the option strategies. The value of F_0 is taken from the most recent closing price, or the most relevant current price, based on the daily gold futures price data, which amounts to 2641.

Risk-Free Interest Rate (r)

The risk-free interest rate (r) used in this analysis is 5.39% annually (or 0.0539). As previously mentioned, this value was selected due to its relevance to the time to maturity of the analyzed option contracts and reflects the prevailing interest rate conditions during the observation period, which spans from January 1, 2024, to December 31, 2024.

Time to Maturity (T)

The time to maturity (T) for the options evaluated is set at 0.25 years, equivalent to 3 months. This period represents a standard duration for many short-term option contracts and aligns with the strategic analysis horizon.

Volatility of Gold Futures Prices (σ)

Volatility (σ) is a crucial parameter in the Black-76 model, measuring the fluctuation level of gold futures prices and significantly affecting option valuation. The annualized volatility estimate, derived from historical analysis of the daily log return data, is 0.151377. This value is then used as the input σ in the model.

Number of Contracts in the Strategy *(n)*

Parameter n is set to 1, indicating that each leg of the constructed and analyzed option strategy involves one unit of the option contract.

Construction of Strike Prices for Option Strategies

Butterfly Spread Strategy

Table 4. *Strike Price* in Butterfly Spread

K_i	**Strike Price**
K_1	2509
K_2	2641
K_3	2773

Table 4 presents the strike price parameters for the Butterfly Spread strategy analysis, namely 2509, 2641, and 2773. The third Strike Price is set by referring to the initial underlying asset price of model F_0 which is 2641. The selection of these prices assists in evaluating the payoff, profit/loss profile, and breakeven points of the Butterfly Spread strategy.

Broken Wing Condor Spread Strategy

Table 5. Strike Price in Broken Wing Condor Spread

K_i	**Strike Price**
K_1	2409
K_2	2491
K_3	2791
K_4	2914

Table 5 presents the strike price structure for the more complex Broken Wing Condor Spread strategy. The selected strike prices (2409, 2491, 2791, and 2914), with F_0 at 2641, reflect an attempt to capitalize on specific price movement expectations or to achieve a desired risk-reward profile.

Payoff Simulation for Option Strategy

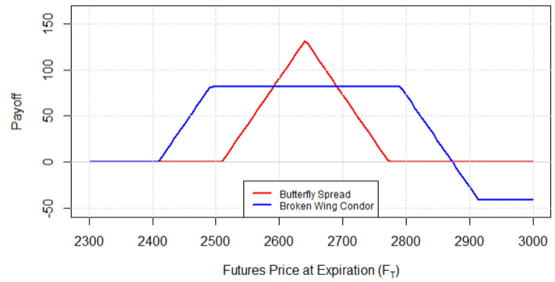

Figure 4. Payoff Profiles of the Butterfly Spread and Broken Wing Condor Spread Strategies at Expiration.

Figure 4 illustrates the comparative payoff outcomes of the Butterfly Spread (blue line) and Broken Wing Condor Spread (red line) strategies across various gold prices at expiration, excluding initial costs. The Butterfly Spread generates maximum profit precisely at the middle strike price of 2641, which is also the reference price F_0. Beyond this price range, the payoff declines until it reaches zero, indicating no profit. In contrast, the Broken Wing Condor Spread yields a positive payoff area that is broader than that of the Butterfly Spread, ranging approximately from 2491 to 2791. This reflects that the Broken Wing Condor Spread offers greater downside protection against extreme price movements compared to the Butterfly Spread.

Profit Simulation for Option Strategies

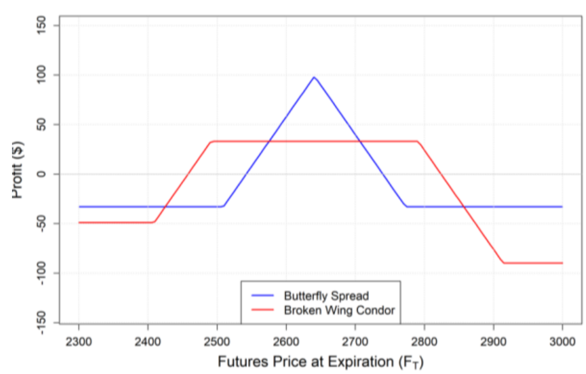

Figure 5. Net Profit Profiles of the Butterfly Spread and Broken Wing Condor Spread Strategies.

Figure 5 illustrates the difference in net profit between the Butterfly Spread and Broken Wing Condor Spread strategies after accounting for initial costs. The Butterfly Spread offers a higher maximum profit at the central strike (2641), but incurs losses outside the strike range, as its initial cost is not compensated for under extreme price conditions. Conversely, while the Broken Wing Condor Spread yields a lower maximum profit, it provides profitability over a broader price range. This strategy reflects a conservative approach suitable for uncertain market conditions, offering a higher probability of profit, albeit with lower potential gains than the Butterfly Spread.

Simulation of Unsecured and Secured Positions

The simulation of unsecured and secured positions on gold futures contracts from January 1, 2024, to December 31, 2024, highlights fundamental differences in risk profiles and return potential. Unsecured positions expose investors to losses proportional to gold price movements, which given the annual volatility of 15.14% can be substantial.

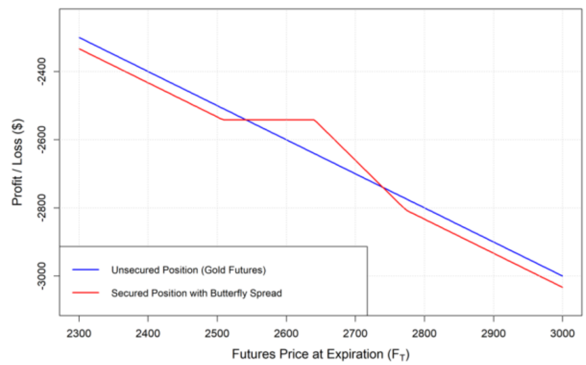

Figure 6. Comparison of Unsecured Futures Position and Secured Position Using a Butterfly Spread Strategy.

Figure 6 visually compares the profit/loss (P/L) profile of an unsecured position (blue line) with that of a secured position using the Butterfly Spread strategy (red line). The blue line shows increasing losses as the gold price moves down (in a long futures context) or up (in a short futures context) at expiration. In contrast, the Butterfly Spread (red line) effectively caps maximum losses at a certain level (approximately 2550 on the profit axis) when the gold price significantly moves outside the strike range (below 2520 or above 2680). The strategy also shows a limited maximum profit, achieved when the gold price at expiration hovers around the middle strike (around 2600). This confirms the Butterfly Spread's characteristic as a strategy designed to profit under stable or slightly volatile market conditions, with clearly defined risks and rewards.

Figure 7. Comparison of Unsecured Futures Position and Secured Position Using a Broken Wing Condor Spread Strategy.

Figure 7 illustrates the comparison between a short futures contract position (unsecured, blue line) and a secured position using the Broken Wing Condor Spread strategy (red line). The short futures position shows increasing profit as gold prices fall and increasing losses as prices rise. The Broken Wing Condor Spread strategy (red line) displays an asymmetric P/L profile. It caps losses when gold prices rise significantly (above 2800, losses capped around 2800 on the profit axis) and also limits profits when prices drop steeply (below 2400, profits capped around 2450). The "broken wing" design offers different protection or profit potential on one side of the price movement compared to the other, aligning with investor directional bias while maintaining risk control.

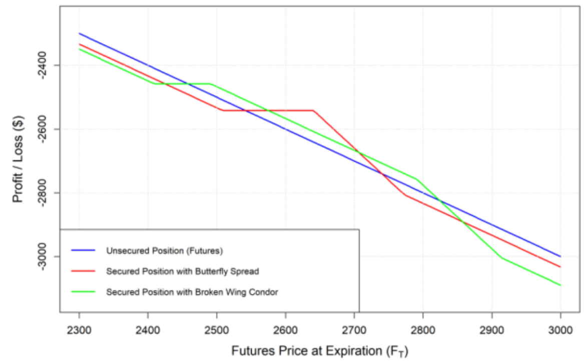

Figure 8. Comprehensive Comparison: Unsecured vs. Secured Positions with Butterfly Spread & Broken Wing Condor Spread.

Figure 8 presents a comprehensive comparison between an unsecured position (green line) and two secured strategies: Butterfly Spread (blue line) and Broken Wing Condor Spread (red line). The chart underscores how both secured strategies effectively mitigate extreme loss risks faced by the unsecured position. The Butterfly Spread (blue) displays a narrower peak in profit and symmetrical loss limitations. The Broken Wing Condor Spread (red) shows a wider and more asymmetric P/L structure, offering more flexibility to accommodate a mildly directional market view. When gold prices fall below 2450 or rise above 2750, both secured strategies show significantly smaller losses compared to the unsecured position.

Table 6. Comparative Risk–Return Characteristics of Unsecured Futures Positions and Option-Based Hedging Strategies.

Strategy	Max Profit Potential	Max Loss Potential	Main Breakeven Points	Optimal Market Condition
Unsecured Position (Long Futures)	Unlimited	Full Contract Value	Purchase Price + Transaction Cost	Strong Bullish Market
Unsecured Position (Short Futures)	Full Contract Value	Unlimited	Sale Price – Transaction Cost	Strong Bearish Market
Butterfly Spread (Call)	Limited	Limited (Net Premium Paid)	Two Breakeven Points	Neutral Market, Low Volatility, Stable Price Around K_2
Broken Wing Condor Spread (Call)	Limited (Asymmetric)	Limited (Asymmetric)	Two Breakeven Points (Asymmetric)	Neutral Market, Mild Directional Bias, Low-to-Moderate Volatility

Overall, the visualizations in Figures 6, 7, and 8 support the finding that the Butterfly Spread and Broken Wing Condor Spread strategies successfully reshape the linear risk profile of unsecured positions into profiles with capped losses, albeit at the cost of also capping profit potential.

Profit Probability Analysis of Hedging Strategies

The profit probability analysis for the Butterfly Spread and Broken Wing Condor Spread strategies is based on projected distributions of gold futures prices and the specific parameters of each strategy. The underlying assumptions of this analysis include an annual historical volatility of 15.14% and the normality of log returns on gold prices (Kolmogorov-Smirnov test p-value = 0.2086). For the Butterfly Spread strategy, the selected strike prices are 2509 (Lower), 2641 (Middle), and 2773 (Upper), with a net initial debit of 33.11288. The lower and upper breakeven points are identified at 2542.113 and 2739.887, respectively.

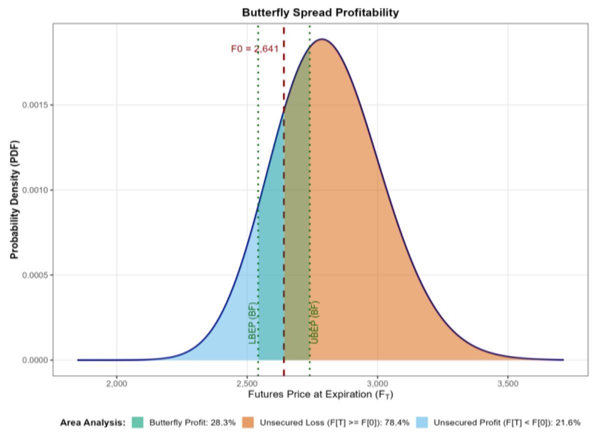

Figure 9. Probability Distribution of Gold Futures Prices and Profit Region for the Butterfly Spread Strategy.

Figure 9 visualizes the probability distribution of gold futures prices at expiration (FT) relative to the initial price F_0 = 2,641. The green-shaded area, bounded by the lower and upper breakeven points, represents the probability of profit for this strategy. Based on the simulation parameters, the probability of profit for the Butterfly Spread strategy is 28.3%, while the probability of loss is 71.7%. Furthermore, the probability that the final price lies very close to the middle strike price (between 2634.4 and 2647.6), which is where maximum profit is realized, is only 1.9%. This indicates that although the strategy offers profit potential in relatively stable markets, the likelihood of achieving this condition and realizing a net profit is relatively low under the simulated scenario.

In contrast, for the Broken Wing Condor Spread strategy, the strike prices used are 2409 (K_1), 2491 (K_2), 2791 (K_3), and 2914 (K_4), with a net initial debit of 48.91415. The lower breakeven point is 2457.914, and the upper breakeven point is 2824.086.

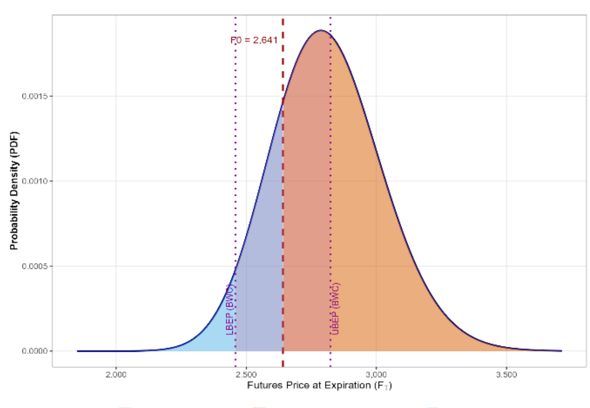

Figure 10. Probability Distribution of Gold Futures Prices and Profit Region for the Broken Wing Condor Spread Strategy.

The profit distribution graph for the Broken Wing Condor Spread displays the probability of final price outcomes. The pink-shaded area, between the lower and upper breakeven points, indicates the probability of a profitable outcome. The parameter analysis shows that the probability of profit for this strategy is 49.8%, while the probability of loss is 50.2%. Notably, the probability that the final price falls within the maximum profit range (between strike prices $K_2 = 2491$ and $K_3 = 2791$) is 41.8%. These findings demonstrate that while the Broken Wing Condor Spread requires a higher initial debit, it offers a significantly higher overall profit probability and a much greater likelihood of reaching the maximum profit range compared to the Butterfly Spread under the simulated market conditions.

Table 7. Comparison of Probability of Profit Metrics for the Butterfly Spread and Broken Wing Condor Spread Strategies.

Metric	Butterfly Spread	Broken Wing Condor Spread
Initial Net Debit	33.11288	48.91415
Lower Breakeven Point	2542.113	2457.914
Upper Breakeven Point	2739.887	2824.086
Probability of Profit	28.3%	49.8%
Probability of Loss	71.7%	50.2%
Probability of Max Profit Range	1.9% (around Mid Strike)	41.8% (between K2 & K3 Broken Wing Condor Spread)

Based on a probability-focused analysis using specific parameters and price distribution visualizations, the Broken Wing Condor Spread demonstrates a more attractive risk-return profile in terms of profit probability. With a near-even 50% chance of profitability and a significantly higher likelihood of achieving maximum profit, this strategy appears more promising than the Butterfly Spread. Although the Butterfly Spread has a lower initial cost, it shows a much smaller probability of generating profit. Ultimately, the choice of hedging strategy will depend on the individual investor's risk tolerance and their expectations regarding futures gold price movements. However, this analysis provides a robust quantitative foundation for making that decision.

From an economic perspective, the results indicate that the Broken Wing Condor Spread offers a superior balance between risk limitation and profit probability under uncertain but low-to-moderate volatility conditions. While the Butterfly Spread remains attractive for highly stable markets, its narrow profit region significantly reduces its likelihood of success in realistic market environments.

The findings of this study offer several practical implications for investors and risk managers engaged in gold futures markets. First, the results highlight that holding unsecured futures positions exposes investors to substantial downside risk, even under low-to-moderate volatility conditions. Option-based hedging strategies, such as the Butterfly Spread and the Broken Wing Condor Spread, provide structured mechanisms to cap potential losses while maintaining predefined profit opportunities.

For investors with a neutral market outlook and strong confidence that gold prices will remain close to a specific level, the Butterfly Spread may be an appropriate choice due to its lower initial cost and clearly defined maximum loss. However, the narrow profit region associated with this strategy implies a relatively low probability of profit, making it less suitable for uncertain or mildly directional market conditions.

In contrast, the Broken Wing Condor Spread demonstrates greater flexibility and a higher probability of profit, particularly in environments characterized by modest volatility and mild directional bias. Although this strategy typically requires a higher initial debit, it offers a broader profitable price range and asymmetric risk protection, which may be attractive to investors seeking more consistent outcomes rather than maximum payoff.

From a risk management perspective, these findings emphasize the importance of aligning hedging strategies with both market expectations and individual risk tolerance. Investors prioritizing stability and capital preservation may prefer strategies with higher profit probability and limited downside risk, even at the expense of lower maximum returns. Consequently, the Probability of Profit (POP) metric serves as a valuable complementary tool to traditional payoff analysis in evaluating the practical effectiveness of option-based hedging strategies.

While the simulation results demonstrate the effectiveness of the Butterfly Spread and Broken Wing Condor Spread in managing risk, real-world implementation of these strategies is inevitably influenced by transaction costs and liquidity conditions. Option-based strategies require multiple option contracts, implying higher cumulative transaction costs compared to holding a single futures position. These costs may include bid–ask spreads, brokerage fees, exchange fees, and margin requirements, all of which can reduce net profitability.

Liquidity constraints also play an important role, particularly for multi-leg option strategies. Although gold futures and their associated options are generally liquid, liquidity may vary across strike prices and maturities. Wider bid–ask spreads for deep out-of-the-money options can increase execution costs and introduce slippage, potentially altering the realized payoff and profit profile relative to theoretical simulations.

Despite these considerations, the structured nature of the Butterfly Spread and Broken Wing Condor Spread still offers meaningful risk control benefits. Even when transaction costs are taken into account, the ability to cap maximum losses and shape asymmetric risk–return profiles remains valuable, especially for investors prioritizing downside protection. Future studies may explicitly incorporate transaction costs and liquidity-adjusted pricing to further refine the practical applicability of probability-based hedging strategy evaluation.

4. Conclusion

This study confirms that taking an unhedged (unsecured) position in gold futures contracts exposes investors to substantial loss risks. In contrast, option strategies such as the Butterfly Spread and Broken Wing Condor Spread have proven effective in limiting these potential losses, albeit at the cost of also capping maximum potential gains. In the simulations conducted, the Broken Wing Condor Spread exhibited a more favorable profit probability profile than the Butterfly Spread, particularly in terms of the likelihood of reaching its maximum profit range. These findings underscore the importance of carefully selecting strategy parameters, especially strike prices, in shaping the desired risk-return profile.

Based on these results, investors are encouraged to consider these option strategies as risk management tools. The choice between Butterfly Spread and Broken Wing Condor Spread should be aligned with each investor's market expectations and individual risk tolerance. For practitioners, these findings suggest that the Broken Wing Condor Spread is more suitable for investors seeking higher consistency of returns, whereas the Butterfly Spread may be reserved for scenarios with strong confidence in price stability.

For future research, it is recommended to explore the performance of these strategies under various market conditions and time horizons, compare them with alternative hedging approaches, and incorporate implied volatility analysis and transaction cost impacts to achieve a more comprehensive understanding.

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