PROJECT REPORT

CORRELATION ANALYSIS

YEAR OF REPORT 2025

Women mentorship program report : 2025

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PART-A : Correlation analysis

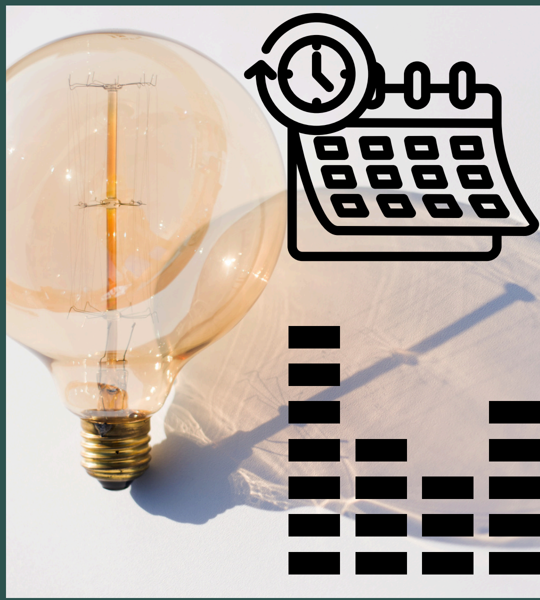
Abstract: This report analyzes the correlation between Gold, Oil, Bitcoin, and a selected Nifty Fifty stock to construct a balanced portfolio. Using Pearson correlation and visual tools, it identifies diversification opportunities and selects Tata Motors to optimize risk-return trade-offs, especially under bullish market conditions.

INTRODUCTION

The primary objective of this project was to perform a correlation analysis among Gold, Oil, Bitcoin, and one additional asset from the Nifty Fifty index. The analysis was structured within the broader context of portfolio management, going beyond basic statistical correlation. Pearson correlation coefficients were calculated for the three core assets—Gold, Oil, and Bitcoin—and their relationships were visualized using a correlation matrix and scatter plots to better understand their interdependencies. Based on these insights, a fourth asset from the Nifty Fifty was selected with the aim of minimizing overall portfolio risk while maintaining strong return potential, particularly under bullish market conditions.

Timeline and Frequency

The portfolio has been structured with a long-term investment horizon in mind. Accordingly, both the data timeline and sampling frequency have been chosen to align with this objective. Historical price data for all assets was sourced from Yahoo Finance. The analysis covers a three-year period—from May 8, 2022, to May 8, 2025—using a weekly frequency. This results in a dataset comprising 156 data points per asset. The rationale for this selection is to capture sufficient market cycles and reduce noise while maintaining a manageable dataset for meaningful statistical analysis.



FREQUENCY

Avoid random spikes

Using weekly frequency helps reduce the impact of random price spikes that are more common in daily or intraday data.

Long term investement

For long-term investing, a longer time horizon is essential, and keeping the data smooth is a key objective.

Optimum amount of data

To ensure a thorough analysis, both the timeline and frequency are adjusted to yield an optimal number of data points.

TIMELINE

Cyclic and seasonal changes

Each year, factors like seasons, festivities, and other cyclical events impact prices. To capture these recurring patterns, a year-over-year timeline is used.

Avoid covid shock

The COVID-19 shock, a short-term disruptive event, had lingering effects until mid to late 2021. To avoid distortion from this major event, the analysis begins in 2022.

Assets Analysis

From the originally provided assets, The first analysis that was conducted was a correlation analysis between the provided three. The beta coefficient i.e, systematic risk for the selected timeline was also determined for all three of them. Then these values were analysed to determine the suitable beta and correlation coefficients for the 4th asset to be selected.

Beta coefficient calculation

According to the timeline the **beta coefficients** for **Gold, Oil, Bitcoin** were calculated as **0.18, 0.37, 0.79** respectively. Assuming that all 4 assets have equal weightage The final goal was to get the overall beta of our portfolio around 0.5-0.7, to keep a balance between avoiding market risk and also profit a little during bull market situations. Hence the beta coefficient of our 4th asset was determined to lie in the range of (0.66, 1.46) The calculations was done according to the following formulae:-

$$\beta = \frac{\text{Covariance}(r_a, r_m)}{\text{Variance}(r_m)} \qquad \beta_{\text{portfolio}} = \sum_{i=1}^{n} w_i \beta_i$$

Correlation coefficient calculation

The correlation analysis was conducted for Gold, Oil, Bitcoin. The details of analysis is in the following pages. According to the analysis, correlation coefficients were:-

1) Gold and bitcoin: 0.92
2) Gold and Oil: -0.49
3) Oil and Bitcoin: -0.58

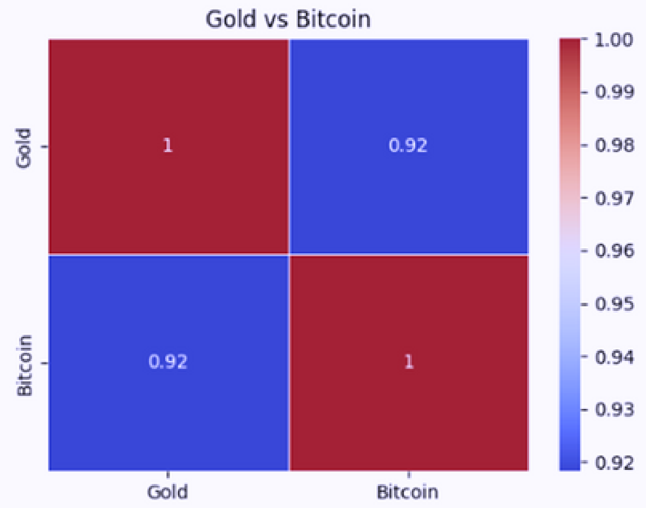
This was indicative of 2 Major points. Bitcoin and gold are highly correlated and will move together. Oil is negatively correlated to both of them providing diversification in the current portfolio. Hence the 4th asset should serve as a stable equity component and be moderately correlated to the other assets.

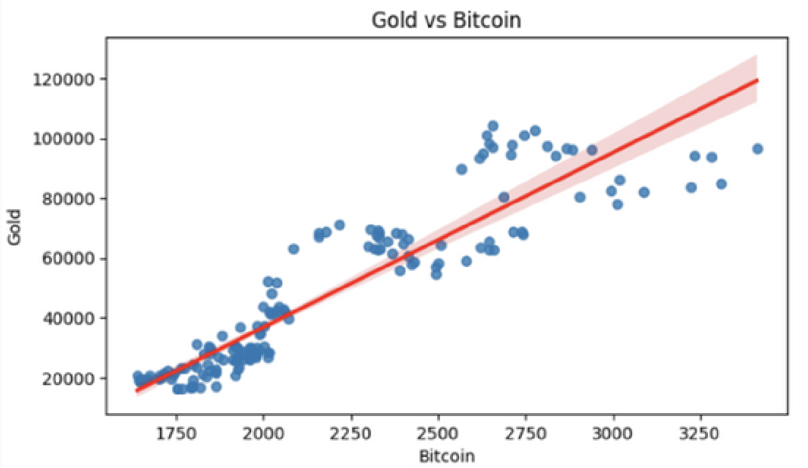
4th Asset selection

Based on the earlier findings, the selection of a fourth asset from the Nifty Fifty began with calculating the beta coefficients for multiple companies. Assets falling within a desired beta range were then evaluated for their correlation with the existing portfolio assets. While the selection may not be perfectly precise, Tata Motors was chosen as the fourth asset due to its relatively suitable correlation profile and a volatility of 1.26. A detailed analysis is provided below.

Pairwise Correlation Analysis

Gold and Bitcoin

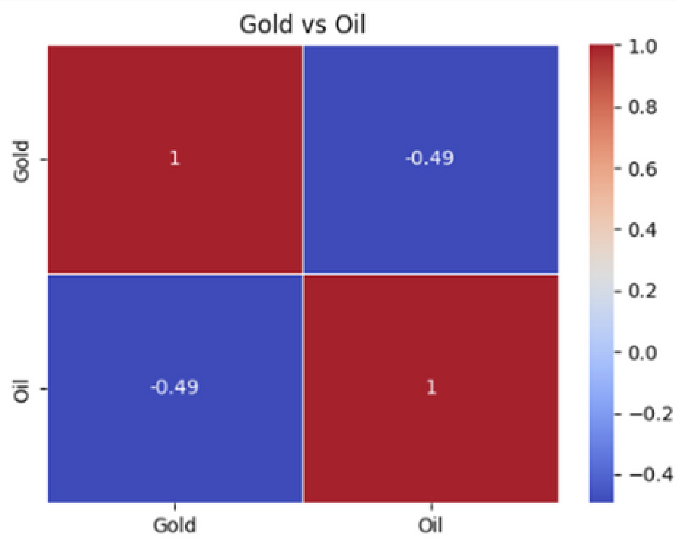


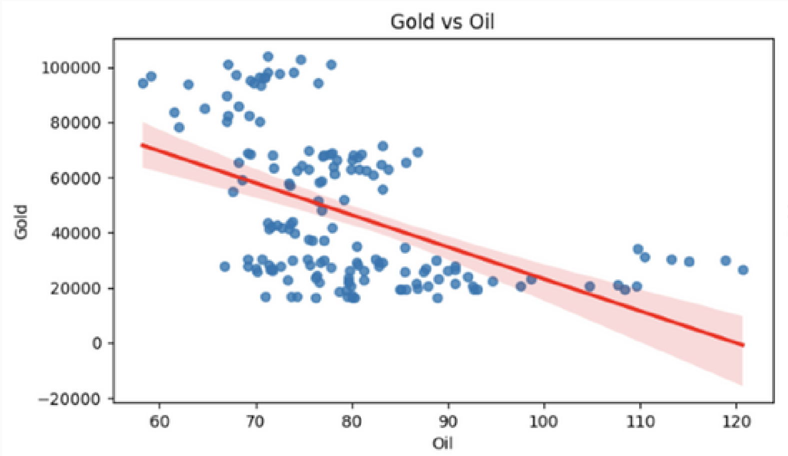


Correlation analysis : The correlation coefficient of gold and bitcoin is 0.92 indicating that they are highly correlated and move almost together. Despite their fundamental differences (Bitcoin is a digital asset, Gold is a traditional store of value), market sentiment often treats them similarly—particularly in times of economic uncertainty or risk aversion.

Scatter plot: The scatter plot indicates that there's little dispersion, meaning both assets tend to rise and fall together with minimal exceptions. The trend line gives us the intuitive idea that the correlation coefficient might be very close to one., also displaying little to no outliers showing consistent growth

Gold and Oil



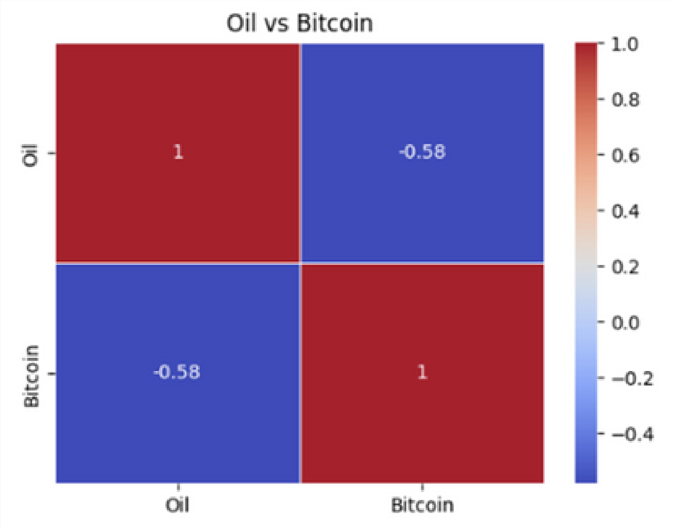


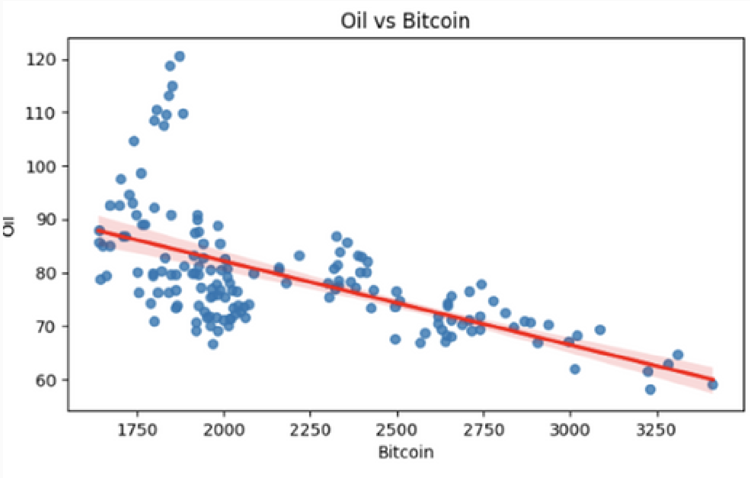
Correlation analysis : The correlation coefficient of -0.49 shows a moderate negative correlation means that these two often move in opposite directions, but not always consistently**.** Gold and Oil offer a natural hedge against each other. When oil spikes (e.g., due to war or supply shock), gold may not follow, making this pair valuable for risk balancing.

Scatter plot: The scatter plot shows a downward slope with noticeable spread. The relationship is not as tight but it does show a clear trend. The trend line gives us an intuitive idea that the correlation coefficient is negative. The spread of points gives us the idea that the absolute value of the coefficient might not be high.

Pairwise Correlation Analysis

Oil and Bitcoin

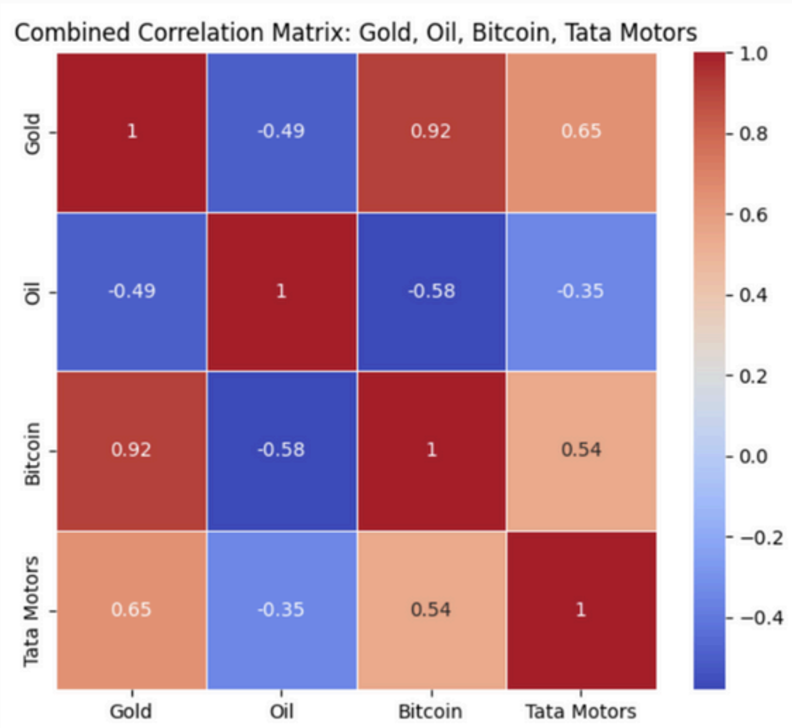




Correlation analysis : The correlation coefficient of -0.49 shows a moderate negative correlation. Not a perfect inverse relationship, but strong enough to consider for diversification. This is the most negative correlation in the trio, Indicative of the fact that Oil and Bitcoin often respond to different macro triggers, being a good hedge for each other.

Scatter plot: The plot is scattered but leans downward, confirming the negative relationship. Moderate dispersion shows that although the trend exists, it's not as predictable. The points show little dispersion from the trend line despite outliers, the data mostly follows the trend, which gives confidence in the stability of the negative relationship**.**

TATA Motors and other assets

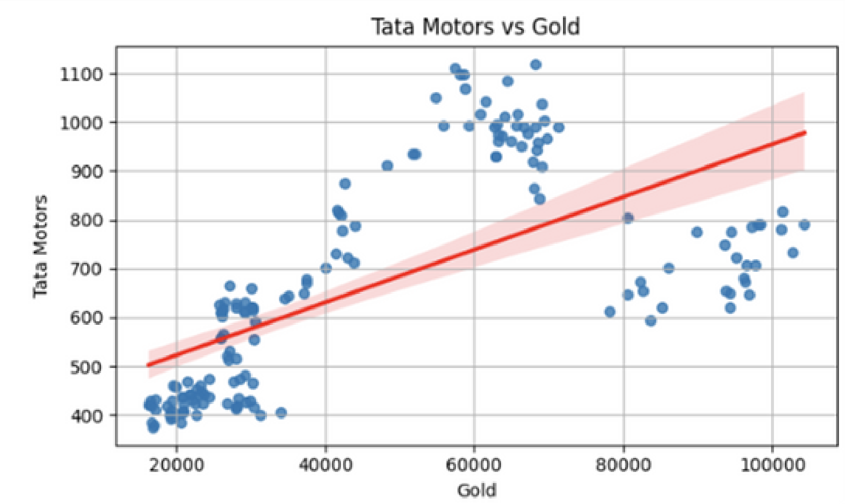


Correlation matrix analysis: The correlation of Tata Motors with other assets is a moderate value acting sort of like a stabilizer. Though it being positively correlated to gold and bitcoin, but negatively with oil makes our portfolio a bit less diverse, but adding a 4th asset from a different sector diversifies our asset class i.e, Commodities (Gold, Oil), Cryptocurrency (Bitcoin), and Equity (Tata Motors). Therefore exposure to different macroeconomic cycles (commodity, equity, and digital asset trends) will not drive our portfolio into a shock.

Correlation coefficients:

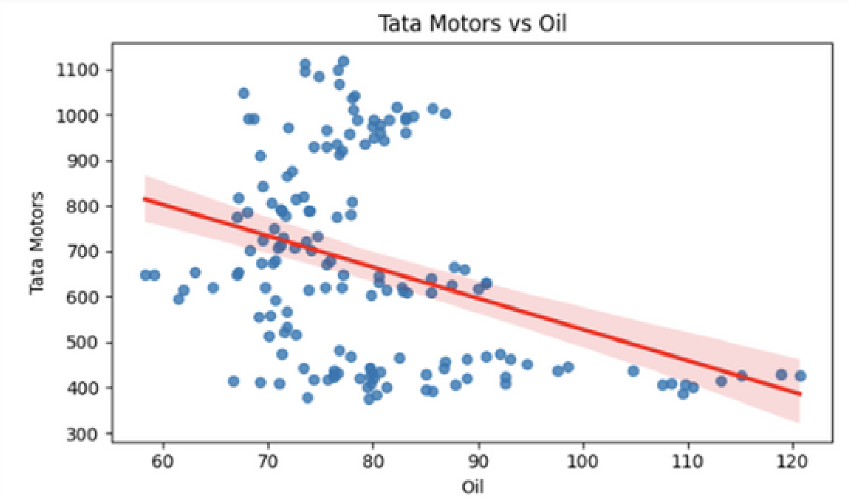
With Gold: 0.65
With Bitcoin:0.54
With Oil: -0.35

Pairwise Correlation Analysis



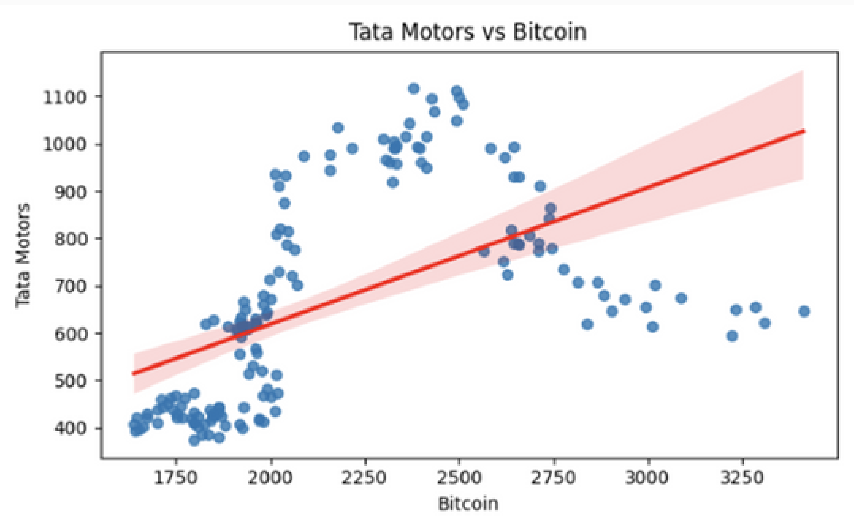
Correlation coefficient of Tata motors and gold is 0.65 showing a good positive correlation. As gold is considered a safe haven asset having a positive correlation is beneficial for the portfolio.

The scatter plot displays a lot of spreading indicative of Tata Motors volatile nature and slightly weak relationship . The trend line helps us have a good understanding of the positive relationship from the scattered points.



Correlation coefficient of Tata motors and oil is -0.35, hence as Oil prices rise, Tata Motors stock tends to decline slightly. This makes sense because higher oil prices increase transportation and manufacturing costs, which can hurt auto company margins. Thus, Oil prices may partially influence Tata Motors, but not enough to reliably predict performance

Regression line slopes downward, confirming the negative correlation. Points are more scattered, indicating a weaker, noisier relationship.



Correlation coefficient of Tata motors and Bitcoin is 0.54, moderately positive. Tata Motors and Bitcoin show signs of shared behavior in bullish phases. This helps align parts of the portfolio toward growth opportunity without complete overlapping.

The Trend line displays a clear positive correlation but the points are heavily dispersed indicating volatile nature of both the assets as well as a moderate correlation.

Market Insights from the analysis

Market insights reveal relevant, actionable, and previously unrealized truths about markets through deep data analysis. They help businesses make informed strategic decisions by uncovering hidden patterns and relationships between different asset classes and market behavior. The following insights can be derived from the analysis

Risk Management

- The Beta Positioning i.e, By selecting Tata Motors with a beta in the desired range (0.66–1.46), the overall portfolio sits in a moderate beta zone—capable of growth in bull phases, while still controlling risk.
- Bitcoin Introduces volatility while Bitcoin introduces volatility, but Gold and Oil act as stabilizers. Tata Motors sits in the middle. Thus giving us a suitable opportunity for high returns (via BTC), Cushioning during shocks (via Gold/Oil)Reasonable beta-linked returns (via Tata).

Hedging Strategies

- Oil acts as the primary hedge, with strong negative correlations to Bitcoin (−0.58) and Gold (−0.49), helping reduce portfolio volatility during crypto or commodity shocks.
- Tata Motors adds further balance through its mild negative correlation with Oil (−0.35), stabilizing equity exposure.
- Gold provides a safe haven buffer during market uncertainty, complementing the high-beta behavior of Bitcoin and Tata Motors.

Diversification

- Oil provides excellent diversification for portfolios containing Gold, Bitcoin, or Tata Motors due to its negative correlations. This asset mix reduces overall portfolio risk by combining high-correlation (Gold–Bitcoin), low-correlation (Tata–Oil), and negatively correlated (Gold–Oil) pairs.
- Despite appearing different, Gold and Bitcoin (0.92 correlation) offer minimal diversification benefit when held together, but Since gold is our safe haven asset, having a positive correlation with it might benefit us long term
- Having assets from different sectors diversifies our asset class i.e, Commodities (Gold, Oil), Cryptocurrency (Bitcoin), and Equity (Tata Motors). . By combining these assets, the portfolio gains resilience to sector-specific shocks. and macroeconomic shifts.

Trading implications

- In bullish markets, Bitcoin and Tata Motors can be positioned for growth, supported by their positive correlation (0.54).
- Oil enables mean-reversion strategies, offering counter-cyclical entries during overheated equity or crypto phases.
- Gold–Bitcoin co-movement (0.92) can be tactically exploited via momentum-based pair trades, especially during high-risk sentiment phases.

Conclusion

This project used Monte Carlo simulation to analyze how six key market parameters—risk-free rate, volatility, dividend yield, time to maturity, strike price, and spot price—impact the pricing and sensitivities (Greeks) of a floating strike lookback call option. Unlike standard options, this exotic option's value depends not just on the final asset price but on the full price path, making its behavior more complex and its Greeks more nuanced. The simulation revealed unique patterns, such as negative Delta behavior, positive Theta in multiple scenarios, and extreme Vega sensitivity under volatility and time shifts. Overall, the study confirmed that floating lookback options respond in highly non-linear ways to market conditions, requiring traders and risk managers to adapt their hedging and valuation strategies accordingly. This also validates the power of simulation-based pricing when closed-form models fall short in capturing path dependency.

Key Outcomes :

- Option value rises sharply with volatility and time.
- Higher interest rates increase Rho and make Theta more positive.
- Dividend yield lowers price and weakens all Greeks.
- Longer maturity boosts Vega, Rho, and Theta; reduces Delta and Gamma.
- Strike price has no impact (as expected for floating strike).
- Higher spot price increases value but pushes Delta negative.