Project 2: Option Pricing and Derivative Strategy Design on Reliance Industries

Objective

To compute option prices using theoretical models, and simulate realistic outcomes under market volatility using Black-Scholes pricing and Monte Carlo Simulation to evaluate optimum trading strategies for Reliance Industries (RELIANCE.NS).

Methodology

Using python, we downloaded the historical price data for Reliance Industries along with spot prices and option chain data. Based on this data, a series of calculations were made, including calculating market premiums which includes computing the average of the bid and ask price for both call and put options. After this, we calculate the daily percentage returns from the historical price data along with the standard deviation of daily returns to calculate historical volatility. Time to maturity is calculated as the difference between the date of the option and the date the code was run on, which is 38 days. The risk free rate has been taken as 6 percent. Using these, we use Black-Scholes to estimate the implied volatility of call and put options. Implied volatility is the market's expectation of future volatility, derived by inverting the Black-Scholes formula using the observed market prices. These functions take the market premium, current stock price, strike price, time to maturity, and risk-free rate as inputs and iteratively adjust the volatility until the Black-Scholes price converges to the market premium. We then check if the put call parity relationship holds. We then use the Monte Carlo simulation to have another alternative approach to option pricing. We then visualise a few possible future stock price paths for Reliance Industries using the same geometric Brownian motion model used in the Monte Carlo simulation.

Based on this data, we choose which derivative strategy is best for this stock to maximise returns. Examples of strategies considered include Bull Call Spread, Covered Call or Protective Put, Long Straddle / Long Strangle, Synthetic Long or Short, Collar Strategy, Futures Hedge and Butterfly Spread.

Market Data Summary

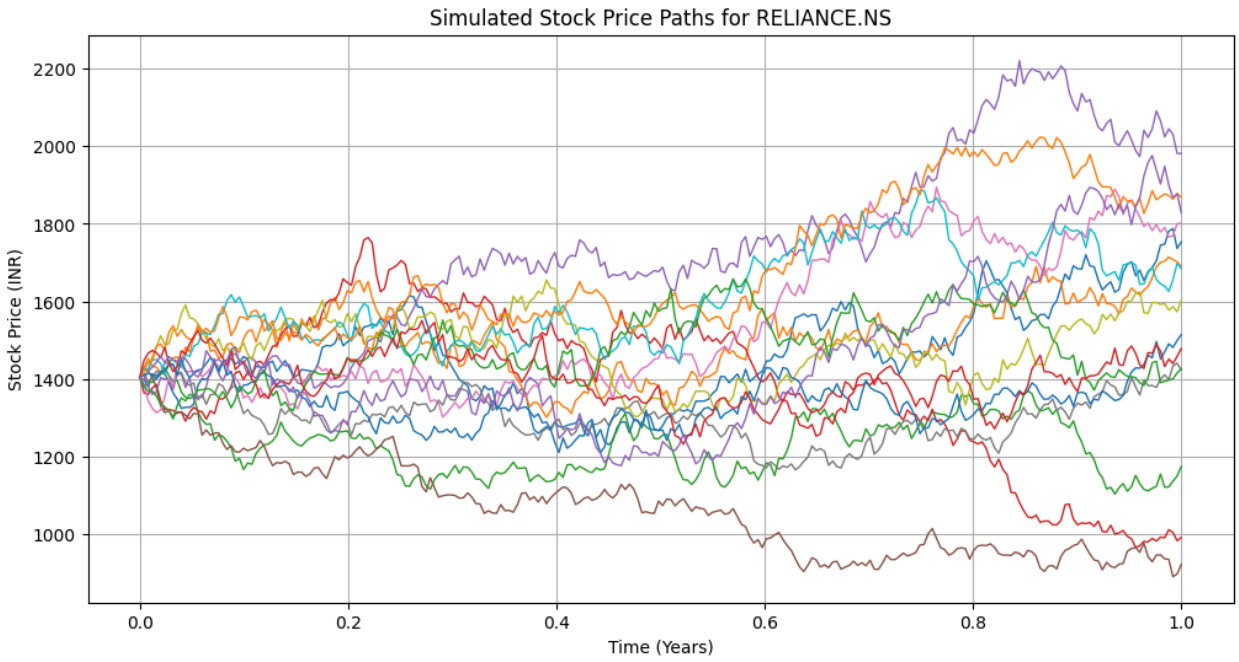
For the option chain for expiry date 29th May 2025, there are 5 options. Strikes observed**:** 960, 970, 980, 990, 1000. On the Call Side, Call Bid prices are decreasing from ₹304.95 (960 strike) to ₹282.55 (1000 strike). Call Ask prices are also decreasing from ₹364.30 to ₹308.25 across the same strikes. Market Call Premium is falling from ₹334.625 to ₹295.400. On the Put Side, Put

Bid prices are relatively low, between ₹0.85 and ₹1.05. Put Ask prices range between ₹1.05 and ₹2.20. Market Put Premium stays very low, between ₹0.975 and ₹1.575. This means that call premiums are significantly higher than put premiums across all strikes. The market is pricing calls much higher, suggesting that the market has bullish sentiments. The put premiums show very little variation, indicating limited downside fear around the strike levels.

On doing Black Scholes analysis, on the Call Side, Market Call Premium (midpoint of bid-ask) falls from ₹334.625 to ₹295.400 whereas Model Call Premium decreases from ₹341.48 to ₹301.73. Implied Call Volatility is constant at 0.0001 which means that the market is expecting very little volatility on the bull side. On the Put Side, Market Put Premium remains very small (₹0.975 – ₹1.575) whereas Model Put Premium increases slightly from ₹0.00029 to ₹0.00325. Implied Put Volatility is higher than Historical Volatility, ranging from 0.2493 to 0.5026, which suggests that the market is expecting a significant downturn in the market. Other metrics from the model, Historical Volatility is constant at 0.2282 across all strikes. Put-Call Parity (Market) is marked as False which indicates market prices are not matching theoretical parity. However, Put-Call Parity (Model) is marked as True meaning theoretical prices satisfy parity. From this we can see a curious case that call options are trading at high premiums as compared to puts, with almost negligible implied call volatilities, which shows some mismatch. Put options appear expensive in terms of implied volatility, but cheap in absolute premium terms.
When doing the Monte Carlo simulation, the simulated call and put prices are extremely similar to the actual prices, with very small differences between them. Differences are small such as the actual call premium being INR 451.3780 and the simulated call premium being 451.1031. On the put side, it is INR 1.5246e-04, and the simulated put price is 5.4076e-05.

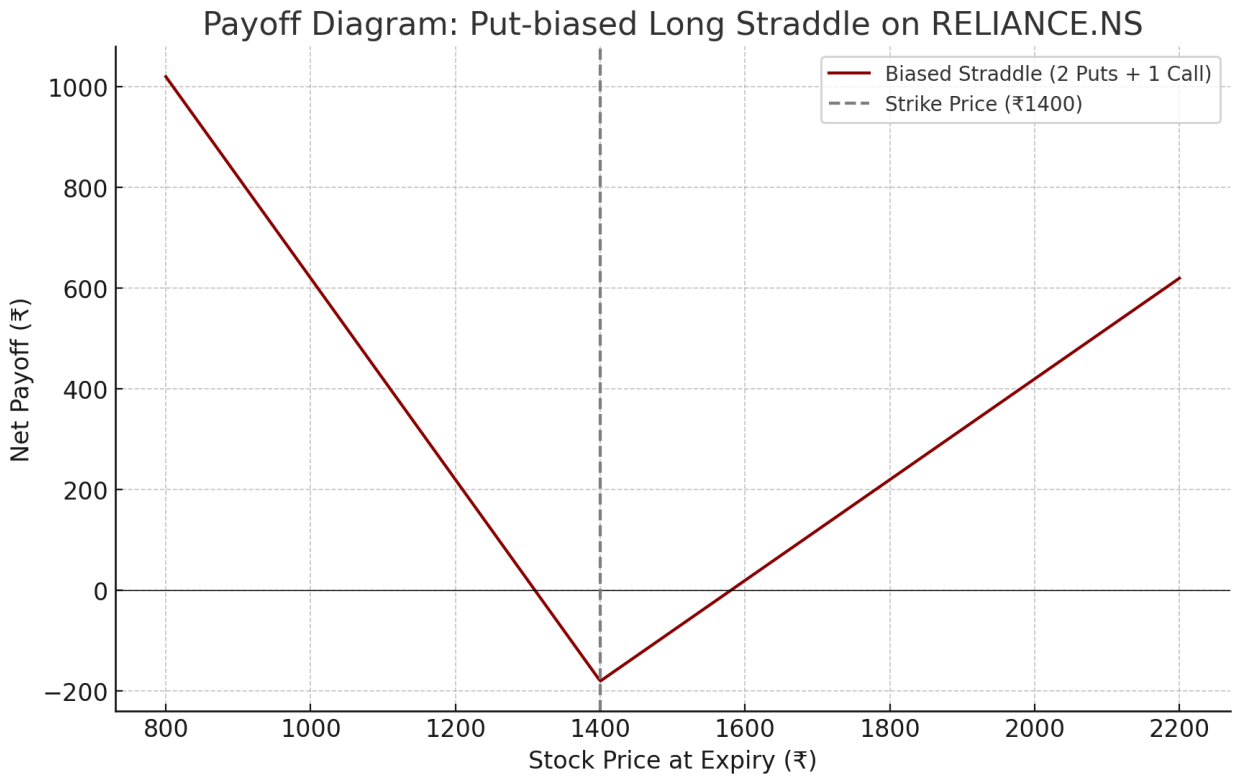
Simulated Stock Price Paths for Reliance show high variation. The stock goes from INR 1400 to around INR 2000 in the upper end forecast and to around INR 900 in the lower end forecast. Most price paths end up in the range of INR 1700 to INR 1450, which are both higher than the starting price. In fact only 3 out of the 15 price paths, or 20 percent of the price paths result in the stock price ending up lower than the starting stock price, although in each case, the stock does fall by 200 INR or more, suggesting that the downside risk needs to be accounted for. 4 price paths or 26 percent of the price paths have the stock end up around 100 INR above, which suggests that there is some risk of the stock ending up by only a small amount, but the majority of the price paths end up in the stock being up or down by large amounts of money.

Chosen Strategy



The Simulated Stock Price Paths show that the stock is expected to move big in either direction. 73 percent of stock paths predict movements in excess of INR 200. This means that we should employ a **Long Straddle** strategy which lets us profit from the stock moving big in either direction. We will not make much profit in 3 of the 15 predictions, but are bound to make money in the above 15. We are helped by the fact that the Implied Volatility is predicting the stock to actually have bearish tendencies but the prices do not reflect this, with the call premium being overpriced when we also view its Implied Volatility. While buying underpriced puts and selling overpriced calls is a good strategy as well, the issue remains that in our prediction, we still have the stock ending above the current price 80 percent of the time. This means that we need to assume that the chance of the stock ending up is also high. A covered call is another strategy that we were heavily considering but ended up dropping because the breakeven points were similar and we were profiting in only 20 percent of the predicted paths and making break even in the other 80 percent, which is not optimum. We did not consider options like the ButterFly spread because the range between the upside and the downside is too vast for us to be able to execute such strategies. The final chosen strategy is therefore the Long Straddle with a bias towards buying the underpriced puts.

Strategy Payoff & Analysis



In this payoff strategy, we are in the negative in around 4 out of the 15 predicted stock paths and we make profit in the remaining 11 predicted stock paths. We have gone with a biased straddle approach because our data shows that the put is underpriced. From this payoff diagram, we can derive an expected value of our profit and compare it with other strategies. We are assuming every predicted stock path is equally likely. This is the expected value for each of the predicted paths -

Path	Final Price (₹)	Put Payoff (₹) (2 Puts)	Call Payoff (₹) (1 Call)	Total Payoff Before Cost (₹)	Net Payoff (Total Payoff - ₹310.45) (₹)
1	1375	0	375	375	64.55
2	1500	0	500	500	189.55
3	1450	0	450	450	139.55
4	1300	0	300	300	-10.45
5	1700	0	700	700	389.55
6	1200	0	200	200	-110.45

7	1800	0	800	800	489.55
8	1250	0	250	250	-60.45
9	1600	0	600	600	289.55
10	1000	0	0	0	-310.45
11	1550	0	550	550	239.55
12	1400	0	400	400	89.55
13	1350	0	350	350	39.55
14	1450	0	450	450	139.55
15	1100	200	100	300	-10.45

The final expected value of the profit is INR 140. The covered call strategy has a much smaller expected profit of INR 18.33. The expected profits of the Butterfly Strategy is INR 21.67. I have attached the exact numbers per strategy and the calculation in the appendix. We can therefore see that the strategy with the most optimum returns is the biased long straddle strategy with the payoff diagram shown above.

Key Takeaways

The market is turbulent and there is a lot of mismatching of expectations. The calls are quite expensive when we look at their implied volatility but that pricing is fair when we consider the fact that the Monte Carlo Simulation assumes that the stock is expected to rise in the future. The puts are quite cheap when we look at their implied volatility but they also do not represent most of the predicted stock paths. The volatility and mismatch of expectations could be a result of the differences between the company's inherent value which is pushing for more bullish claims and the current macroeconomic situation due to high inflation and the continued threat of tariffs and global uncertainty. As such, we cannot expect markets to remain still. If Reliance reports positive earnings growth that surpasses market expectations then we can expect the stock to increase by large amounts as it could be considered a safe stock during volatile times whereas underperformance could lead to positions being cut.

Appendix

Python Code