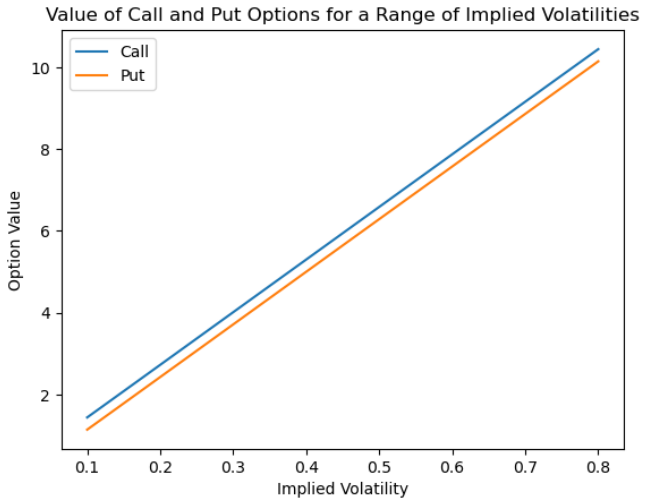
Zhiqiang Tian Fintech 545 11/04/2023

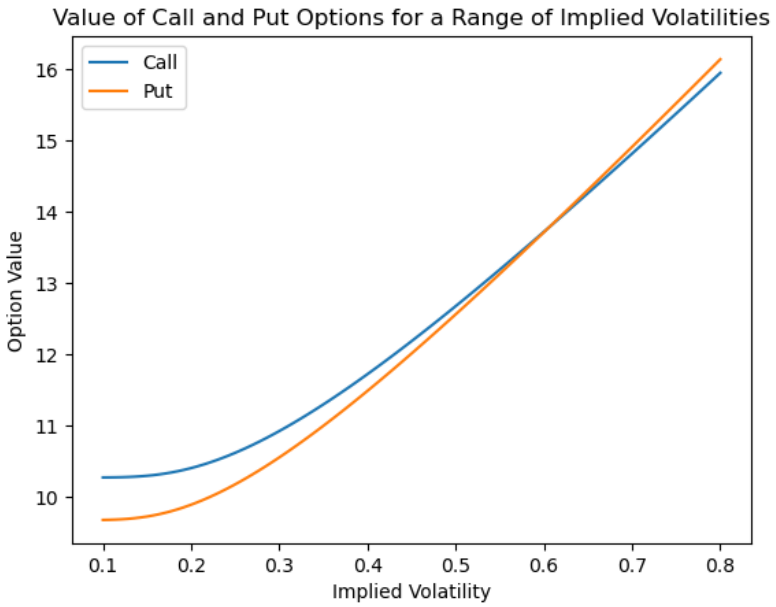
Week06 Project

Problem1

If we assume the strike price is equals with the current stock price, the graph is shown below:



The option value, for both calls and puts, demonstrates a linear relationship with implied volatility. This is understandable because when ln(S/X) is zero in the Black-Scholes model, it signifies that the current stock price S is identical to the strike price X, classifying the option as at-the-money (ATM). In such a case, the variables d1 and d2 are determined solely by the risk-free interest rate r, the cost of carry b, the asset's price volatility sigma, and the time remaining until maturity T. This condition highlights the direct sensitivity of ATM options to changes in implied volatility.



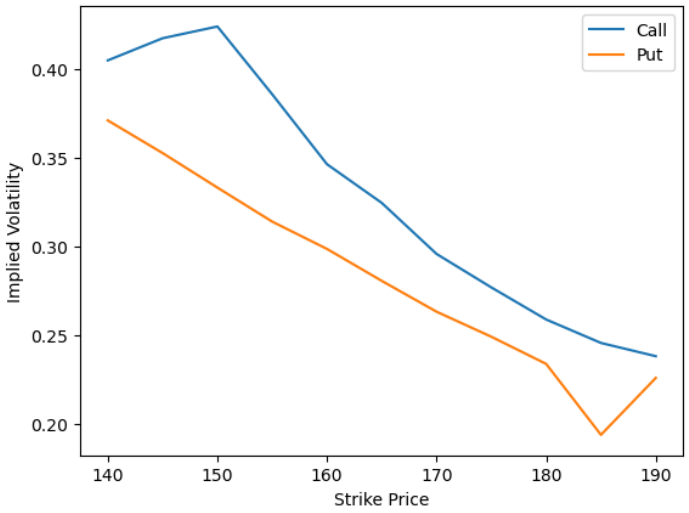
The chart illustrates that the value of call and put options increases as implied volatility increases with a strike price of “call” = 155 and a put option with a strike price of “put” = 175. The values start at just above 10 and increase to 16 as implied volatility approaches 0.8, with the put option initially having a higher value but converging with the call option at higher volatility.

Thus, we can obtain the following investment strategy:

If volatility is expected to rise and the stock price will be above the strike price, it may be advantageous to buy the call option.

If volatility is expected to be higher and the stock price may fall below the strike price, then buying a put option may be a strategy.

Problem2

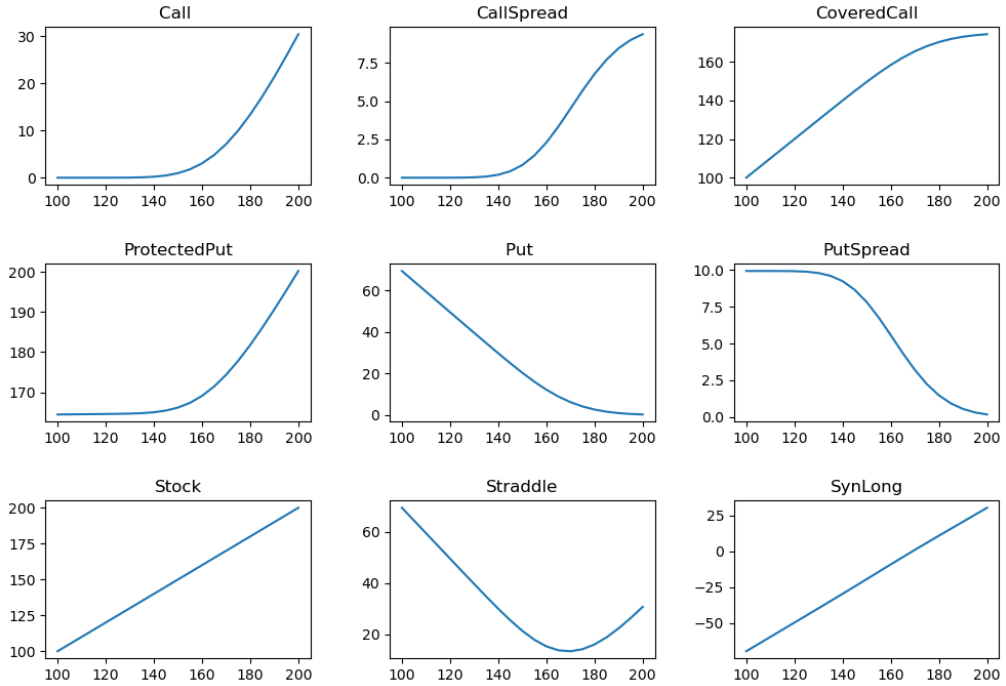


The graph illustrates the relationship between implied volatility and strike prices for call and put options, displaying the phenomenon known as volatility skew. In the chart, we observe that for call options, the implied volatility is higher at lower strike prices and decreases as the strike price increases, which presents a typical 'reverse skew' or 'volatility smile' pattern. This indicates that market participants expect less uncertainty in price movements as the underlying asset's price increases.

Conversely, the implied volatility for put options appears to slightly increase at higher strike prices, especially noticeable at the tail end on the right side of the graph. This could indicate a market concern for downside risk, where there is an anticipation of more dramatic price movements if the asset's price were to fall.

Such volatility skew is usually caused by asymmetric expectations of future price movements of the underlying asset. If investors anticipate that the risk of a price decrease is greater than the risk of a price increase—or that price movements will be more volatile on the downside—then the implied volatility for call options at low strike prices and put options at high strike prices will be elevated. This is because investors are willing to pay a premium to protect against a potential decline in price.

Problem3



1. Call: The shape starts flat and then slopes upward after a certain point (the strike price), reflecting that a long call option has no value until the underlying asset's price exceeds the strike price, beyond which it offers unlimited profit potential.

2. Call Spread: The shape rises with the underlying price but then flattens out, showing a capped profit potential. This is because the call spread strategy limits both potential gain and loss.

3. Covered Call: The shape is linearly increasing and then flattens. It combines the linear profit potential of owning the stock with a plateau at the point where the sold call option caps further gains.

4. Protected Put: This is a mirror image of the Covered Call graph but flipped vertically, indicating stock ownership with a put option for protection, guaranteeing a minimum payout (the put strike price) if the stock falls.

5. Put: The graph slopes downwards and then flattens out, reflecting that a long put option increases in value as the underlying price decreases, with maximum profit at or below the strike price.

6. Put Spread: The shape descends and then levels out, indicating a limited profit range. This is typical for a vertical put spread, where you benefit within a range when the underlying asset's price falls.

7. Stock: The shape is a straight line with a positive slope, illustrating the direct, one-for-one correlation between the stock price and the payoff.

8. Straddle: The graph forms a V shape, indicating that the strategy profits from significant price movements in either direction but has a maximum loss limited to the premiums paid if the underlying price stays near the strike price.

9. SynLong: The graph is a straight line with a positive slope starting below the horizontal axis, showing that it mimics long stock exposure but begins with an initial cost (loss) equal to the net premium of the options.

Calls, Puts, and Stock show linear relationships with the underlying asset price once in-the-money, with calls and stock gaining with an upward price movement and puts with a downward move.

Covered Call and Protected Put indicate a modification of the linear relationship by options, capping gains or losses, respectively.

Spreads show how buying and selling options can limit both risk and reward, as reflected by the plateau in their payoff diagrams.

The Straddle shape demonstrates a strategy designed to profit from volatility rather than directional movement.

SynLong shows that combining options can simulate other positions (like stock ownership), but with different cost structures as indicated by the graph starting below the horizontal axis.

Portfolio	Mean	VaR	ES
Call	0.604972	15.797181	18.914327
CallSpread	-0.160003	1.986177	2.990954
CoveredCall	-0.130899	2.454929	4.122473
ProtectedPut	0.584594	16.685168	20.277700
Put	0.098163	0.273888	0.276006
PutSpread	0.077448	0.157878	0.159198
Stock	0.535874	17.441673	21.771266
Straddle	0.703135	14.538330	16.547867
SynLong	0.506809	17.056031	21.280787

From the result, we can discuss the calculated Mean, VaR (Value at Risk), and ES (Expected Shortfall) for different option-based portfolios:

1. Mean: The Call, Protected Put, Put, PutSpread, Stock, Straddle, and SynLong strategies show positive mean returns, indicating that, on average, these positions are expected to be profitable over the simulation period. The CallSpread and CoveredCall strategies have negative mean returns, suggesting an expected average loss.

2. VaR: The Call, Protected Put, Stock, Straddle, and SynLong have higher VaR values, implying a greater risk of financial loss compared to other strategies.

The Put and PutSpread strategies show the lowest VaR, indicating they are the least risky in terms of potential losses.

The negative mean in CallSpread and CoveredCall might seem contradictory given their low VaR. This is because VaR, while a useful risk measure, does not capture tail risk.

3. ES: Protected Put, Stock, and SynLong exhibit the highest ES values, indicating that losses could be substantial in the tail end of the distribution of returns.

The Put and PutSpread maintain the lowest ES, which aligns with their conservative risk profile suggested by VaR.

Despite CallSpread and CoveredCall showing negative means, their ES is relatively low, reflecting that losses beyond the VaR threshold are not expected to be excessive.