Project Week 06

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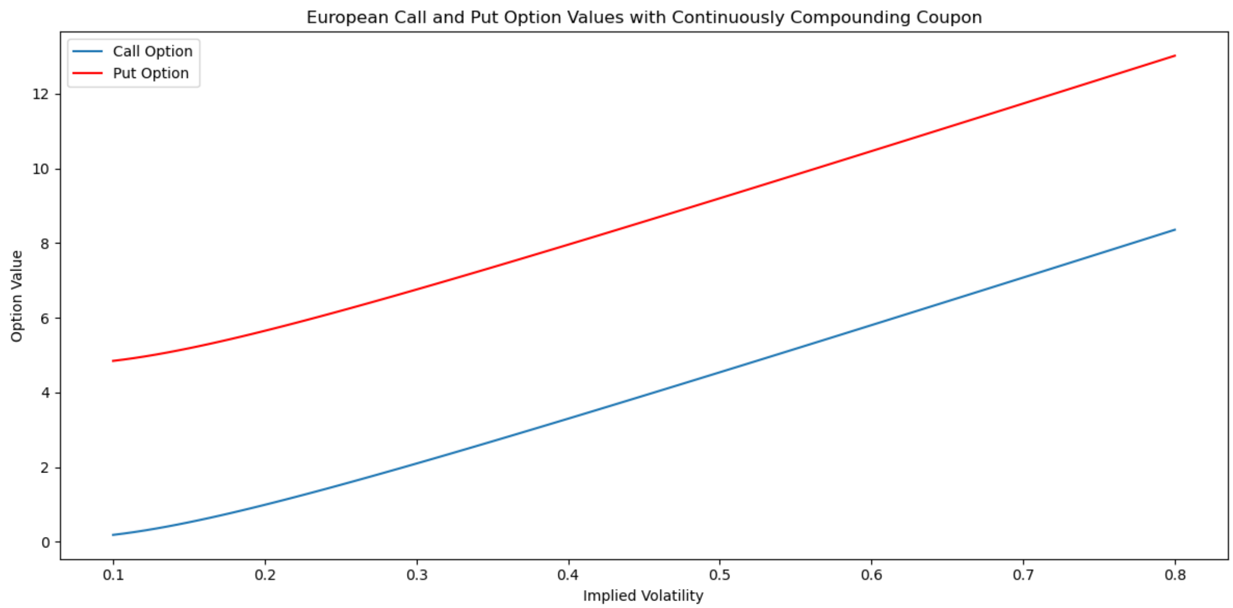
Problem 1:

For a range of implied volatilities between 10% and 80%, plot the value of the call and the put



Discuss these graphs. How does the supply and demand affect the implied volatility?

What I see is that as the implied volatility increases, there is a near linear but still concave relationship between increases in implied volatility and option values. This intrinsically makes sense. High implied volatility means that there is not as much of a certainty of the outcome of the call or put, therefore the increased risk must be met with an equivalent increase in option value. For a call, higher volatility means the likelihood of the underlying's price rising above the strike price and therefore possibly making it more valuable. For a put, it means that there is a higher likelihood that the price can fall below the strike price. Therefore, for both, the value must increase as implied volatility does.

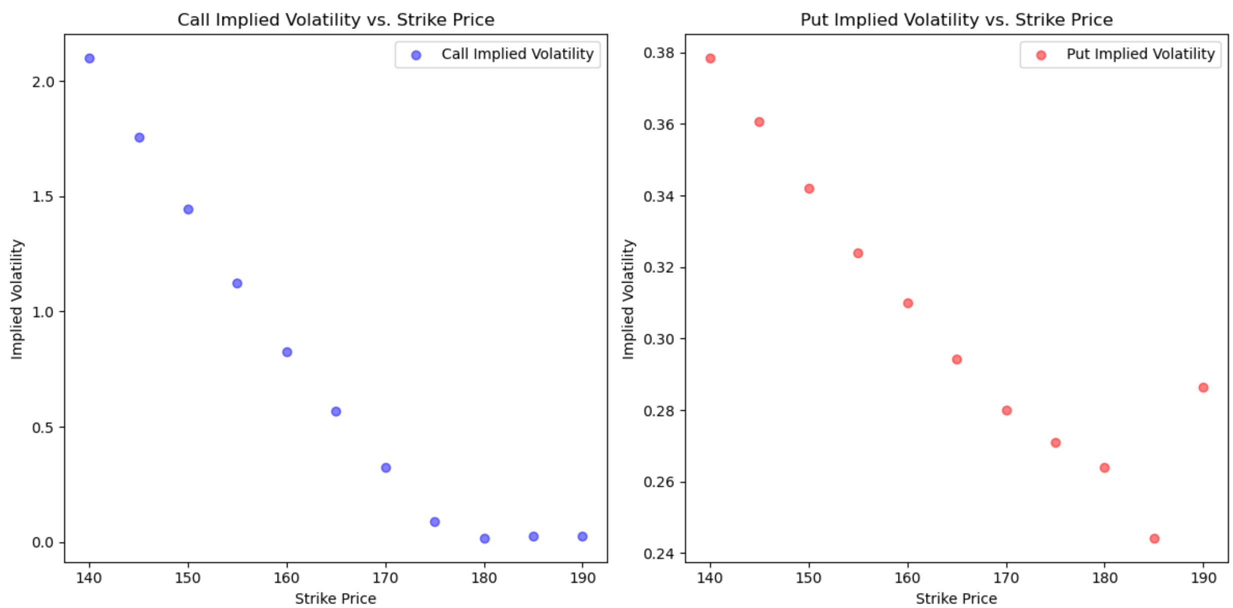
When demand for options rises it means that option risk premiums and implied volatilities increase. This is because sellers increase the underlying prices with higher demand. Decreased demand means lower implied volatilities. Larger supplies will inversely reduce implied volatilities, while decreased supply can increase implied volatilities.

I performed these calculations by using the normal Black-Scholes model I created inside of *integral_bsm_with_coupons.* With an adjustment for a continuously compounding coupon. I added this present coupon value to the payoff structure during the max process.

Problem 2

Calculate the implied volatility for each option. Plot the implied volatility vs. the strike price for Puts and Calls. Discuss the shape of these graphs. What market dynamics make these graphs?

In order to calculate the implied volatility I created a minimizable method using a built in optimizer to find the minimum of the market price and the option price that I calculate in my options_price method, which is just a simplified version of the Black-Scholes that allows for an input of the Merton cost of carry, which I used for the dividend rate addition. I found the implied volatility that best fit the given strike price for the options prices I produce and graphed them below.



What I see is that for both calls and puts, as the strike price increases, the implied volatility decreases. Although, the implied volatility decreases much more drastically for the calls. Hypothetically, there should be a general increase in implied volatility on either side of the At-The-Money strike price of $170.15. It makes sense that for the strike prices that are very much Out-of-the-Money, the implied volatility should be higher. I can even see that for a very far out In-the-Money strike price of $190, the implied volatility also spikes higher.

What I imply about the market conditions are several-fold after researching more about this topic. Firstly, there is volatility skew between the calls and the puts. The relatively massive call implied volatilities at Out-of-the-Money strikes shows that there is very high uncertainty regarding the long-term strategies related to Apple. I am assuming that there must be higher demand for low strike prices on Apple, which means that investors are bullish on its future performance. The low implied volatilities for high call strikes would have to mean the inverse, that there is low demand.

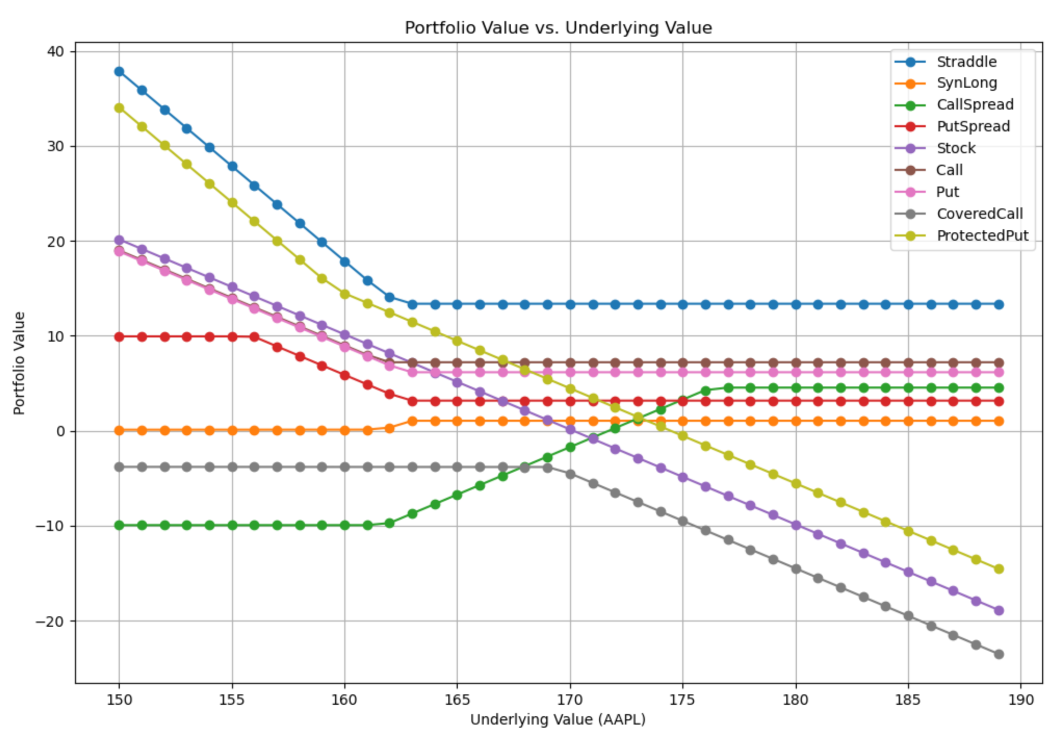
Separately for the puts I see a more typical volatility smile shape. The higher implied volatility at very low strikes shows that there must be higher price uncertainty for Out-of-the-Money options, which makes sense as higher volatilities usually imply further reaches away from the underlying. It appears that there is less of a need for protective puts once I am ATM though the likelihood of big price decreases went down. The big jump once I am ITM though shows that investors are more leaning towards future price increases.

Overall, what these graphs show me is that investors think that Apple is currently undervalued in the market. This could be due to their recent failure to produce enough cash on hand to reach the prior levels of revenue growth YoY. Despite this though, Apple is a huge and successful company that people expect to perform well in the long term.

Problem 3

For each of the portfolios, graph the portfolio value over a range of underlying values. Plot the portfolio values and discuss the shapes. Bonus points for dying these graphs to other topics discussed in the lecture.

In order to plot the portfolio value vs. the underlying value, I created a function called *calculate_portfolio_value*. This function takes in a portfolio and an underlying value and then performs implied volatility minimization to find an implied volatility that I can then use to calculate the option value. I also made sure to only use the dividend rate if I was utilizing a Call rather than a Put, since only in the Call option should I gain the dividends. Then I added the total values based on the quantity in holding to produce the graph below.



For this graph I can see several things. Firstly, for the all of the portfolios that just held the stock, I can see that the value is monotonically decreasing as the underlying value increases. This intuitively makes sense, as if the underlying value is greater than the current price of the stock, I am generally losing money even if I have a covered call or protected put to retain it. In the case of the covered call, I am always losing money though. At least for the protected put, I generally am retaining money even after my option would be slightly out of the money. The call spread is the only one that monotonically increased in value, despite being generally at a loss. It appears that all of the portfolios that don't hold a stock stagnate at a slight profitability shortly before the current value, while the call spread only stagnates later.

The straddle stagnates as the underlying increases since the profitable leg starts to be balanced out by the loss of the other. The synthetic long's short put and long call balance out and result in only a slight increase in portfolio value due to mimicking the underlying. The put spread at separate prices helps to limit losses but stagnates as the underlying gets too large. The normal call and put both just decrease as the underlying value increases, up until it is slightly OTM, then they stagnate.

Note that for my straddle, I am using dividends for the call but not for the put. This leads to a slight breaking of put-call parity.

Using DailyPrice.csv, calculate the log returns of AAPL. Deman the series so there is 0 mean. Fit an AR(1) model to AAPL returns. Simulate AAPL returns 10 days ahead and apply those returns to the current AAPL price. Calculate Mean, VaR, and ES. Discuss

Calculated next 10 days prices (rounded to nearest cent):

173.48

170.02

166.68

168.66

161.55

165.58

167.79

168.80

173.90

174.34

Mean Price: $171.71607

VaR: 165.80020

There is a 5% risk that the price of Apple will fall below this level in the next 10 days.

ES: 171.71607

If the price falls below the VaR, the expected loss is ~$171.72. The ES is higher than the VaR, so there could be more losses in the tail of the distribution. Also, note that these lean towards a sightly bullish outlook for Apple since the average price is higher than the current price. But also, if the price does drop below the VaR, there is a very large expected shortfall.