Problem 1

Assume you a call and a put option with the following

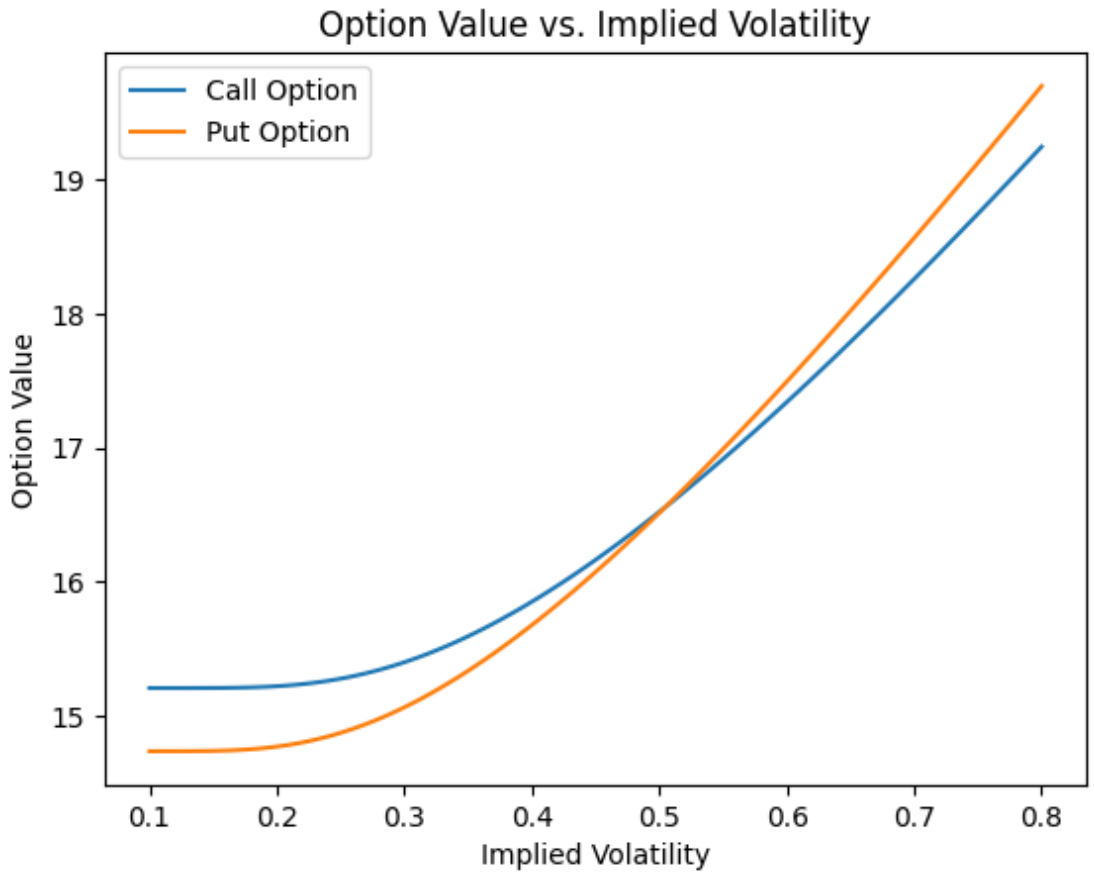
- *Current Stock Price $165*
- *Current Date 03/03/2023*
- *Options Expiration Date 03/17/2023*
- *Risk Free Rate of 4.25%*
- *Continuously Compounding Coupon of 0.53%*

Calculate the time to maturity using calendar days (not trading days).

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?

1. Count the number of calendar days from current date to maturity date.
2. Divide the date to maturity to 365 which represent time to maturity with 1-year base
3. Write the function that calculate option values with input either call or put option, and all the parameters given above.
4. Notice that we do not have strike price given, so for data input, we assume Call strike price under market price, and Put strike price over the current price.
5. Set an implied volatility list from 0.1 to 0.8.
6. Plot the result of option values versus implied volatility:



Conclusion:

We can see when vol start from 0.1, the option value of Call is greater than that of Put, as implied volatility increases, put option value becomes greater than call option value.

So, put option is more sensitive to volatility change. I believe that the supply and demand can positively impact the volatility because the more supply and demands means the market has more chance to fluctuate. That brings more instability which means more implied volatility. It also means higher option values.

Problem 2

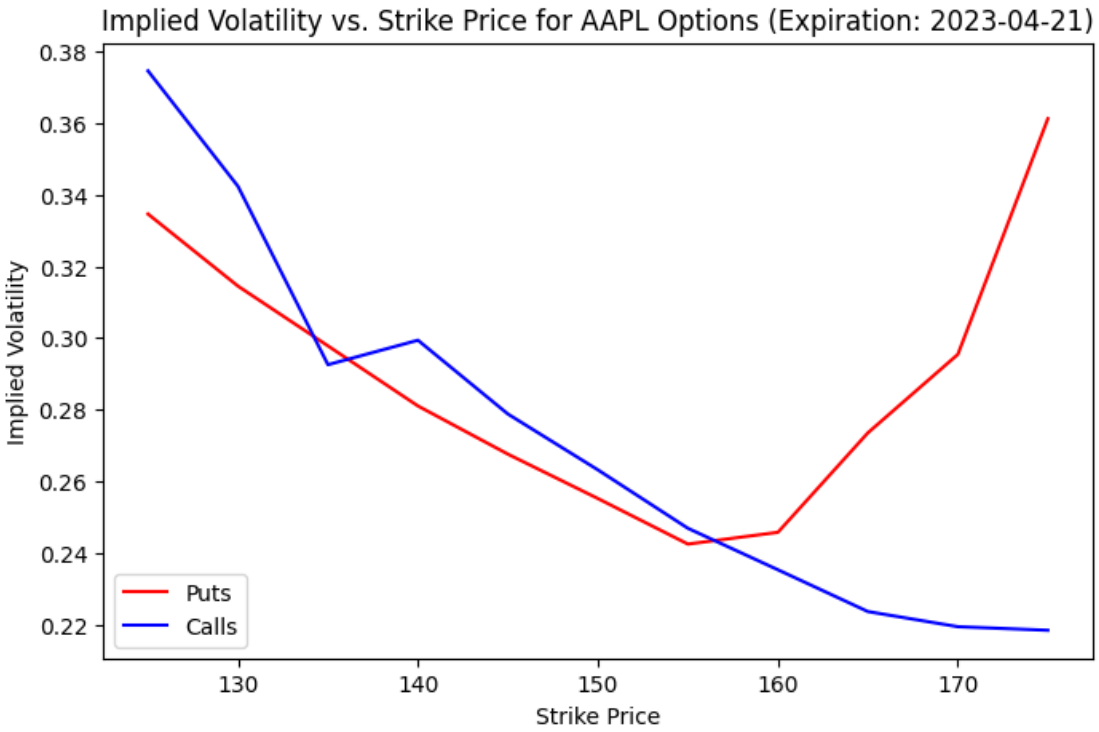
Use the options found in AAPL_Options.csv

- *Current AAPL price is 151.03*
- *Current Date, Risk Free Rate and Dividend Rate are the same as problem #1.*

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 could make these graphs?

1. Read the AAPL_Options.csv by pd.read_csv.
2. Calculate the time to maturity with yearly unit by using calendar days divide 365.
3. Write the function calculate implied volatility.
4. Appy step 2 and step 3 to add to the data frame with new columns.
5. Plot the relationship between Implied volatility and strike price for both Puts and Calls:



Conclusion:

The shape of Puts option volatility is approximately a V shape, the implied volatility at its minimum when strike price is around 155, which is close to the current price. And the V shape is skewed to the left so more sensitive to prices larger than current stock price.

Calls option volatility is approximately a linear relationship with negative coefficient. The higher strike price generally led to a lower implied volatility because with call option strike price greater than current price, the buyer of call option could directly get the arbitrage.

Problem 3

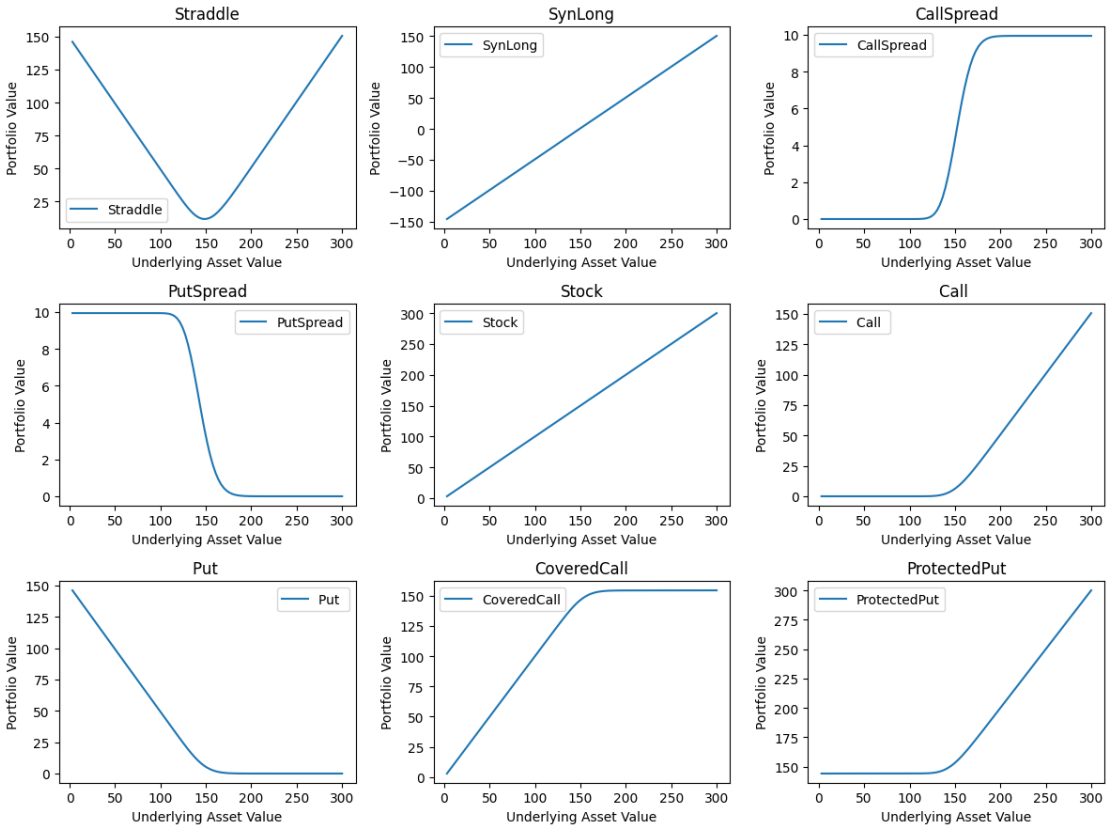
Use the portfolios found in problem3.csv

- *Current AAPL price is 151.03*
- *Current Date, Risk Free Rate and Dividend Rate are the same as problem #1.*

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 available for tying these graphs to other topics discussed in the lecture.

Using DailyPrices.csv. Calculate the log returns of AAPL. Demean 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 (above). Calculate Mean, VaR and ES. Discuss.

1. Read problem3.csv in pd.DataFrame, and add Time to maturity column and Implied volatility column just like we did in problem 2.
2. Read DailyPrices.csv in pd.DataFrame, select AAPL column, then use log return function in our risk_mgmt package to calculate the log returns of AAPL, minute the mean.
3. Use ARIMA library in stats to fit the model of AR(1) of the demean returns we get from last step.
4. We want to do a 10-step simulation, use coefficient from the model we fit to get a 10x1000 data (We do 10 step simulation for 1000 times)
5. Then we get 1000 simulation price of AAPL, remember, since we are calculating 10 days ahead. Write the function that calculate the portfolio values given input of portfolio data, we need to consider date change in calculating maturity days.



6. Apply the 1000 simulation prices of AAPL to our portfolio calculation function to get the distribution of 10 days ahead portfolio value, use the same function calculate the current portfolio value. Then subtract the current portfolio value from simulation portfolio value.
7. Apply function that calculate VaR and ES and mean on the portfolio value difference:

	Mean	VaR	ES
Straddle	1.681096	1.380783	1.387824
SynLong	0.215258	16.437672	20.414538
CallSpread	-0.039387	3.912805	4.219456
PutSpread	0.26704	2.629686	2.819268
Stock	0.419859	16.193816	20.14699
Call	0.948177	6.063505	6.404707
Put	0.732919	4.366393	4.611642
CoveredCall	-0.632114	12.368091	16.202312
ProtectedPut	1.051666	8.117699	8.761803

Conclusion:

The portfolio with greatest expected return is Straddle, with relatively lowest VaR and ES value the least expected return is from Covered Call portfolio. Synlong has the largest VaR and ES, which means the largest risk.
Overall, The Straddle portfolio is the best portfolio according to AR(1) model simulation for 10 days ahead of AAPL.