Project 06

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Problem 1

Assume you a call and a put option with the following

- Current Stock Price $165
- Current Date 02/25/2022
- Options Expiration Date 03/18/2022
- Risk Free Rate of 0.25%
- Continuously Compounding Coupon of 0.53%

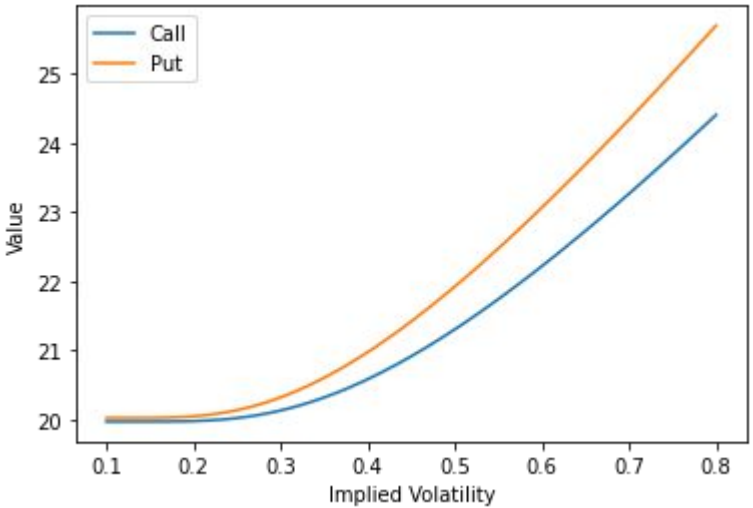
Calculate the time to maturity using calendar days (not trading days).

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?

Problem 1 Solution

Time to maturity: 0.057534246575342465



From the plot we can see that the values of the options rise with the implied volatilities. It is easy to understand that the increase in demand or decrease in supply for an option will cause its price to rise, and with the relationship we discovered above, it's clear that the implied volatility will move in same directions.

That is to say:

- The increase in demand or decrease in supply for an option will cause its implied volatility to rise.
- The decrease in demand or increase in supply for an option will cause its implied volatility to fall.

Problem 2

Use the options found in AAPL_Options.csv

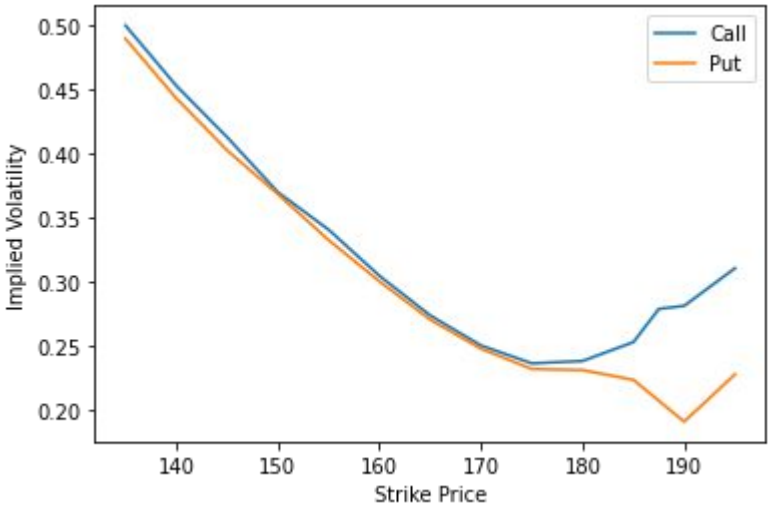
- Current AAPL price is 164.85
- Current Date, Risk Free Rate and Dividend Rate are the same as problem #1.

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?

There are bonus points available on this question based on your discussion. Take some time to research if needed.

Problem 2 Solution

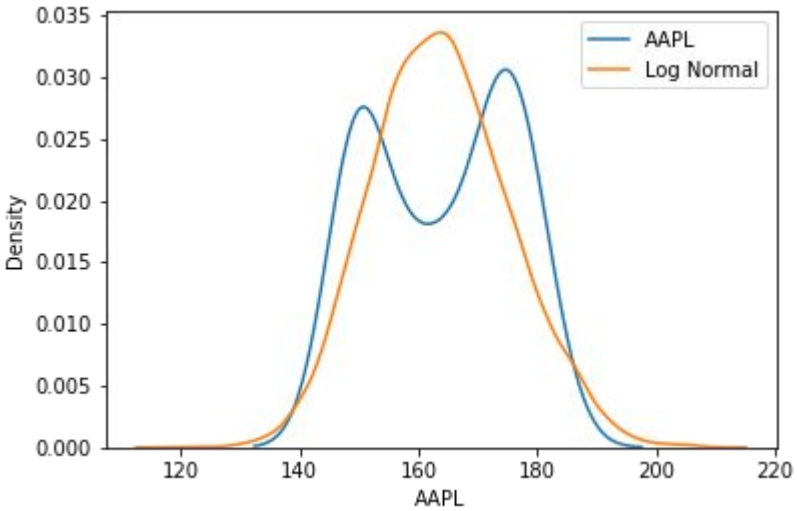


From the plot we can see a clear pattern of how the implied volatility changes based on different strike prices. The pattern is typical and it's commonly known as a "Volatility Smile".

For a given expiration, options whose strike price differs substantially from the underlying asset's price command higher prices (and thus implied volatilities) than what is suggested by standard option pricing models. These options are said to be either deep in-the-money or out-of-the-money. And this kind of market dynamics could lead to the "Volatility Smile" pattern.

This anomaly implies deficiencies in the standard Black–Scholes option pricing model which assumes constant volatility and log-normal distributions of underlying asset returns. We can plot the actual distribution of the return and compare it with the lognormal distribution assumption.

Problem 2 Solution



From the plot we can see that the actual distribution is very different from the log normal distribution assumption used by Black–Scholes method. This is one major reason for the "Volatility Smile" pattern.

Problem 3

Use the portfolios found in problem3.csv

- Current AAPL price is 164.85
- 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.

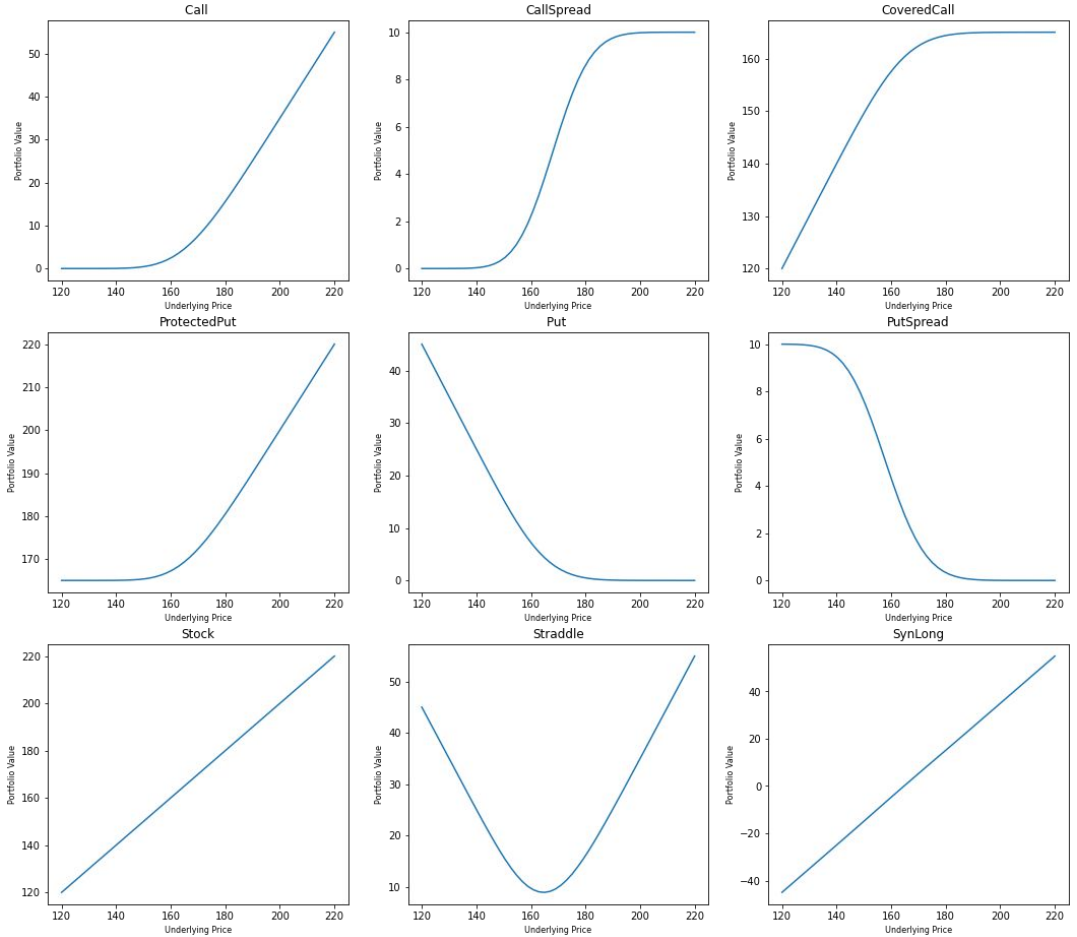
Using DailyReturn.csv. Fit a Normal distribution to AAPL returns – assume 0 mean return. Simulate AAPL returns 10 days ahead and apply those returns to the current AAPL price (above). Calculate Mean, VaR and ES. Discuss.

Hints:

- you will need to calculate the implied volatility – not the same value as in #2
- you need to take into account the change in dates for option valuations. You are simulating forward in time and options valuations are a function of time
- Calculate the PL from the current portfolio value using Current Date

Problem 3 Solution

Portfolio values over a range of underlying prices plots for different portfolios.



Problem 3 Solution

Portfolio	Mean	VaR	ES
Call	0.12274332045919473	4.349409974790256	4.431032403554611
CallSpread	-0.22099544552141348	3.629788377554571	3.711144170641994
CoveredCall	-0.08403849585527873	8.959942355351403	12.038749323442277
ProtectedPut	0.2468617870778979	4.129920939476676	4.191795197730967
Put	0.2081569624739886	4.2437069661004205	4.3290903142024195
PutSpread	0.35929580586285104	2.6645946411618917	2.7384322924623685
Stock	0.038704824603916645	13.309352330141673	16.46978172699689
Straddle	0.33090028293318285	2.443504957071009	2.4521588480755145
SynLong	-0.08541364201479133	13.528841365455257	16.70901893282053

Problem 3 Solution

From the plots and data above, we can see that:

- For Call and Put: The basic options. Makes money as the stock price goes up or down. The risks are moderate.
- For CallSpread and PutSpread: They add a limit the the basic Call and Put. Lowering the risk by sacrificing returns.
- For CoveredCall and ProtectedPut: Basically a mix of stocks and options. The patterns are similar as Call or Put. The risks are also between stocks and options.
- For SynLong and Stock: SynLong has the same straightforward pattern as Stock, but with double returns. Both have high risks.
- Straddle: The most special portfolio here, since it makes money as long as the price moves regardless of the direction. The risk is low among all portfolios.