Week06 project

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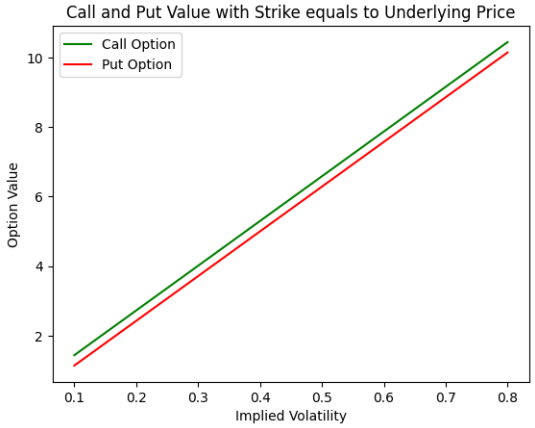
Question1

Time to Maturity is 0.0384.

From the graph, we can see that in all three cases, as implied volatility increases, the prices of call and put options both rise. This is because higher volatility means the underlying asset's price is more likely to move, increasing the option's value.

According to the supply and demand principle, when the demand for options in the market increases, their prices go up. To match these higher prices, implied volatility needs to rise. On the other hand, when market demand for options is low, implied volatility decreases.

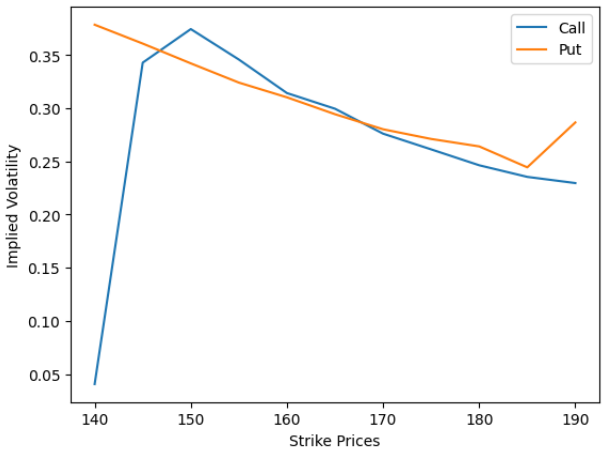


Question2

The implied volatility for each option:

	implied_vol		
0	0.040555	11	0.378369
1	0.342728	12	0.360649
2	0.374271	13	0.342034
3	0.345630	14	0.323954
4	0.314111	15	0.310123
5	0.299383	16	0.294251
6	0.275944	17	0.280079
7	0.261183	18	0.270984
8	0.246236	19	0.263976
9	0.235327	20	0.244299
10	0.229500	21	0.286510

The graph below shows the implied volatility vs the strike price for Puts and Calls:



For calls, the implied volatility decreases as the strike price increases. This might indicate that lower strike prices have higher demand due to perceived higher risk. For puts, the curve also trends downward but shows an upward turn at higher strike prices.

The difference between put and call implied volatilities comes from the way risk is viewed. Investors often buy puts for protection against price drops, increasing their demand and implied volatility. Calls may only show higher implied volatility if there is strong expectation of a price increase.

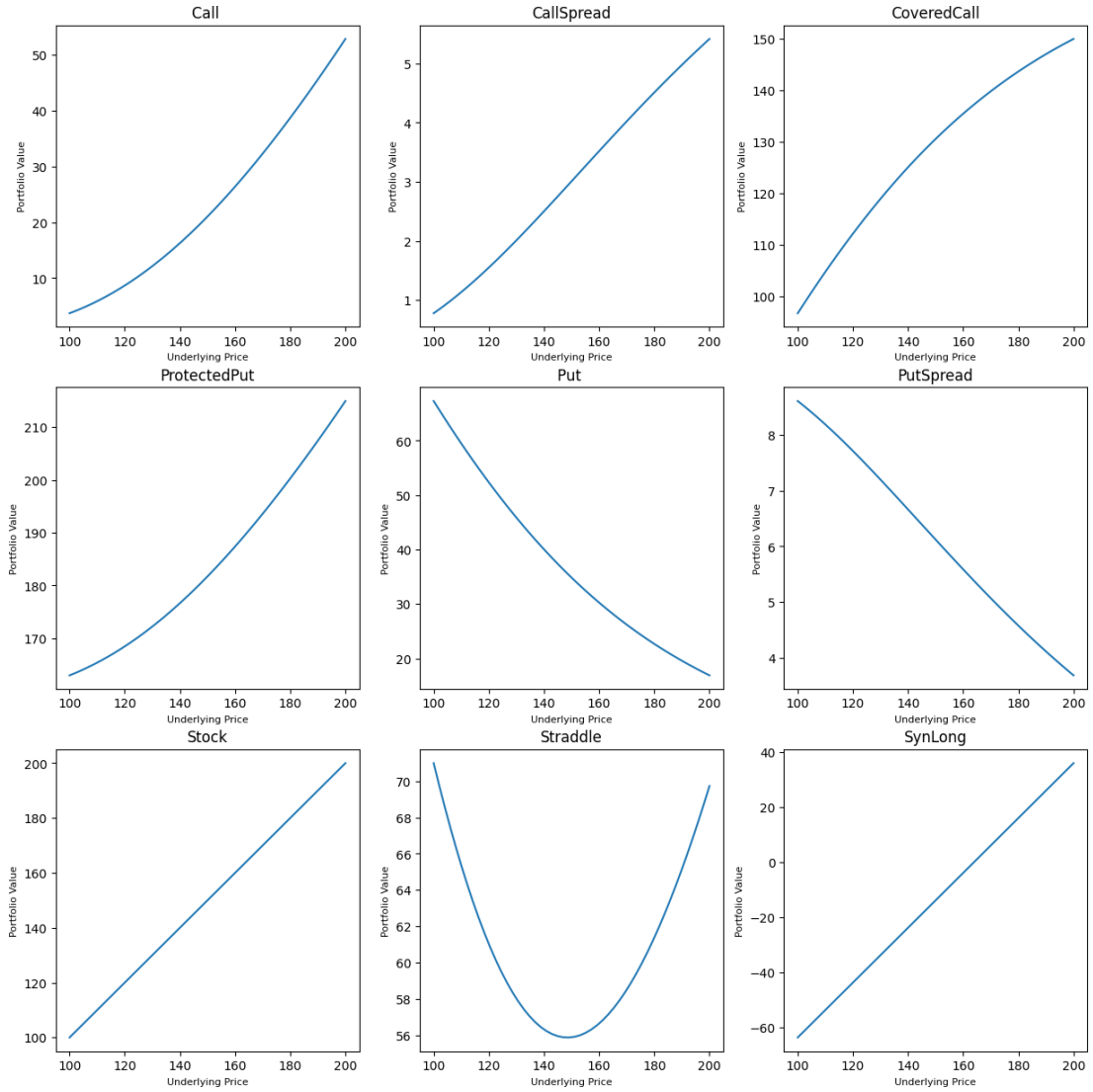
Also, we can see a small “smile” at the end of the put line. Implied volatility tends to be higher for options that are far out-of-the-money (OTM) or deep in-the-money (ITM) compared to at-the-money (ATM) options. This happens because the market prices these options higher due to the risk of big price moves, especially during uncertain times or before major events.

A famous example is the 1987 stock market crash, which showed a big volatility smile because of the high demand for OTM put options.

Question3

3.1

The portfolio values over a range of underlying values:



In the chart, we see that the call option curve goes up because the value of a call increases when the underlying price rises. The put option curve goes down because its value decreases as the underlying price goes up. The stock price moves in a straight line with the underlying asset's price, but the call and put options show a curved relationship with the underlying price.

Therefore, we believe that using options, compared to directly buying stocks, can help adjust an investor's portfolio value. The curve shape of the option value depends on the type and quantity of options purchased. This curve reflects the potential additional income or loss that options can provide investors compared to directly buying stocks.

From the chart, we can see that a straddle has a curve shaped like a smile. The option values

are high at both ends of the horizontal axis, but they are the lowest in the middle. This is because a straddle is often used by traders who expect the price of the underlying asset to move significantly but are not sure in which direction. They believe there will be high market volatility and that the asset price will go up or down sharply, but they do not know the exact direction of the move.

3.2

	Mean of Portfolio Value($)	Mean of Losses/Gains($)	VaR($)	ES($)	Current Value (on 2023/10/30)
Call	32.257378	25.047378	-16.336616	-14.476146	7.21
CallSpread	4.053522	-0.486478	1.235709	1.422406	4.54
CoveredCall	140.348577	-25.171423	31.522624	33.344962	165.52
ProtectedPut	193.763875	19.293875	-10.136935	-8.163772	174.47
Put	25.835316	19.675316	-14.159353	-12.870250	6.16
PutSpread	5.046901	1.876901	-1.099569	-0.896595	3.17
Stock	170.518025	0.368025	14.316127	17.904212	170.15
Straddle	58.092695	44.722695	-41.924931	-41.769508	13.37
SynLong	6.422062	5.372062	9.248708	12.821305	1.05

Analysis of Portfolio Metrics:

Mean of Portfolio Value: The protected put and stock have the highest mean values at $193.76 and $170.52, respectively. This indicates that these strategies could potentially provide more stable and higher returns compared to others. Covered calls also exhibit a relatively high mean value, reflecting a more conservative approach.

Mean of Losses/Gains: The straddle position shows the highest mean of gains at $44.72, suggesting that this strategy is well-suited for profiting from high market volatility. Conversely, the covered call has a negative mean of losses/gains at -$25.17, indicating potential losses if the stock remains below the strike price.

Value at Risk (VaR): The highest VaR is associated with the straddle at -$41.92, suggesting that it carries significant risk if the market moves against the strategy. Covered calls also have a high VaR of -$31.52, highlighting their risk under certain market conditions. The protected put has a relatively moderate VaR of -$10.14, showing lower risk exposure.

Expected Shortfall (ES): The straddle strategy also displays the highest ES at -$41.76, confirming that extreme losses could be substantial. Covered calls similarly have a high ES at -$33.34. The stock itself has a more moderate ES at -$17.90, indicating its position as a benchmark with typical stock risk.

Current Value: On 10/30/2023, the current values show that protected puts and covered calls are valued at $174.47 and $165.52, respectively. This is consistent with their use as hedging strategies in portfolios.

Divided into 4 types:

Stock and Synthetic Long (SynLong): A synthetic long is a strategy that behaves like owning

a long call option but uses a mix of other options or assets. It combines a long stock position and a put option to create upside potential with downside protection. This strategy tends to have high Value at Risk (VaR) and Expected Shortfall (ES).

Call, Put, Covered Call, Protected Put: These involve standard call and put options and strategies that include holding the underlying asset. A covered call involves holding the asset and selling a call, which can lead to higher potential losses than just holding the option. A protected put involves owning the asset and buying a put for protection. VaR is usually higher for covered calls and protected puts compared to simple calls or puts.

Call Spread and Put Spread: A call spread is buying a call and selling another call at a higher strike price, used when expecting a moderate price rise. A put spread is buying and selling puts at different strike prices, used when expecting a moderate fall. Both limit potential gains and losses, leading to lower VaR and ES.

Straddle: A straddle involves buying both a call and a put at the same strike price. This strategy benefits from large price movements, up or down. It can show a negative VaR and ES due to high potential payoffs in volatile conditions, like when modeled with an AR(1) process.