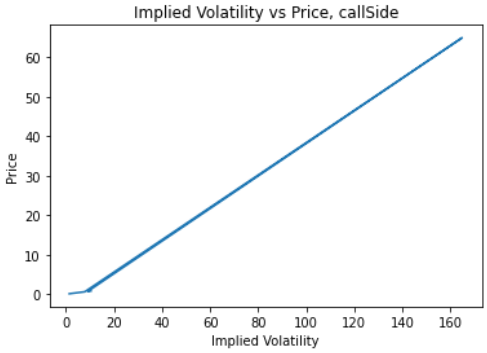
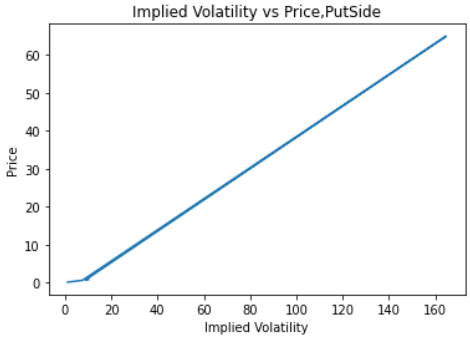
Problem 1

for all the calculations, I did all of the calculations using a legacy options class that I built before that I use daily for options trading. For Problem 1, Attached are the graphs for the relationship between Implied Volatility and Price. They are labeled accordingly:





As it can be seen implied volatility and prices have a positive linear correlation since the plot volatility is the main driver behind supply and demand of the option.

Here is a table of prices respective of the IVs:

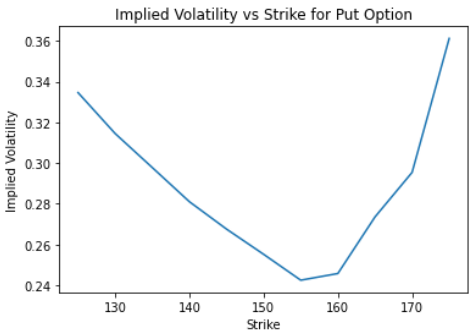
IV	CALL	PUT
0.1	1.408996	1.173782
0.15	2.051806	1.816591
0.2	2.695138	2.459923
0.25	3.338636	3.103421
0.3	3.98217	3.746956
0.35	4.625677	4.390463
0.4	5.269117	5.033903
0.45	5.91246	5.677246
0.5	6.555684	6.32047
0.55	7.198767	6.963553
0.6	7.841691	7.606477
65	164.9665	164.7312
0.7	9.126992	8.891777
0.75	9.769334	9.53412
0.8	10.41145	10.17624

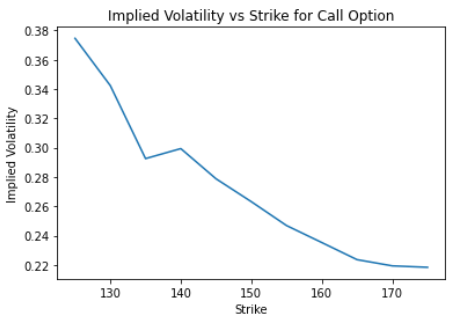
supply and demand affects implied volatility mainly due to the concept of open interest that goes into the open market pricing for an option. if an option as little open interest in as thinly traded, the incremental buying of one option has a much bigger price impact and therefore bigger impact on implied volatility. That's because in a technical sense implied volatility is also standard deviation and less supply will cause bigger standard deviations in the price of the option.

Problem 2

below is a graph of the options implied volatilities for calls and puts:

CALL IV	PUT IV
37.46%	33.46%
34.23%	31.45%
29.25%	29.78%
29.94%	28.10%
27.87%	26.75%
26.31%	25.51%
24.68%	24.24%
23.52%	24.57%
22.36%	27.35%
21.93%	29.54%
21.83%	36.12%





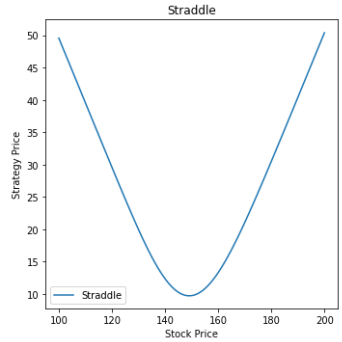
To answer the question what type of market dynamics could cause these types of implied volatility curves, the main general explanation that would explain higher implied volatilities for options that are out of the money is due to low supply or market makers demanding compensation for selling that far out tail risk that is “supposedly not to happen”. Aka, Tail risks or fat tails or kurtosis depending on who you ask. Here's for all the bonus points, people typically call what you see the shape of volatility curve on put options a volatility smile. Let's start off with put side or as we’ll now call it the volatility smile. Volatility smile typically dictates an even distribution of supply and demand across a set of option strikes. the reason for this is that most of the buyers and sellers are at the money as it can be seen here where the volatility is the lowest NTM or near the money. The put side of the options chain usually has higher IV for options that deep out of the money because even though probability says they shouldn't be in the money market makers still require some form of compensation for that risk by pricing IV higher. This is why a lot of hedge funds and traders try to sell out of the money puts and are very profitable at it… until the Black Swan comes. Black Swan is being referred to as the mother of all sell offs that will bankrupt anyone everyone who sells puts.

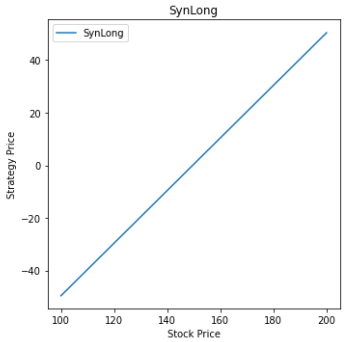
On the call side we have the volatility smirk. This volatility smirk is what we call a reverse skew. reverse skew typically express market sentiment of possible downturn and traders looking for downside protection. This can be seen by higher implied volatility for options that are below at the money strikes. specifically on the call side, and also possibly can be said on the put side for options that are deep in the money, the IV it's higher in the money since most of those options people originally bought OTM or ATM have been executed if American, or closed if European Cash Settled. This leaves out much lower supply available thus driving up the price of implied volatility. For volatility smirks when looking at the put side, typically the further OTM an option is and further dated it is the higher the implied volatility will be since people are willing to pay extra for more time for that protection. the opposite of a reverse skew volatility smirk is a forward skew volatility smirk. This generally happens when there is a tight supply in the market for options and buyers are willing to pay extra premium for either the downside protection for puts or potential future upside on the call side. example of this could be The Fed announces they will stop raising rates for the call side or the Ukraine war gets announced to be worse and people who are selling puts OTM are trying to grab puts that are in the money or close to the money to offset the major losses.

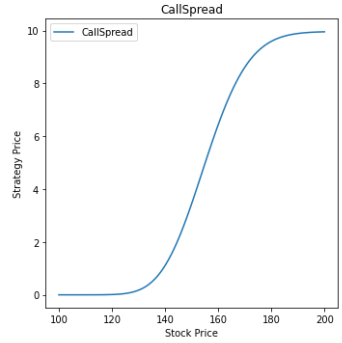
the VIX futures curve typically follows a contango distribution given that people are willing to pay that time premium that's baked into the implied volatility for protection. this follows the shape of a forward smirk. major sign that something that is brewing in the market is the VIX futures curve switches to a backwardation distribution where front contracts are trading higher than future contracts. this typically is the shape of a reverse skew volatility smirk.

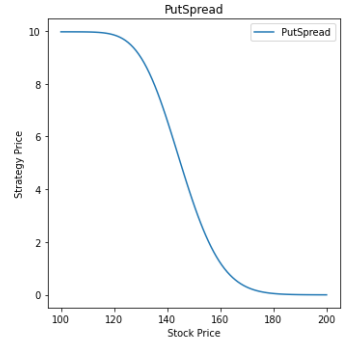
Problem 3

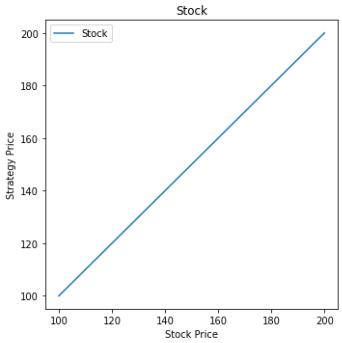
Below is a layout of all the different options strats for problem 3.

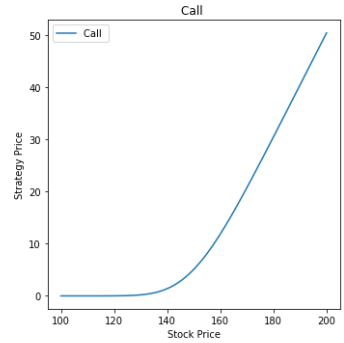


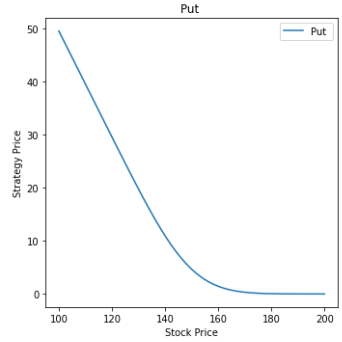


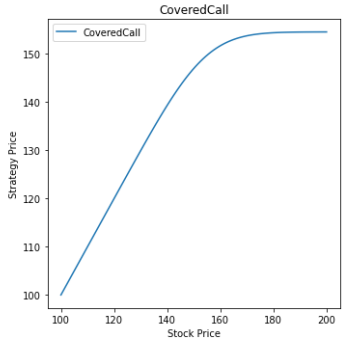


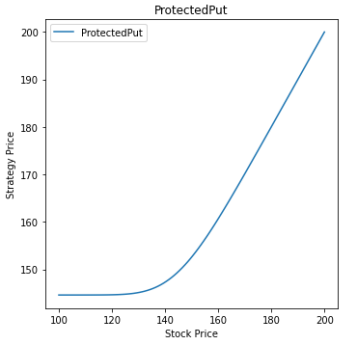












Straddle: straddles have the shape of a V typically due to with the fact that it's a combination of two options prices that year long, one call one put. the reason for the wide U-ish shape between $140 and $160 is due to combined price for that straddle being around $10 and in between that range as the call increases in price the put will decrease in price offsetting each other until it reaches out of those bounds of $10 where theoretically the delta on the call is he able to outpace the delta on the put allowing for the options price to increase exponentially. this also can happen respectively on the put side. given how far out the expiration is for these options they will be able to maintain above the break even point for a little bit until Theta starts kicking sub 30 days.

SynLong: synthetic longs, these strategies do what their name suggests, act as a synthetic long stock. you sell one put in buy one call. typically when executed correctly the put option should offset the price of the call. these strategies are typically very dangerous because he has infinite gain or infinite loss so if you have one bad day you have really one bad day.

Call/Put Spreads: Call Spreads and Put Spreads, otherwise sometimes known as a vertical spread takes this shape by buying one option that is in the money and selling one that is out of the money. this is typically done for risk mitigation purposes so that you can reap the upside on the call side or reap the downside on the put side while limiting your losses. the reason that the options have a S shape curve is because when you initially buy the long portion of the option strategy it will have much more delta than the short side option strategy. the derivative of delta is gamma which increases delta as option moves closer to in the money. As the short leg of the option strategy gets closer in the

money The gammas will increase on the option which will then increase deltas and then increase the price until you get to a point where deltas are equal and the gammas are equal which typically happens At the halfway point between the long strike and short strike. as the stock pushes the short strike in the money Gamma on the short strike will outpace the long strike thus starting to cause diminishing returns giving that S curve. also once the long strike is far in the money delta approaches the maximum of 1. Because of that also the positive difference between the deltas will decrease thus causing a maximum limit of return on the option. So net maximum return is the strike price of the long leg of the option minus the strike price of short leg of the option, minus costs.

cover call Strat :is typically being long a stock and then selling an option at a certain option strike out of the money. there are two purposes for doing this. First purpose of doing this is so that you can reap the upside of the stock price moving upward And having a “take profit” price. an expiration date if the stock is above that strike price you will typically sell at that strike price. that's why the shape is an upside down hockey stick. This is the scenario for when the strategy ends in the money. It's called a covered call strategy because you’re covering your obligation to sell someone those shares by having stock on hand in the case that option gets exercised. For the scenario when the stock does not end in the money, you just get to collect the premium that you sold.

I tried to execute the ARIMA model and was successful we're getting the simulation itself to work, but when I try to implement it with my BS Merton class to calculate var and expected shortfall, the implementation began to fail due to my BS Merton class having design issues where it was set up to accept an object with an array of parameters and when they would return the values it would return as an item. entire time I've been using that options calculator, I've always assumed it was just returning values since it gave numbers that looked like floats.