	October 21, 2022		t5								
In [52]:	<pre>import pandas as pd import numpy as np import statsmodels.a import matplotlib.py import seaborn as sn from scipy.stats imp from scipy import st from scipy.optimize from ft545 import my</pre>	olot as plt o rt norm ats import minim: functions	ize								
		functions datetime import fsolve	e	ving							
	-Current Stock Price 165 -Current Date 02/25/202 -Options Expiration Date -Risk Free Rate of 0.25%	2 03/18/2022									
	-Continuously Compoun Calculate the time to ma For a range of implied vo Discuss these graphs. H	turity using cal	endar days en 10% and	d 80%, plot	the values of		·				
In [86]:	<pre>def d1(S,X,b,sigma,T return (np.log(S def d2(S,X,b,sigma,T return d1(S,X,b,</pre>	 /X)+(b+sigma):	**2/2)*T)	/sigma/T**	0.5						
	<pre>def bs_call(S,b,r,T, return S*np.exp(def bs_put(S,b,r,T,X) return X*np.exp(</pre> Calculate the time	<pre>(,sigma): (b-r)*T)*norm ,sigma): -r*T)*norm.com</pre>	m.cdf(d1(df(-d2(S,	S,X,b,sigm X,b,sigma,	T))-S*np.ex	xp((b-r)*	Γ)*norm.cdf(
In [44]: In [50]:	<pre>T = datetime(2022,3, print("the time to m T = T.days/365 the time to maturity S = 165 X = 165 r = 0.0025</pre>	aturity is",									
	<pre>b = r-0.0053 sigmas = np.linspace call = [] put = [] for sigma in sigmas: call.append(bs_c put.append(bs_pu plt.plot(sigmas,call</pre>	all(S,b,r,T,X,s	X , sigma))								
Out[50]:	<pre>plt.plot(sigmas,put) plt.xlabel("sigma") plt.ylabel("call/put Text(0, 0.5, 'call/p</pre>										
	call/put values 9 8 01										
	4 -										
	0.1 0.2 The call/put values and t makes sense because no		sigma ositively co	orrelated. As	sigma increa						e put line overlap which the same volatilities. When
		an supply, the vale	values of a s decrease	n option incr	rease which n	nakes the	olatilities incr	rease. On the othe			demand, the values of an
	-Current AAPL price is 16 -Current Date, Risk Free Calculate the implied vol Plot the implied volatility	Rate and Divid	option.				ese graphs. V	Vhat market dynar	mics could make thes	se graphs?	
	There are bonus points a get inputs S = 164.85 T = 21/365 r = 0.0025	vailable on this	s question	based on yo	ur discussion	. Take som	e time to rese	earch if needed.			
Out[96]:	0 AAPL 3/18/2022	/pe Strike La Call 135.0	30.175								
	 2 AAPL 3/18/2022 3 AAPL 3/18/2022 4 AAPL 3/18/2022 5 AAPL 3/18/2022 	Call 140.0 Call 145.0 Call 150.0 Call 155.0 Call 160.0 Call 165.0	25.300 20.525 15.850 11.525 7.525 4.225								
	 7 AAPL 3/18/2022 8 AAPL 3/18/2022 9 AAPL 3/18/2022 10 AAPL 3/18/2022 	Call 170.0 Call 175.0 Call 180.0 Call 185.0 Call 187.5	1.935 0.715 0.260 0.115 0.120								
	 13 AAPL 3/18/2022 14 AAPL 3/18/2022 15 AAPL 3/18/2022 16 AAPL 3/18/2022 	Call 190.0 Call 195.0 Put 135.0 Put 140.0 Put 145.0	0.075 0.055 0.320 0.435 0.640								
	 18 AAPL 3/18/2022 19 AAPL 3/18/2022 20 AAPL 3/18/2022 21 AAPL 3/18/2022 	Put 150.0 Put 155.0 Put 160.0 Put 165.0 Put 170.0 Put 175.0	1.015 1.610 2.640 4.350 7.075 10.850								
	24 AAPL 3/18/202225 AAPL 3/18/2022	Put 180.0 Put 185.0 Put 190.0 Put 195.0	15.400 20.225 25.175 30.175								
In [131	<pre>def implied_vol_call f1 = lambda z: (return fsolve(f1 def implied_vol_put(f1 = lambda z: (return fsolve(f1)</pre>	(S,b,r,T,X,p) os_call(S,b,) , x0 = 0.2)[(S,b,r,T,X,pr) os_put(S,b,r)	rice): r,T,X,z)- 0] ice): ,T,X,z)-p	price)							
In [111	<pre>for i in range(len(d X = data.loc[i," price = data.loc if data.loc[i,"T data.loc[i,"</pre>	ata)): Strike"] [i,"Last Prio /pe"]=="Call	ce"] ":		vol_call(S,	b,r,T,X,	orice)				
Out[111]:	<pre>else: data.loc[i," data</pre>	Implied Vola Type Strike Land	tility"]	= implied_	vol_put(S,b						
	 2 AAPL 3/18/2022 3 AAPL 3/18/2022 4 AAPL 3/18/2022 5 AAPL 3/18/2022 6 AAPL 3/18/2022 7 AAPL 3/18/2022 	Call 150.0 Call 155.0 Call 160.0 Call 165.0	20.525 15.850 11.525 7.525 4.225	0.4127 0.3697 0.3403 0.3043 0.2733	706 394 316 378						
	 7 AAPL 3/18/2022 8 AAPL 3/18/2022 9 AAPL 3/18/2022 10 AAPL 3/18/2022 11 AAPL 3/18/2022 12 AAPL 3/18/2022 	Call 170.0 Call 175.0 Call 180.0 Call 185.0 Call 187.5 Call 190.0	1.935 0.715 0.260 0.115 0.120 0.075	0.2498 0.2359 0.2377 0.2528 0.2784 0.2808	938 799 563 469						
	 13 AAPL 3/18/2022 14 AAPL 3/18/2022 15 AAPL 3/18/2022 16 AAPL 3/18/2022 17 AAPL 3/18/2022 	Call 195.0 Put 135.0 Put 140.0 Put 145.0 Put 150.0	0.055 0.320 0.435 0.640 1.015	0.310 0.4895 0.4430 0.4024 0.3687	545 027 427						
	 18 AAPL 3/18/2022 19 AAPL 3/18/2022 20 AAPL 3/18/2022 21 AAPL 3/18/2022 22 AAPL 3/18/2022 	Put 165.0 Put 170.0 Put 175.0	1.610 2.640 4.350 7.075 10.850	0.3322 0.2999 0.270 0.2473 0.2315	955 110 330 569						
	 23 AAPL 3/18/2022 24 AAPL 3/18/2022 25 AAPL 3/18/2022 26 AAPL 3/18/2022 Draw scatter plots 	Put 180.0 Put 185.0 Put 190.0 Put 195.0	15.400 20.225 25.175 30.175	0.2306 0.2230 0.1904 0.2274	064 425						
In [114 Out[114]:	<pre>sns.scatterplot(data plt.axvline(S) <matplotlib.lines.l. -<="" 0.50="" pre=""></matplotlib.lines.l.></pre>				olatility",	hue="Type Type Call	pe")				
	0.45 - 0.40 - 0.35 -	•				• Put					
	<u>pelld</u> 0.30 - 0.25 -	•	•	•	•	•					
	0.20 - 140 The market dynamic here which means that in-the-			e skew). As t							t of the higher strike price
	a greater demand for in- The other two popular cu tell us that the demand is	money calls hat the-money call urves are volati s greater for op	ave become Is and thus Ility smile a	e popular alt , there is a ir	ernatives to c ncreased impl	outright sto	ock purchases	because they have	ve the ability to levera	age and results in a	greater ROI which causes market. Volatility smiles
		coto triat out o			_	of-the-mor	ney. For forwa	rd skew, the implie			kes are lower than the IV at nev puts. The forward
	3.Problem 3 Use the portfolios found -Current AAPL price is 16	in problem3.cs	of-the-mone	ey calls and	in-the-money	of-the-mor	ney. For forwai n greater dem	rd skew, the implienand compared to		nd out-of-the-mor	ney puts. The forward
	3.Problem 3 Use the portfolios found -Current AAPL price is 16 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fi	in problem3.cs 64.85 Rate and Divid s, graph the po d in the lecture t a Normal dist	of-the-monors in the constitution of the constitution of the constitution to the constitution to the constitution to the constitution to the constitution of the const	ey calls and ommodities are the same are over a range AAPL return	in-the-money market. Wher as problem1. ge of underlyi	of-the-mon y puts are in n supply is	n greater dem tight, busines	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
In [174	3. Problem 3 Use the portfolios found -Current AAPL price is 16 -Current Date, Risk Free For each of the portfolios to other topics discussed	in problem3.cs 64.85 Rate and Divid 6, graph the po d in the lecture t a Normal dist Mean, VaR and	of-the-monous in the consin the consin the considerate and Rate and ortfolio value.	ey calls and ommodities are the same are over a range AAPL return	in-the-money market. Wher as problem1. ge of underlyi	of-the-mon y puts are in n supply is	n greater dem tight, busines	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
In [174 Out[174]:	3.Problem 3 Use the portfolios found -Current AAPL price is 16 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fiprice(above). Calculate No. 10025 The state of the portfolios of the portf	in problem3.cs 34.85 Rate and Divid s, graph the pod in the lecture t a Normal dist Mean, VaR and Oroblem3.csv Underlying H AAPL AAPL AAPL AAPL	of-the-monons in the constitution to the constitution to the ES. Discus	ey calls and ommodities are the same are over a range. AAPL returness.	in-the-money market. Wher as problem1. ge of underlyi	of-the-more puts are in supply is ing values. Strike Common 165.0 165.0 165.0	n greater dem tight, busines Plot the portf urn.Simulate A	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
	3.Problem 3 Use the portfolios found -Current AAPL price is 16 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fiprice(above). Calculate Novel Calcu	in problem3.cs 34.85 Rate and Divid s, graph the po d in the lecture t a Normal dist Mean, VaR and Oroblem3.csv Underlying AAPL AAPL AAPL AAPL AAPL AAPL AAPL AAP	dend Rate and ortfolio value. Tribution to ES. Discuss 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ey calls and ommodities are the same are over a range. AAPL return as. Call Put Call Put Call Put Call Put Call Put NaN	in-the-money market. When as problem1. ge of underlyins - assume 0 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 NaN	of-the-more puts are in supply is ing values. Strike Cu 165.0 165.0 165.0 165.0 165.0 165.0 175.0 185.0 NaN	Plot the portfurn.Simulate A urrentPrice 4.50 4.40 4.50 4.40 4.50 0.72 4.40 1.60 164.85	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
	3.Problem 3 Use the portfolios found -Current AAPL price is 16 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fiprice(above). Calculate Nove (above). Calculate Nov	in problem3.cs 34.85 Rate and Divid 5, graph the politin the lecture t a Normal dist Mean, VaR and Oroblem3.csv Underlying AAPL AAPL AAPL AAPL AAPL AAPL AAPL AAP	dend Rate and ortfolio value. Tribution to ES. Discuss 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	ey calls and ommodities are the same are over a range call. AAPL return cs. Call Put Call Put Call Put Call Put Call Put Call Put Put Put	in-the-money market. When as problem1. ge of underlyins - assume 0 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022 3/18/2022	Strike Constant (165.0) 165.0 165.0 165.0 165.0 165.0 165.0 165.0 165.0 NaN 165.0 NaN 165.0 NaN 165.0	Plot the portfurn.Simulate A urrentPrice 4.50 4.40 4.50 4.40 4.50 4.40 4.50 4.40 4.50 1.60	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
	3.Problem 3 Use the portfolios found -Current AAPL price is 16 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fiprice(above). Calculate Notes and the portfolios of the portf	in problem3.cs 64.85 Rate and Divid 6, graph the po d in the lecture t a Normal dist Mean, VaR and Oroblem3.csv Underlying AAPL A	Insin the consin the consin the consin the consin the consin the consint to the constant of th	ey calls and ommodities are the same are over a range call. AAPL return cs. Call Put Call Put Call Put Call Put NaN Call Put NaN Call NaN Call NaN	in-the-money market. When when we will be a sproblem of a sproblem of a spiration of the sp	Strike Constant (165.0) 165.0 165.0 165.0 165.0 165.0 165.0 165.0 165.0 NaN 165.0 NaN 165.0 NaN 165.0	rrentPrice 4.50 4.40 4.50 4.40 4.50 4.40 1.60 164.85 4.50 4.40 164.85	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
Out[174]:	3.Problem 3 Use the portfolios found -Current AAPL price is 10 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fiprice(above). Calculate Novel Calcu	in problem3.cs 64.85 Rate and Divid 6, graph the polition the lecture t a Normal dist Mean, VaR and Oroblem3.csv Underlying AAPL	dend Rate and ortfolio value. Itribution to ES. Discuss Itribution to	ey calls and ommodities are the same the over a range call and put cal	in-the-money market. When as problem1. ge of underlying as - assume 0 and a symmetric	of-the-more y puts are in supply is in supply in supply is in supply in supply is in supply is in supply is in supply is in supply in s	Plot the portfurn.Simulate A 4.50 4.40 4.50 0.72 4.40 1.60 164.85 4.50 4.40 164.85 4.50 164.85 4.40	folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
Out[174]:	3.Problem 3 Use the portfolios found -Current AAPL price is 10 -Current Date, Risk Free For each of the portfolios to other topics discussed Using DailyReturn.csv. Fiprice(above). Calculate Novel Calcu	in problem3.cs 64.85 Rate and Divid 6, graph the politing the lecture of the l	dend Rate and ortfolio value. Itribution to ES. Discuss Itribution to	ey calls and ommodities are the same the over a range call and put cal	in-the-money market. When as problem1. ge of underlying as - assume 0 and a symmetric	Strike Constitution of the more purpose of the more properties of supply is a	Plot the portfurn.Simulate A 4.50 4.40 4.50 0.72 4.40 1.60 164.85 4.50 4.40 164.85 4.50 164.85 4.40	rd skew, the implied nand compared to sses would rather p folio values and dis	in-the-money calls a pay more to secure s scuss the shapes. Bo	nd out-of-the-mor upply than to risk s nus points availabl	ney puts. The forward supply disruption.
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