

EF4820
Derivatives Pricing I: Stock and FX
Group Project

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1. Introduction

1.1. Objectives

In this project, we will apply option pricing theory to an investment situation in the real life and to gain practical knowledge and experience. Our project includes two parts. The first one is conduct three hedging strategies (delta hedge, delta gamma hedge and delta gamma vega hedge) on call options, by making use of the underlying E-mini S&P 500 futures and different kinds of options. We would like to compare with these three hedge strategies and draw the general conclusion of effectiveness. The other one is using underlying futures and different types of put options (ITM, OTM and ATM) in order to check whether the property of put option will have different impact on hedging. The profit or loss situation and effectiveness will be compared between these strategies in each part. Both real-time data and simulation will be applied in order to generate a more general conclusion.

Our analysis will be made of two different parts, which is hedge call option (OTM) using:

1. Hedging process: Underlying future & different kinds of options

Future	Delta hedge
Future & vanilla put option (OTM)	Delta Gamma hedge
Future, vanilla put option (OTM) & vanilla put option (ITM)	Delta Gamma Vega hedge

2. Further consideration: Underlying future & different types of put options

Future & vanilla put option (OTM)	Delta Gamma hedge
Future & vanilla put option (ITM)	Delta Gamma hedge
Future & vanilla put option (ATM)	Delta Gamma hedge

1.2. Choice of Assets

In the project, S&P 500 was chosen as our underlying. The index is traded as futures in the market, so the E-mini S&P 500 futures contract with ticker ES was chosen in our project, which is traded in CME. For active traders, E-mini S & P 500 futures are the ideal way to trade S & P 500 index. E-mini S & P has enhanced leverage, stable volatility and solid market depth, which is welcomed by any traders. We have also chosen E-mini S&P 500 call option and put option as the plain vanilla options. In particular, we chose the out-of-the-money call option and three types of put options (OTM, ITM and ATM).

1.3. Data Sources

We collected the daily data of chosen futures and options starting from 9th of March 2020 to 9th April 2020 from the Bloomberg Terminal. The daily data includes future price, last price and implied volatility of options with corresponding dividend yield, free interest rate, expire

data and strike price. The close price will be made use of to apply and analyze the hedging strategies.

2. Hedging Process

2.1. Overview

In this project, we want to utilize the methodology of delta, gamma and vega hedging to hedge the trade of the in-the-money E-mini S&P 500 call option (SCJ0C 2860 Index). In our hedging process, we in total utilize 4 trading assets, which are the E-mini S&P 500 futures contract, an out-of-the-money E-mini S&P 500 put option, an in-the-money E-mini S&P 500 put option and an at-the-money E-mini S&P 500 put option. Next, we will show our hedging process and P&L results in the turn of no hedging, only delta hedging, delta & gamma hedging and the vega hedging. A comparison and analysis of our three methods will also be discussed. Moreover, we will make a decision of the specific hedging method and further discuss about the choice of hedging option based on our real data and the large sample simulation.

2.2. Portfolio 1: No hedging

2.2.1 Result

Firstly, we just trade 1 unit of in-the-money E-mini S&P 500 call option (SCJ0C 2860 Index) and monitor the P/L during our trading period, which is 2020-3-9 to 2020-4-9. We borrow \$123 at the first day to long the call and calculate the everyday accumulated value increasing with the risk-free rate. Then, we list the everyday P/L by differencing the option value and the cash position, which is plotted in the below chart. We also calculate the key statistic of this portfolio in the table below.



Chart 1: The profit/loss performance of the no hedge strategy

2.2.2 Analysis

As for the no hedge portfolio, the minimum P/L is -119.55646 and the average return is -78.420032, which is also negative. During the 1-month trading, we are facing a gradual loss, while the volatility of the portfolio performance is also at a high level (1808.26964).

Min	-119.55646
Max	47.4977422
Average	-78.420043
Variance	1808.26964

Table 1: Key statistic of the performance of our portfolio 1

2.3. Portfolio 2: Delta hedging portfolio

2.3.1 Result

In this portfolio, we use the corresponding future contract (SCM0 Index) to hedge the 1-unit long position of the in-the-money call option (SCJ0C 2860 Index). The everyday implied volatilities are utilized to calculate the daily delta of the hedged call option. Based on the calculated delta, we constructed and rebalanced our everyday hedging portfolio, which consists of 1 unit of the call option at long position and δ units of the underlying in short position. During the whole hedging period, our cash position varies every day with the dividend paying, interest accumulated, and the value changed by rebalancing the underlying futures. We calculate the daily cash position and added up the portfolio value to get the daily value of P/L, which are plot in the chart below. Moreover, we also calculate some key statistics of this hedging portfolio to capture the performance of this strategy.

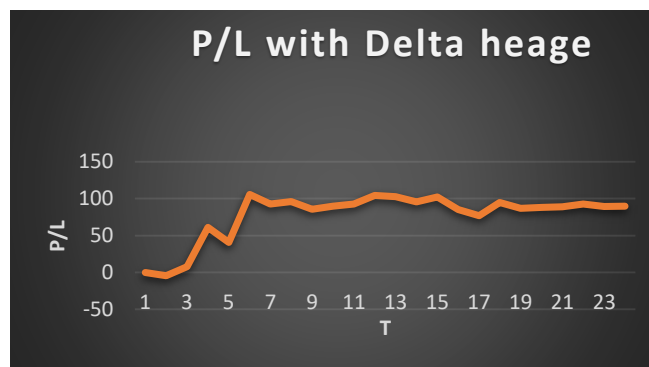


Chart 2: The profit/loss performance of the delta hedging strategy

2.3.2 Analysis

Referring to the P/L chart, in almost all of the trading date, our delta hedging portfolio earned a satisfiable profit. This P/L line indicates the success of our delta hedge that the minimum loss (-4.4589874) has been significantly minimized compared with the portfolio having only call option (-119.55646). The average P/L is improved successfully, while the volatility of this portfolio has also been lowered. This indicates the profitability and the stability of our hedging portfolio.

Min	-4.4589874
Max	105.713229
Average	77.684004
Variance	1066.37835

Table 2: Key statistic of the performance of our portfolio 2

2.4. Portfolio 3: Delta & Gamma hedging portfolio

2.4.1 Result

In this portfolio, we use the corresponding future contract (SCM0 Index) and the out-of-the-money put(SCJ0P 2600 Index) to hedge the 1 unit long position of the in-the-money call option(SCJ0C 2860 Index). In this hedging process, we first calculate the daily Greeks of the out-of-the-money put based on the daily implied volatility. Then, using the daily Greeks of both the in-the-money call and out-of-the-money put to construct and rebalance our hedging portfolio that is delta and gamma neutral. Similar to the previous portfolio, we calculate the daily cash position and the value of our hedging portfolio in order to get the corresponding P/L.

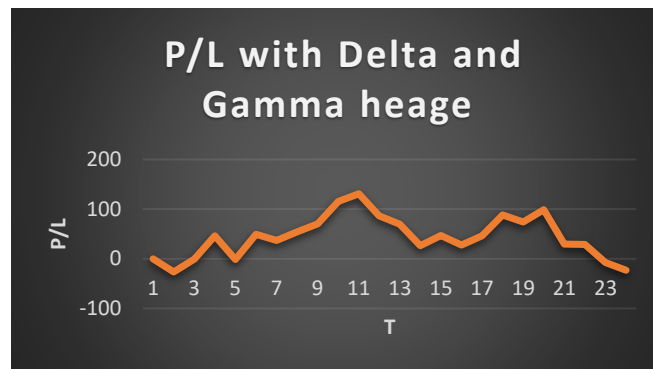


Chart 3: The profit/loss performance of the delta & Gama hedging strategy

2.4.2 Analysis

Referring to the P/L chart, in almost all of the trading date, our delta hedging portfolio earned a positive amount of profit. The minimum loss of our delta & gamma hedging portfolio (-26.483359) has been successfully minimized compared with the portfolio with only call option (-119.55646). The average P/L is also improved successfully. However, the stability of this portfolio are not as good as the portfolio 2.

Min	-26.483359
Max	131.039537
Average	44.6014354
Variance	1785.63783

Table 3: Key statistic of the performance of our portfolio 3

2.5. Portfolio 4: Delta & Gamma & Vega hedging portfolio

2.5.1. Result

As the price of the call option is not only affected by the underlying spot price but also the futures volatility. We want to get a portfolio that is also Vega neutral in order to improve our hedging performance. In this case, we add another out-of-the-money put into our portfolio. We first calculate the daily Greeks of this option. Next we use the excel solver to construct and rebalance a portfolio that the corresponding Vega is zero. In this step, we set the constraint that the Gammas equal to zero. Similar to the previous portfolios, we calculate the daily cash position and the value of our hedging portfolio in order to get the corresponding P/L.

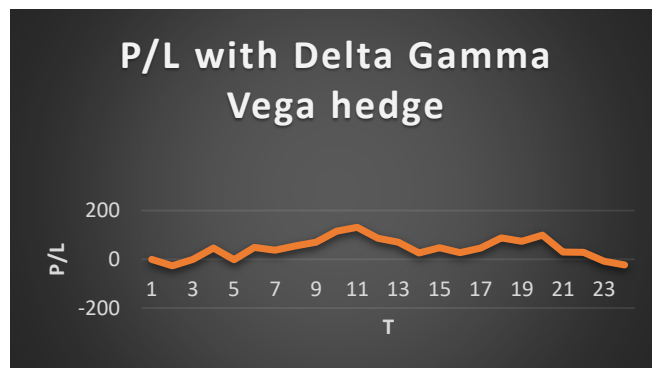


Chart 4: The profit/loss performance of the delta & Gama & Vega hedging strategy

2.5.2. Analysis

Our Vega neutral portfolio perform almost the same as the Gamma neutral portfolio with the positive earning and minimized loss. The stability is also not as good as the delta neutral portfolio.

Min	-26.505861
Max	131.256273
Average	44.6397453
Variance	1789.49218

Table 4: Key statistic of the performance of our portfolio 4

3. Further consideration

In the real-life hedging process, one of the questions is how to choose an option that can maximized the total profit of our strategy? There is a trade-off between the in-the-money option and the out-of-the-money option that the in-the-money option has a higher price with a more positive prospect, while the out-of-the-money has a lower price with a risk of zero payoff at

maturity. In this project, we want to investigate whether the choice of the hedging option affects the portfolio performance. We take the Gamma hedging strategy to further investigation.

3.1. In our case

As we previously use the out-of-the-money put (SCJ0P 2600 Index) into our Gamma hedging portfolio. This time, we replicate the previous procedure with different option choices, which respectively are SCJ0P 2700 Index (an almost at-the-money put) and SCJ0P 2950 Index (an in-the-money put) to get the corresponding P/L lines.

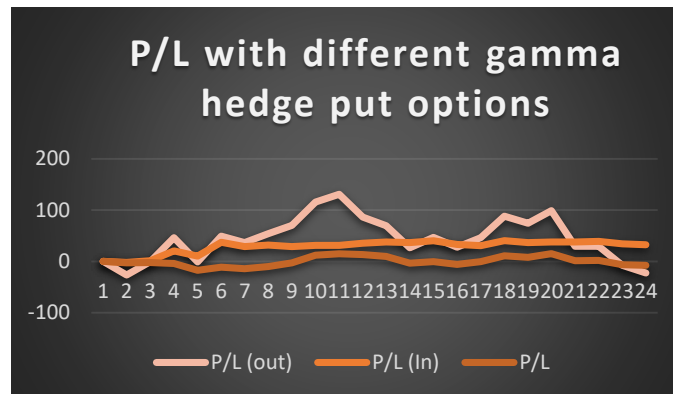


Chart 5: P/L lines with different Gamma hedging put choice

Therefore, at our specific trading dates, the hedging performance with an out-of-the-money put dominates the other option choices.

3.2. Simulation

As our hedge process of this call option is just in a specific trading period, the result of this case may not be suitable for other period in real life investment. We consider to use the VBA code to simulate the daily hedge performance with different option choices in a relatively large sample, say 500, to check whether the choice of the option indeed affects the hedging performance. In this case, we assume the daily spot prices follow the log normal distribution. The results are shown below.

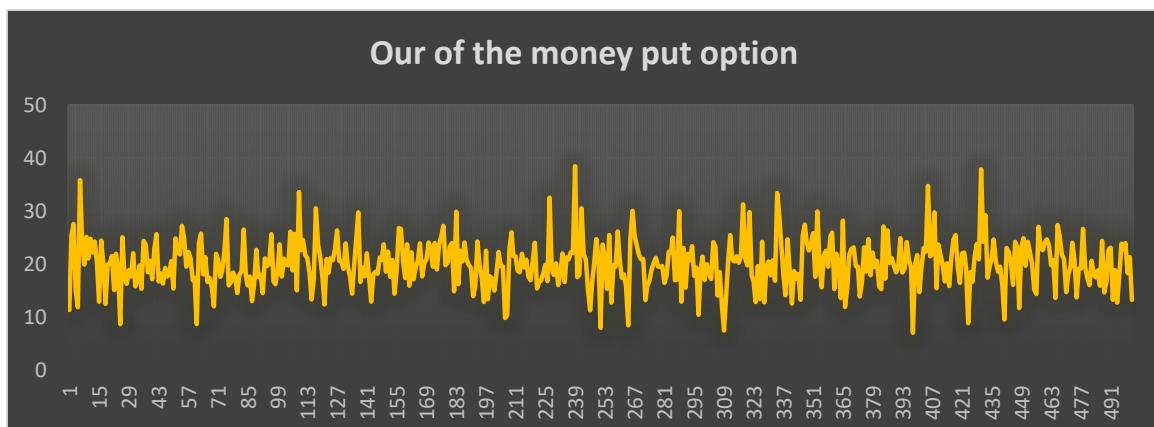


Chart 6: Simulated hedging performance with out-of-the-money put option.

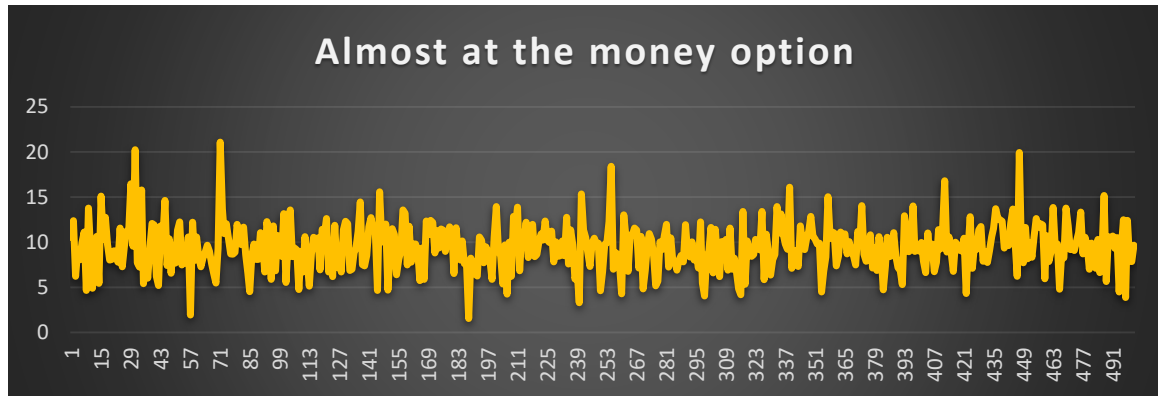


Chart 7: Simulated hedging performance with at-the-money put option.

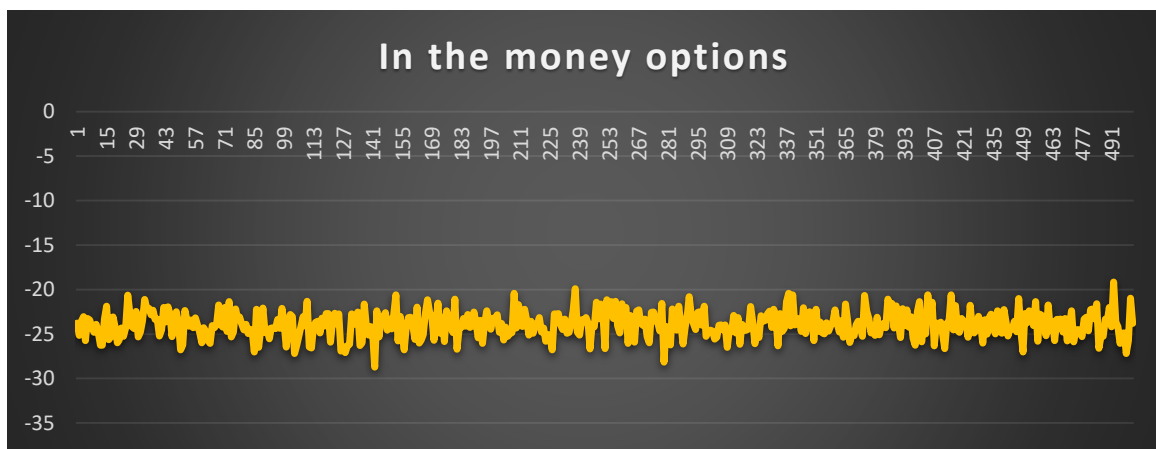


Chart 8: Simulated hedging performance with in-the-money put option.

According to the 3 charts above, we can see that the hedge portfolio with out-of-the-money put option has the highest mean profit while the one with in-the-money put option has the lowest mean profit. Therefore, it might be a wise decision to choose the out-of-the-money put.

4. Conclusion

For the first part, it is concluded that the delta hedging portfolio earned a satisfiable profit compared with no hedging option. The average profit is improved successfully, while the volatility of this portfolio has also been lowered. This indicates our delta hedging portfolio is more effective on making profit and lower volatility. For the delta-gamma hedging and delta-gamma-vega hedging, in almost all of the trading dates, our portfolios earned a positive profit. The volatilities are lower than that of no hedging portfolio. However, the stabilities of these portfolios are not as good as the delta hedging portfolio. Only using delta hedging, a position has been protected from small changes in the underlying security. However, larger changes will change the delta hedge so that the position will be vulnerable. By using delta and gamma hedge together, the delta hedge remains intact.

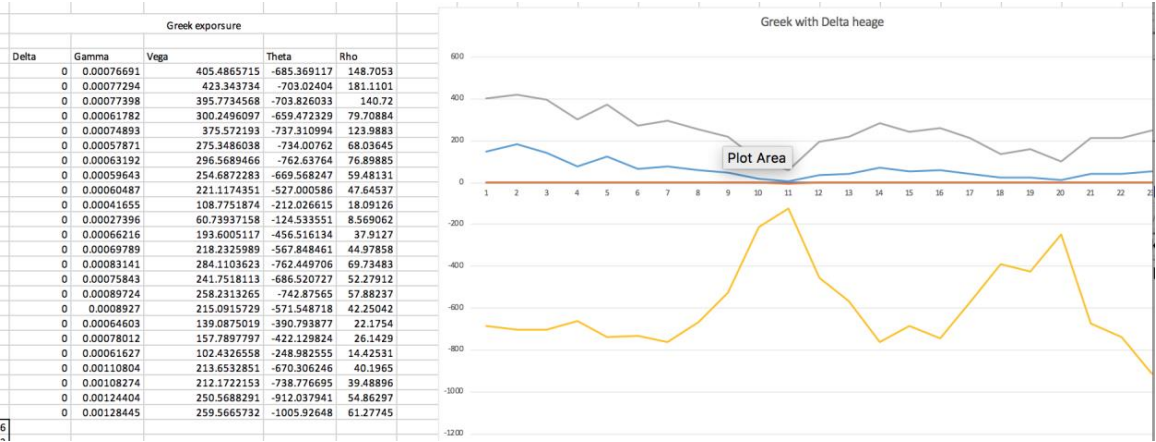
For our second part, we have seen that the hedging performance with an OTM put option dominates the other kind of put option during delta-gamma hedging process. The reason may be that the out-of-the-money has a lower price with a risk of zero payoff at maturity. However, there is a trade-off between the ITM option and the OTM option, because the ITM option has a higher price with a more positive prospect. Also, we only check this condition during the delta-gamma hedging process, so there should be further investigations on other hedging strategies.

5. Appendix

Appendix A: Delta hedging process

Date	Stock Price	Last price	Call				CALL									
			N/M	T	dt	d1	d2	N(d1)	N(d2)	Delta	gamma	theta	Vega	Rho		
2020/3/9	2735.25		123	49.6053143	0.14246575	-0.1570608	-0.3442943	0.44	0.37	0.4361607	0.0008	-685.36912	405.486571	148.705316		
2020/3/10	2854.25		170.5	48.1157877	0.13972603	0.00273973	0.06599798	-0.1138586	0.53	0.45	0.52461427	0.0008	-703.02404	423.343734	181.110078	
2020/3/11	2729		117	50.1224266	0.1369863	0.00273973	-0.1720957	-0.3576071	0.43	0.36	0.43031731	0.0008	-703.82603	395.773457	140.719952	
2020/3/12	2456		53	60.0152137	0.13424658	0.00273973	-0.5926162	-0.81251	0.28	0.21	0.27586222	0.0006	-659.47233	300.24961	79.7088412	
2020/3/13	2684		95.5	52.9342366	0.13150685	0.00273973	-0.246123	-0.4380831	0.40	0.33	0.40157174	0.0007	-737.31099	375.572193	123.988311	
2020/3/16	2405.25		48.75	66.7089817	0.12328767	0.00821918	-0.6308205	-0.8650514	0.26	0.19	0.26332793	0.0006	-734.00762	275.348604	68.0364543	
2020/3/17	2485.5		56.75	63.02006	0.12054795	0.00273973	-0.5410589	-0.7598646	0.29	0.22	0.2934153	0.0006	-762.63764	296.568947	76.8988543	
2020/3/18	2401.5		35.5	62.8503818	0.11780822	0.00273973	-0.7110613	-0.9267839	0.24	0.18	0.23787491	0.0006	-669.56825	254.687228	59.4813128	
2020/3/19	2389		22.25	55.6633811	0.11506849	0.00273973	-0.8685916	-1.0574116	0.19	0.15	0.19202417	0.0006	-527.00059	221.117435	47.6453707	
2020/3/20	2288.5		7	44.3889196	0.11232877	0.00273973	-1.4364349	-1.5852065	0.08	0.06	0.07524382	0.0004	-212.02662	108.775187	18.0912574	
2020/3/23	2220.5		5	43.1914102	0.10410959	0.00821918	-1.7586338	-1.8979953	0.04	0.03	0.03922541	0.0003	-124.53355	60.7393716	8.56906189	
2020/3/24	2438		25	48.5253519	0.10136986	0.00273973	-0.966816	-1.1213141	0.17	0.13	0.16642784	0.0007	-456.51613	193.600512	37.9127015	
2020/3/25	2467		28.25	52.0934895	0.09863014	0.00273973	-0.8316136	-0.9952154	0.20	0.16	0.202352	0.0007	-567.84846	218.232599	44.9785825	
2020/3/26	2608		50	52.3937373	0.09589041	0.00273973	-0.4970873	-0.6593307	0.31	0.25	0.30887878	0.0008	-762.44971	284.110362	69.7348279	
2020/3/27	2524		30.5	53.7145084	0.09315068	0.00273973	-0.6896809	-0.8536208	0.25	0.20	0.2446704	0.0008	-686.52073	241.751811	52.2911174	
2020/3/30	2611.25		35	49.6972284	0.08493151	0.00821918	-0.5654609	-0.7102935	0.29	0.24	0.28531985	0.0009	-742.87565	258.231327	57.8823713	
2020/3/31	2569.75		14.75	44.3923739	0.08219178	0.00273973	-0.7877981	-0.915067	0.22	0.18	0.21499883	0.0009	-571.54872	215.091573	42.2504215	
2020/4/1	2448		6.5	45.2176391	0.07945205	0.00273973	-1.166918	-1.294374	0.12	0.10	0.12139874	0.0006	-390.79388	139.087502	22.1753971	
2020/4/2	2516.5		6.75	41.6349951	0.07671233	0.00273973	-1.0628299	-1.1781463	0.14	0.12	0.14367473	0.0008	-422.12982	157.78978	26.1428958	
2020/4/3	2482.75		3.5	36.4530281	0.0739726	0.00273973	-1.3894164	-1.488561	0.08	0.07	0.08221248	0.0006	-248.98256	102.432656	14.4253075	
2020/4/6	2644.5		17.5	41.9322728	0.06575342	0.00821918	-0.6848409	-0.7923655	0.25	0.21	0.24634769	0.0011	-670.30625	213.653285	40.1965039	
2020/4/7	2642		20.5	44.5517504	0.0630137	0.00273973	-0.662265	-0.7741012	0.25	0.22	0.25353138	0.0011	-738.77767	212.172215	39.4889585	
2020/4/8	2735		40.75	44.6732733	0.06027397	0.00273973	-0.3616483	-0.4713246	0.36	0.32	0.3583082	0.0012	-912.03794	250.568829	54.8629726	
2020/4/9	2779.75		57.5	45.4563436	0.05753425	0.00273973	-0.2151652	-0.3241981	0.41	0.37	0.41426832	0.0013	-1005.9265	259.566573	61.2774491	

Position						
CALL	Underlying (short)	DIV	Change in underlying	Cash	Portfolio Value	P/L
1	-0.436160703			1070.008564	-1070.008564	0
1	-0.524614265	-0.075505123	252.4685791	1322.421279	-1326.880267	-4.458987394
1	-0.43031731	-0.094768709	-257.3363923	1065.014393	-1057.335938	7.678455435
1	-0.275862219	-0.074323339	-379.3417013	685.6179184	-624.517611	61.10030737
1	-0.401571743	-0.042879869	337.4043612	1022.991985	-982.3185582	40.67342689
1	-0.263327926	-0.204657308	-332.5109411	690.3327229	-584.6194938	105.7132291
1	-0.293415304	-0.040085749	74.78217937	765.0874885	-672.5337392	92.5537493
1	-0.237874908	-0.04615613	-133.3802614	631.6751152	-535.7565922	95.91852295
1	-0.192024168	-0.036154643	-109.5374189	522.1131369	-436.495737	85.6173999
1	-0.075243816	-0.029033868	-267.2518358	254.8418513	-165.1954723	89.64637898
1	-0.039225412	-0.032696655	-79.97886477	174.844324	-82.10002809	92.74429594
1	-0.166427839	-0.005512532	310.119517	484.961538	-380.7510723	104.2104657
1	-0.202351997	-0.025679853	88.62489624	573.5696565	-470.9523759	102.6172806
1	-0.308878784	-0.031594356	277.8218612	851.370452	-755.5558687	95.81458339
1	-0.244670398	-0.050983368	-162.0619675	689.2731292	-587.0480833	102.2250459
1	-0.285319847	-0.117260672	106.1458762	795.339703	-710.0414517	85.29825134
1	-0.214998828	-0.047153431	-180.7074406	614.5997086	-537.7432375	76.8564711
1	-0.121398739	-0.034967117	-229.1330182	385.4430051	-290.684112	94.75889305
1	-0.143674728	-0.018808686	56.05752723	441.4887989	-354.8074528	86.68134609
1	-0.082212479	-0.022882853	-152.5953987	288.8786215	-200.6130321	88.26558942
1	-0.246347688	-0.038757195	434.0555591	722.911332	-633.9664596	88.94487231
1	-0.253531379	-0.0412311	18.97931226	741.8626831	-649.3299027	92.53278043
1	-0.358308196	-0.042393316	286.5645944	1028.398502	-939.2229153	89.17558676
1	-0.414268321	-0.062022166	155.5551577	1183.910515	-1094.062365	89.84815047



Year	SCoP 2600 Index	put	out-of-the-money, E-mini S&P 500 put option.										put	
Date	Stock Price	Price (Avg[midask])	IVM	T	dt	d1	d2	N(d1)	N(d2)	Delta	gamma	theta	Vega	Rho
2020/3/9	2735.25	138.5	49.627631	1.0244658		-0.156906	-0.344224	0.56	0.63	-0.560493	8.04	-729.5335	405.49643	-258.3472
2020/3/10	2854.25	93.75	48.100913	1.039726	0.0027397	0.0659628	-0.113888	0.47	0.55	-0.477177	8.04	-749.3871	423.34472	-271.7137
2020/3/11	2729	139	50.148744	1.0369863	0.0027397	-0.170198	-0.357517	0.57	0.64	-0.566485	7.04	-747.9219	395.78623	-250.3717
2020/3/12	2456	300.25	59.991141	1.0342466	0.0027397	-0.592942	-0.812748	0.72	0.79	-0.72115	6.04	-696.4915	300.19159	-303.7417
2020/3/13	1684	162.75	52.975814	1.0315068	0.0027397	-0.245779	-0.43789	0.60	0.67	-0.595262	7.04	-780.629	375.60396	-251.496
2020/3/16	2405.25	343	66.695144	1.023877	0.0082192	-0.631	-0.865182	0.74	0.81	-0.733887	6.04	-770.0284	275.31743	-284.1501
2020/3/17	2485.5	283.25	63.0544	1.0205479	0.0027397	-0.504605	-0.75957	0.71	0.78	-0.736662	6.04	-801.3361	296.63534	-267.4074
2020/3/18	2401.5	328.25	62.319302	1.0178082	0.0027397	-0.710137	-0.926075	0.76	0.82	-0.759122	6.04	-706.8574	254.85449	-277.0074
2020/3/19	2389	311.25	55.649139	1.0150685	0.0027397	-0.868862	-1.057634	0.81	0.85	-0.805395	6.04	-562.6333	221.06546	-281.1236
2020/3/20	2288.5	350.75	44.521286	1.0123288	0.0027397	-1.431721	-1.580937	0.92	0.94	-0.921494	4.04	-247.6832	109.51297	-302.7378
2020/3/23	2220.5	401	43.397991	1.0141096	0.0082192	-1.749598	-1.889626	0.96	0.97	-0.9576	3.04	-159.1515	61.709807	-288.7968
2020/3/24	2438	249	48.687656	1.0113699	0.0027397	-0.967688	-1.122606	0.83	0.87	-0.834155	7.04	-492.8122	193.47334	-251.7515
2020/3/25	2467	240	52.130664	0.998301	0.0027397	-0.830902	-1.049432	0.80	0.84	-0.795172	7.04	-606.4001	218.36139	-236.8038
2020/3/26	2650	164.25	52.39169	0.995890	0.0027397	-0.497113	-0.695651	0.69	0.75	-0.686868	6.04	-803.3718	176.1067	-204.2277
2020/3/27	2524	208	53.734229	0.991507	0.0027397	-0.689368	-0.853368	0.75	0.80	-0.753082	8.04	-725.9191	241.80404	-213.867
2020/3/30	2611.25	147.5	49.684532	0.9849315	0.0082192	-0.565499	-0.710324	0.71	0.76	-0.712733	9.04	-783.8693	258.2527	-184.805
2020/3/31	2569.75	146.75	44.395988	0.9821918	0.0027397	-0.787649	-0.914939	0.78	0.82	-0.783061	9.04	-811.8064	215.11677	-192.6328
2020/4/1	2448	218.25	45.258287	0.9794521	0.0027397	-1.165755	-1.293326	0.88	0.90	-0.876533	6.04	-428.9707	139.27622	-190.8665
2020/4/2	2516.5	164	41.655136	0.9767123	0.0027397	-1.06226	-1.177632	0.86	0.88	-0.854426	8.04	-641.4669	157.88532	-198.0863
2020/4/3	2482.75	169.75	36.842946	0.9739726	0.0027397	-1.388196	-1.487422	0.92	0.93	-0.915895	6.04	-287.7117	102.60646	-196.9822
2020/4/6	2644.5	91.25	41.828285	0.9657534	0.0082192	-0.68681	-0.794068	0.75	0.79	-0.752755	0.001	-709.5696	213.36489	-147.8253

CALL	Position		Underlying(Shc DIV	Change of put	change of unde/ cash		Portfolio value	P/L	
	PUT(short)								
1	-1.000425572	-0.99689216				2742.30823	-2742.30823		0
1	-0.99968854	-0.99664443	-0.172575073	-0.069096731	-0.70707917	2741.40982	-2767.89318	-26.4833595	
1	-1.000492757	-0.99704619	-0.180038387	0.111786142	1.096401803	2742.48829	-2742.00756	-0.51926658	
1	-0.999792092	-0.99686254	-0.172207346	-0.210374703	-0.45105234	2741.705	-2695.48198	46.2230222	
1	-1.000700805	-0.99725127	-0.154951754	0.147893118	1.043340076	2742.79161	-2743.98646	-1.19484874	
1	-0.99905779	-0.99714547	-0.508239842	-0.272694065	-0.2546657	2741.90725	-2692.60183	49.3054276	
1	-1.000320974	-0.99730283	-0.15179295	0.117603991	0.391109352	2742.3145	-2705.38709	36.9274122	
1	-1.000340807	-0.99725548	-0.156882202	0.006510214	-0.11371014	2742.10076	-2687.7709	54.3288625	
1	-0.999979195	-0.99740252	-0.151573012	-0.112551554	0.35128861	2742.23826	-2671.78815	70.4501116	
1	-0.996224956	-0.99325914	-0.150806295	-1.316799492	-9.4821237	2731.33887	-2615.49945	115.839418	
1	-0.98981903	-0.98627485	-0.186131566	-2.904464124	-15.5086213	2712.64458	-2581.60505	131.039537	
1	-1.000066025	-0.99793332	-0.138605861	2.759946434	28.42334112	2743.73906	-2656.97787	86.7611947	
1	-1.000123393	-0.99762238	-0.153981335	0.013768306	-0.76706813	2742.88214	-2672.91404	69.9681064	
1	-0.999973823	-0.99777838	-0.155764395	-0.024566915	0.406839412	2743.159	-2716.45172	26.707282	
1	-1.000151057	-0.99786596	-0.16469277	0.036864671	0.221054791	2743.30258	-2696.14511	47.1574729	
1	-0.99996753	-0.99802994	-0.478236984	-0.026565474	0.428194717	2743.77005	-2715.85099	27.5260587	
1	-1.000045373	-0.99809529	-0.164939579	0.011423409	0.167926493	2743.44182	-2696.86203	46.5797851	
1	-0.999542695	-0.997551	-0.16232886	-0.109709474	-1.38137841	2743.38376	-2653.60609	88.3236732	
1	-0.999878346	-0.99799637	-0.154550592	0.055046726	1.171596402	2742.96118	-2668.68841	74.2727703	
1	-0.999125409	-0.99730632	-0.158949381	-0.127811007	-1.71370673	2741.01107	-2642.16381	98.8472553	
1	-0.998868428	-0.99825057	-0.470157277	-0.023449545	2.497072008	2743.16548	-2713.52039	29.6450925	
1	-0.999904882	-0.99852292	-0.167076742	0.100536078	0.719547255	2743.86884	-2714.58834	29.2805031	
1	-0.999450692	-0.99837339	-0.166964335	-0.027819126	-0.40896827	2743.31546	-2751.01758	-7.70212614	
1	-0.999152199	-0.9982914	-0.172815697	-0.014402308	-0.22972114	2742.95067	-2765.70961	-22.7598965	

Greek exposure					
Delta	Gamma	Vega	Theta	Rho	
0	0	-0.182424422	44.47485661	407.162457	
0	0	0.130871794	46.12067069	398.755978	
0	0	-0.207803333	44.46442304	391.215061	
0	0	0.120431305	36.87439167	383.387346	
0	0	-0.294991448	43.86508216	375.660599	
0	0	0.057117792	35.94823966	352.159778	
0	0	-0.161603429	38.95563863	344.392088	
0	0	-0.254119811	37.53007173	336.583071	
0	0	0.05657636	35.62104481	328.763095	
0	0	-0.324363225	34.72159432	319.68618	
0	0	-0.290511267	32.86442959	294.18383	
0	0	0.150396242	36.32859777	289.720827	
0	0	-0.155733165	38.52646983	281.811601	
0	0	0.011063122	40.90107374	273.957043	
0	0	-0.088755047	39.54084336	266.178444	
0	0	0.014013166	40.96823839	242.681556	
0	0	-0.03495302	40.28543856	234.882937	
0	0	-0.12503036	37.98063713	226.948232	
0	0	-0.076329907	39.28092263	219.20566	
0	0	-0.084069394	38.47747096	211.235258	
0	0	0.529836205	38.4603841	187.854552	
0	0	0.041417765	41.49402995	180.095788	
0	0	0.165935271	42.69754484	172.209951	
0	0	0.236572524	43.08841065	164.351444	

2020/3/16	2405.13	570.73	45.1291291	0.25041090	0.00821918	-0.030704	-0.5214359	0.74	0.82	-0.7353379	0.0003	Plot Area	730205	-673.9838
2020/3/17	2485.5	497	46.8311736	0.28767123	0.00273973	-0.5753018	-0.8264807	0.72	0.80	-0.7127045	0.0005			

Position									
CALL	PUT1	PUT2	Underlying	DIV	Change of put1	Change of put2	change of undel.cash	Portfolio value	P/L

Greek exposure				

Appendix D: Gamma with in-the-money put

Security				in-the-money, E-mini S&P 500 put option.														
SCDP 2950 Index																		
		put									put							
Date	Stock Price	Price (Avg(mid,ask))	IVM	T	dt	d1	d2	N(d1)	N(d2)	Delta	gamma	theta	Vega	Rho				
2020/3/9	2735.25	296.5	39.33112	0.1424658	0.0027397	-0.4506416	-0.5990955	0.67	0.73	0.67	-0.671662	9E-04	-540.06795	370.8816	-304.59493			
2020/3/10	2854.25	213.5	37.321587	0.139726	0.0027397	-0.1831806	-0.3226922	0.57	0.63	0.63	-0.5708264	1E-03	-582.47207	417.20794	-258.01126			
2020/3/11	2729	296.5	38.950191	0.1369863	0.0027397	-0.4836622	-0.6278233	0.69	0.73	0.73	-0.6835208	9E-04	-536.59921	357.33934	-296.72391			
2020/3/12	2456	522.5	44.715239	0.1342466	0.0027397	-1.0501519	-1.2139871	0.85	0.89	0.89	-0.8505342	6E-04	-374.1188	206.19074	-351.20725			
2020/3/13	2684	319.25	37.036693	0.1315068	0.0027397	-0.6524797	-0.7867891	0.74	0.78	0.78	-0.7407006	9E-04	-471.04665	312.89701	-303.99643			
2020/3/16	2405.25	570.75	49.129129	0.1232877	0.0082192	-1.1089283	-1.2814322	0.87	0.90	0.90	-0.8638059	5E-04	-392.17357	181.66135	-327.05088			
2020/3/17	2485.5	497	46.831174	0.1205479	0.0027397	-0.9845715	-1.1471694	0.84	0.87	0.87	-0.8352536	6E-04	-441.40424	211.44428	-310.68014			
2020/3/18	2401.5	567.25	46.220385	0.1178082	0.0027397	-1.229551	-1.3881942	0.89	0.92	0.92	-0.8881471	5E-04	-333.24586	153.99844	-318.59756			
2020/3/19	2389	572.25	42.204504	0.1150685	0.0027397	-1.4149355	-1.5581005	0.92	0.94	0.94	-0.9190102	4E-04	-249.45618	118.49828	-318.9731			
2020/3/20	2288.5	665.75	41.589784	0.1123288	0.0027397	-1.7650883	-1.9044785	0.96	0.97	0.97	-0.9587346	3E-04	-150.48538	64.276075	-321.70881			
2020/3/23	2220.5	732.5	45.233885	0.1041096	0.0082192	-1.8850699	-2.0310216	0.97	0.98	0.98	-0.9679591	2E-04	-135.11935	48.246693	-300.42525			
2020/3/24	2438	527.5	44.712819	0.1013699	0.0027397	-1.2795527	-1.4219122	0.90	0.92	0.92	-0.8975446	5E-04	-332.83056	136.25606	-275.67038			
2020/3/25	2467	498.5	43.132901	0.0986301	0.0027397	-1.2641673	-1.3996281	0.90	0.92	0.92	-0.8948738	5E-04	-336.11595	138.69711	-267.26915			
2020/3/26	2608	368	38.743804	0.0958904	0.0027397	-0.9801826	-1.1001573	0.84	0.86	0.86	-0.8346511	8E-04	-434.92177	198.84622	-244.3526			
2020/3/27	2524	440.5	39.284738	0.0931507	0.0027397	-1.253551	-1.3734503	0.89	0.92	0.92	-0.8930736	6E-04	-328.73509	139.77675	-251.33333			
2020/3/30	2611.25	354.5	35.001328	0.0849315	0.0082192	-1.1584457	-1.2604501	0.88	0.90	0.90	-0.8749406	8E-04	-354.23745	154.89239	-224.42497			
2020/3/31	2569.75	385.5	30.089224	0.0821918	0.0027397	-1.5722211	-1.6584741	0.94	0.95	0.95	-0.9402623	5E-04	-193.04416	85.238484	-230.55228			
2020/4/1	2448	504.75	35.182492	0.0794521	0.0027397	-1.8445093	-1.943679	0.97	0.97	0.97	-0.9656716	3E-04	-146.38241	50.14129	-228.17581			
2020/4/2	2516.5	436.5	31.630679	0.0767123	0.0027397	-1.7847415	-1.8723489	0.96	0.97	0.97	-0.9611437	4E-04	-153.10844	56.453442	-219.26853			
2020/4/3	2482.75	469	31.8657	0.0739726	0.0027397	-1.9603058	-2.0469738	0.98	0.98	0.98	-0.9733553	3E-04	-121.27178	39.371619	-213.67678			
2020/4/6	2644.5	311.5	28.648018	0.0657534	0.0082192	-1.4661392	-1.5395997	0.93	0.94	0.94	-0.9272853	7E-04	-238.98688	92.210679	-181.89932			
2020/4/7	2642	315.25	30.755232	0.0630137	0.0027397	-1.4030754	-1.4802788	0.92	0.93	0.93	-0.9183651	7E-04	-278.59846	98.72967	-172.9167			
2020/4/8	2735	231	29.747837	0.060274	0.0027397	-1.0131736	-1.0862068	0.84	0.86	0.86	-0.8433364	0.001	-431.37301	160.11112	-153.08549			
2020/4/9	2779.75	195.25	30.739784	0.0575342	0.0027397	-0.7821349	-0.8558682	0.78	0.80	0.80	-0.7818925	0.001	-556.97127	195.64343	-136.40114			

Detla and Gamma Natural		with SP500 mini future (underlying) and vanilla put option with same strike							
CALL		Position	Underlying(Sho DIV		Change of put	change of undel cash	Portfolio value	P/L	
		PUT(short)							
		1	-0.866860643		-1.018398061	2919.597477	-2919.597477	0	
		1	-0.78709057		-0.973906352	-0.176298026	-17.03091052	-126.9904595	2775.453402
		1	-0.860683217		-1.018612232	-0.175930877	21.82021979	122.0023454	2919.150984
		1	-1.084944433		-1.198644536	-0.175932179	117.1764853	442.1593392	3478.364461
		1	-0.839822616		-1.023628861	-0.186316634	-78.2551403	-469.7420719	2930.244782
		1	-1.116285026		-1.227581478	-0.521682938	157.7909209	490.5570311	3578.23242
		1	-1.042283737		-1.163986524	-0.186871645	-36.77864064	-158.065258	3383.267332
		1	-1.216232174		-1.318067974	-0.183102628	98.67225093	370.0266032	3851.845188
		1	-1.4148166		-1.492255107	-0.200333352	113.6399379	416.1330597	4381.488558
		1	-1.585596143		-1.595409683	-0.225627526	113.6964806	236.0692481	4731.109088
		1	-1.318576273		-1.315553343	-0.693273723	-195.5920546	-621.4210025	3913.663299
		1	-1.309224237		-1.341514922	-0.184880922	-4.933199284	63.29432893	3971.911388
		1	-1.302799033		-1.36819278	-0.206996054	-3.202963953	65.81427463	4034.388613
		1	-1.056556265		-1.190734673	-0.213623636	-90.61733888	-462.8107417	3480.820965
		1	-1.264931678		-1.374347486	-0.196542034	91.78936955	463.4387396	4035.916427
		1	-1.174170606		-1.312649438	-0.658669422	-32.17480016	-161.1090291	3842.196187
		1	-1.7103709		-1.823196073	-0.216935221	206.7052136	1311.977217	5360.732211
		1	-2.158297589		-2.205605328	-0.296522129	226.090996	936.1378546	6522.762942
		1	-2.123432411		-2.184598327	-0.341721319	-15.21865011	-52.86411761	6454.458187
		1	-2.274285617		-2.295900457	-0.347937621	70.75015346	276.335364	6801.314247
		1	-1.582976732		-1.714218733	-1.082349807	-215.3427177	-1538.25732	5047.006409
		1	-1.483525644		-1.615949492	-0.286908005	-31.35195545	-259.6273342	4755.832856
		1	-1.04210907		-1.237156657	-0.270205045	-101.9672285	-1035.998404	3617.684318
		1	-0.897200932		-1.115782982	-0.214148425	-28.29331405	-337.3884716	3251.854791

Greek exposure				
Delta	Gamma	Vega	Theta	Rho
0	0	83.98390543	-217.2054687	412.74668
0	0	94.96329491	-244.5657646	384.18831
0	0	88.2174854	-241.9840984	396.10524
0	0	76.54411768	-253.5742212	460.7492
0	0	112.7942117	-341.7153675	379.29138
0	0	72.56276039	-296.2301371	433.11846
0	0	76.18401189	-302.5691772	400.71571
0	0	67.38937462	-264.2639154	446.96991
0	0	53.46409616	-174.0658356	498.93381
0	0	6.859290154	26.58241985	528.19151
0	0	-2.872299263	53.63162378	404.70267
0	0	15.21077536	-20.76629596	398.82704
0	0	37.53813617	-129.9569265	393.17658
0	0	74.01814784	-302.9303893	327.9071
0	0	64.94377689	-270.6933011	370.19861
0	0	76.36123776	-326.9404472	321.39557
0	0	69.30214976	-241.3716042	436.58033
0	0	30.8676769	-74.85707336	514.64669
0	0	37.91471038	-97.01438968	491.74481
0	0	12.89034862	26.82411992	500.38734
0	0	67.68592638	-291.9955698	328.1389
0	0	65.70421735	-325.4687304	296.01532
0	0	83.7155822	-462.5002105	214.39476
0	0	84.02510416	-506.7112466	192.65669

Appendix E: Gamma with at-the-money put

Security		S&P 2700 Index		almost at-the-money, E-mini S&P 500 put option.													
Date	Stock Price	put		T	dt					put				Vega	Rho		
		Price (Avg(mid,ask))	IVM			d1	d2	N(d1)	N(d2)	Delta	gamma	theta					
2020/3/9	2735.25	175.5	47.1824233	0.14246575		0.14875963	-0.0293287	0.44	0.51	-0.43942315	0.0008	-690.823643	406.001597	-196.641005			
2020/3/10	2854.25	121.25	45.6015288	0.13972603	0.00273973	0.3977152	0.2275693	0.35	0.41	-0.34430696	0.0008	-654.970024	392.004625	-154.574183			
2020/3/11	2729	176	47.5541164	0.1369863	0.00273973	0.13593819	-0.04006749	0.45	0.52	-0.44452619	0.0008	-709.487573	397.983614	-190.666968			
2020/3/12	2456	355.75	56.4585138	0.13424658	0.00273973	0.36509061	-0.57195276	0.64	0.72	-0.64048881	0.0007	-727.427908	334.810787	-259.409129			
2020/3/13	2684	201	49.654124	0.13150685	0.00273973	0.04504733	-0.13501776	0.48	0.55	-0.48057268	0.0008	-749.890454	386.729064	-196.42866			
2020/3/16	2405.25	399.5	62.314329	0.12328767	0.00821918	-0.4281672	-0.64696741	0.67	0.74	-0.66384202	0.0007	-798.167538	306.537974	-246.515679			
2020/3/17	2485.5	334	58.5771193	0.12054795	0.00273973	-0.31504219	-0.51842203	0.62	0.70	-0.62190099	0.0007	-816.835182	326.694762	-226.974599			
2020/3/18	2401.5	385.25	58.0873988	0.11780822	0.00273973	-0.49763211	-0.69700667	0.69	0.76	-0.68875142	0.0007	-738.856686	289.750857	-240.630238			
2020/3/19	2389	372.5	50.9987552	0.11506849	0.00273973	-0.63180459	-0.80480127	0.74	0.79	-0.73428832	0.0008	-611.502847	264.100879	-245.106909			
2020/3/20	2288.5	431.25	41.7135709	0.11232877	0.00273973	-1.12602982	-1.26593487	0.87	0.90	-0.8676692	0.0007	-330.261885	161.900883	-271.909197			
2020/3/23	2220.5	481	42.7845289	0.10410959	0.00821918	-1.35965169	-1.48970083	0.91	0.93	-0.91083678	0.0005	-262.342372	113.144103	-262.04994			
2020/3/24	2438	317.5	46.7378576	0.10136986	0.00273973	-0.62271587	-0.77152283	0.73	0.78	-0.73154934	0.0009	-613.789801	254.49365	-213.285681			
2020/3/25	2467	298.75	48.1245742	0.09860104	0.00273973	-0.53226579	-0.68340311	0.70	0.75	-0.70112979	0.0009	-679.330155	267.654932	-200.345605			
2020/3/26	2608	208.25	48.2946734	0.09589041	0.00273973	-0.16755658	-0.31710672	0.57	0.62	-0.56528041	0.001	-821.020269	316.990902	-161.560733			
2020/3/27	2524	259.5	49.1758942	0.09315068	0.00273973	-0.38425071	-0.53433848	0.65	0.70	-0.64820738	0.001	-776.928468	284.837029	-176.811182			
2020/3/30	2611.25	188	45.1484184	0.08493151	0.00821918	-0.1988164	-0.33039248	0.58	0.63	-0.57766238	0.0011	-813.053503	297.069111	-144.259864			
2020/3/31	2569.75	194.75	39.3674711	0.08219178	0.00273973	-0.39359273	-0.50645576	0.65	0.69	-0.65182038	0.0013	-676.325191	271.488323	-153.866647			
2020/4/1	2448	283.5	40.4623493	0.07945205	0.00273973	-0.81348252	-0.92753472	0.79	0.82	-0.79057696	0.001	-532.390957	197.369005	-176.494084			
2020/4/2	2516.5	221.25	36.5125782	0.07671233	0.00273973	-0.65784673	-0.75897558	0.74	0.78	-0.74336324	0.0013	-561.220609	223.561414	-160.658833			
2020/4/3	2482.75	237.25	32.032873	0.0739726	0.00273973	-0.9132002	-1.03032491	0.82	0.85	-0.82323378	0.0012	-408.699651	173.992682	-168.926883			
2020/4/6	2644.5	130.75	36.8327115	0.06575342	0.00821918	-0.18410023	-0.27854825	0.57	0.61	-0.57216287	0.0016	-767.766221	265.578813	-108.195706			
2020/4/7	2642	136.75	39.3807151	0.0630137	0.00273973	-0.18069577	-0.27955133	0.57	0.61	-0.57086525	0.0015	-835.99653	259.919063	-103.754911			
2020/4/8	2735	90.25	40.1750777	0.06027397	0.00273973	-0.16987635	-0.07124349	0.43	0.47	-0.43195185	0.0015	-897.497605	263.670289	-71.773905			
2020/4/9	2779.75	73	41.3150841	0.05753425	0.00273973	0.33376551	0.23466592	0.37	0.41	-0.36878779	0.0014	-918.435939	251.253285	-63.2363557			

Detla and Gamma Netural									
Position									
CALL	PUT(short)	Underlyi(Shor DIV	Change of put	change of undely cash	Portfolio value	P/L			
1	-0.949950051	-0.853590743			2378.500314	-2378.500314		0	
1	-1.023513907	-0.87701723	-0.147767723	8.91961754	66.86504884	2454.180873	-2456.827489	-2.646615354	
1	-0.943490431	-0.84972352	-0.158428384	-14.08413176	-74.48453385	2365.498829	-2367.949802	-2.450972377	
1	-0.843628212	-0.816196652	-0.146762139	-35.52598432	-82.34198681	2247.527518	-2251.699714	-4.172196687	
1	-0.910972545	-0.839360264	-0.12686915	13.5362108	62.17113473	2323.149251	-2340.448431	-17.29918034	
1	-0.839077755	-0.820342999	-0.427777216	-28.72196838	-45.74127857	2248.386167	-2259.59156	-11.20539308	
1	-0.843786749	-0.818167122	-0.124878754	1.572804103	-5.40814017	2244.467225	-2258.629157	-14.16193237	
1	-0.812374807	-0.797399208	-0.128702994	-12.10145081	-49.87414563	2182.404125	-2192.421593	-10.01746781	
1	-0.767084372	-0.75528526	-0.121196827	-16.87068693	-100.6102213	2064.842081	-2067.865416	-3.02333481	
1	-0.631369239	-0.623063461	-0.1141984	-58.52715126	-302.5895883	1703.649046	-1691.158715	12.49033152	
1	-0.531774786	-0.523585445	-0.270747714	-48.90087631	-220.8909342	1433.680308	-1418.722901	14.95740709	
1	-0.732705848	-0.702438318	-0.073581934	63.79561224	436.0433052	1933.47196	-1920.178727	13.29323338	
1	-0.753230372	-0.730464252	-0.108386391	6.131701506	69.13997828	2008.670745	-1998.832883	9.837861864	
1	-0.82615233	-0.775886512	-0.114051493	15.18599776	118.4612541	2142.240818	-2145.558246	-3.317428647	
1	-0.777023134	-0.748342528	-0.128067416	-12.74902642	-69.52101564	2059.882032	-2059.954044	-0.072012295	
1	-0.78969939	-0.741499474	-0.358650447	2.383136117	-17.86892432	2044.151031	-2049.703987	-5.552956503	
1	-0.702589068	-0.672960702	-0.12254403	-16.96473525	-176.1275087	1850.973766	-1851.419986	-0.446220119	
1	-0.630597677	-0.619934731	-0.109449413	-20.40955921	-129.8075781	1700.681156	-1689.874663	10.80649331	
1	-0.618964876	-0.603790463	-0.096048423	-2.573757386	-40.62705017	1657.415519	-1649.634679	7.780839498	
1	-0.517332463	-0.508098037	-0.09616478	-24.11228992	-237.5803721	1395.657116	-1380.717527	14.93958891	
1	-0.70664524	-0.650663853	-0.239531209	24.75264567	377.0153022	1797.262391	-1795.574425	1.687966437	
1	-0.721554609	-0.665441828	-0.108901312	2.038856122	39.04340831	1838.268746	-1836.269901	1.998844463	
1	-0.854623438	-0.727464373	-0.111269405	12.00946184	169.6316626	2019.832345	-2025.994826	-6.162481727	
1	-0.938968583	-0.760548474	-0.125922088	6.157195608	91.96552936	2117.866224	-2125.179328	-7.313103502	

Greek exporsure				
Delta	Gamma	Vega	Theta	Rho
0	0	19.80533325	-29.12116235	335.504448
0	0	22.12154911	-32.65311194	339.318904
0	0	20.27972493	-34.43129705	320.612412
0	0	17.79378414	-45.7936231	298.553701
0	0	23.27263362	-54.18137979	302.929427
0	0	18.1394087	-64.28299355	274.882277
0	0	20.9082353	-73.40293703	268.417013
0	0	19.30093204	-69.33968929	254.963256
0	0	18.52977828	-57.926309	235.66305
0	0	6.555950333	-3.509420345	189.76636
0	0	0.572190448	14.97350796	147.920613
0	0	7.131525917	-6.788757179	194.188367
0	0	16.6267745	-56.15635617	195.884977
0	0	22.22759017	-84.16189701	203.208604
0	0	20.42684999	-82.82933423	189.665496
0	0	23.63603108	-100.8077946	171.804298
0	0	24.34684481	-96.37003209	150.355446
0	0	14.6270656	-55.06937616	133.472157
0	0	19.41311723	-74.75397948	125.58507
0	0	12.42059296	-37.57999803	101.816668
0	0	25.98328087	-127.7679001	116.652485
0	0	24.62641765	-135.559546	114.353793
0	0	25.23002052	-145.0154517	120.427453
0	0	23.64763213	-143.5439923	120.6544

Appendix F: Simulation

		11.36246452			10.53968				-23.77557
		25.32948656			12.37463				-25.14405
		27.58191873			6.234397				-23.55885
Out of money put option		14.90739755	Almost at the money opt		9.157435	in the money PUT option			-23.05299
S0	2,735.25	11.9077443	S0	2,735.25	8.074617	S0	2,735.25		-25.7257
C0	123	35.81720879	C0	123	9.97708	C0	123		-23.23976
K1(strike of call)	2860	23.95273176	K1(strike of	2860	11.12879	K1(strike of c	2860		-23.43015
P0	138.5	19.91508201	P0	175.5	4.658493	P0	296.5		-24.2529
K(strike of put)	2600	25.15149136	K(strike of p	2700	13.76815	K(strike of pu	2950		-24.7994
r	0.67%	21.10994172	r	0.67%	9.593012	r	0.67%		-23.9192
sigma	0.4	24.80583044	sigma	0.4	4.909537	sigma	0.4		-24.85729
q	2.31%	22.18770067	q	2.31%	8.698676	q	2.31%		-26.27125
T	0.25	24.27718347	T	0.25	10.65097	T	0.25		-26.27281
mu	0.12	20.30012773	mu	0.12	5.454164	mu	0.12		-23.32
M	500	12.93712385	M	500	15.10058	M	500		-21.88336
N	90	24.46705103	N	90	10.32653	N	90		-25.64877
		20.02914855			12.75438				-25.28606
		12.51556886			9.769791				-23.06992
		19.93020231			8.014958				-24.25119
		20.14852467			8.09877				-25.99352
		21.53567861			9.036025				-25.68972
		15.13471833			8.279958				-24.32609
		21.99003816			7.775889				-25.26705
		18.87190838			11.56805				-24.3162
		8.752702156			7.287524				-20.6257
		25.10694963			9.570024				-22.70661
		17.41356655			11.24149				-24.17667
		16.3239364			11.14569				-24.39417
		18.89446962			16.47378				-22.4739
		17.66581061			9.569738				-25.34449
		22.09010892			20.24146				-24.77419
		15.85053491			7.706389				-23.50067
		16.76029774			7.260746				-21.1177
		19.78742899			15.77283				-22.16153
		15.38801087			5.405372				-22.12263
		24.389308			7.702305				-22.83315
		23.65845134			6.032193				-22.31677
		18.50366255			9.463932				-23.37458
		20.6160988			12.07274				-23.33465
		17.17135491			11.90359				-25.22608
		22.90400705			6.230773				-24.54341
		25.66975292			5.211599				-21.99903
		16.73490447			11.79439				-23.63703
		18.24489164			10.3186				-21.94318
		16.35329304			14.64002				-22.70261
		19.30603235			7.399856				-25.28233
		17.66026498			10.36492				-23.48845
		18.06061873			6.576963				-22.49988
		20.60175347			9.674989				-23.73886
		15.43463177			7.698946				-26.78596
		24.85462526			11.31468				-26.23082
		22.40816884			12.23527				-22.35864
		21.82532866			7.477562				-23.31733
		27.22879375			8.529653				-24.10444
		24.94379659			7.678924				-23.44043
		19.53215029			10.57904				-24.30628
		22.29893196			1.918362				-23.20173
		21.18202197			12.2039				-23.98444
		16.98431694			7.985906				-24.81281
		17.45196861			10.59486				-25.97367
		8.739099386			8.371875				-24.29728