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 been 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.

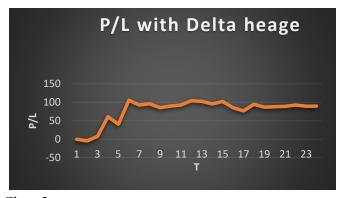


Chart 2: The profit/loss performance of the delta hedging strategy

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.

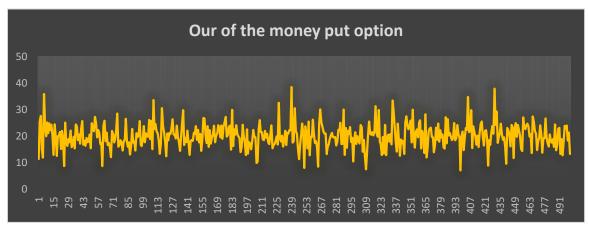


Chart 6: Simulated hedging performance with out-of-the-money put option.

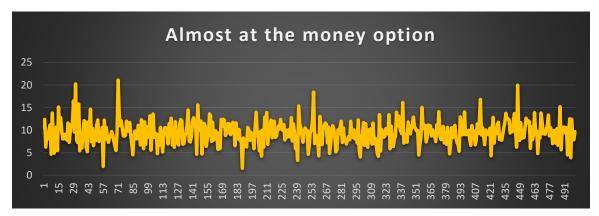


Chart 7: Simulated hedging performance with at-the-money put option.

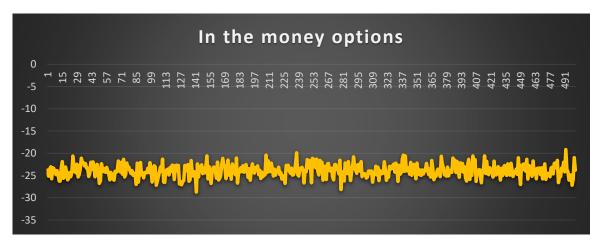


Chart 8: Simulated hedging performance with in-the-money put option.

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 samll 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.

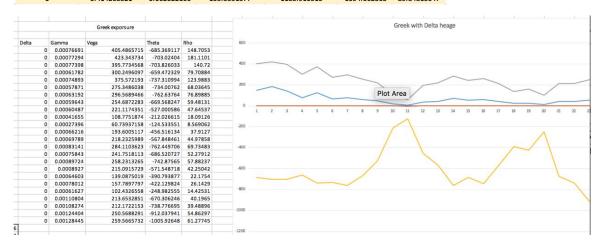
For our second part, we have seen that the hedging performance with an OTM put option dominates the other kind of put option during delta-gamma hedging process. The reason may be that the out-of-the-money has a lower price with a risk of zero payoff at maturity. However, there is a trade-off between 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

| | | | | 0 | 0 1 | | | | | | | | | |
|-----------|-------------|------------|---------------|------------|------------|------------|------------|-------|-------|------------|--------|------------|------------|-----------|
| | | Ca | II | | | | | | | CALL | | | | |
| Date | Stock Price | Last price | IVM | T | dt | d1 | d2 | N(d1) | N(d2) | Delta | gamma | theta | Vega | Rho |
| 2020/3/9 | 2735.25 | 1 | 23 49.6053143 | 0.14246575 | | -0.1570608 | -0.3442943 | 0.44 | 0.37 | 0.4361607 | 0.0008 | -685.36912 | 405.486571 | 148.70531 |
| 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 | 181.11007 |
| 2020/3/11 | 2729 | 1 | 17 50.1224266 | 0.1369863 | 0.00273973 | -0.1720957 | -0.3576071 | 0.43 | 0.36 | 0.43031731 | 0.0008 | -703.82603 | 395.773457 | 140.71995 |
| 2020/3/12 | 2456 | | 60.0152137 | 0.13424658 | 0.00273973 | -0.5926162 | -0.81251 | 0.28 | 0.21 | 0.27586222 | 0.0006 | -659.47233 | 300.24961 | 79.708841 |
| 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 | 123.98831 |
| 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 | 68.036454 |
| 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 | 76.898854 |
| 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 | 59.481312 |
| 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 | 47.645370 |
| 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 | 18.091257 |
| 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 | 8.5690618 |
| 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 | 37.912701 |
| 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 | 44.978582 |
| 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 | 69.734827 |
| 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 | 52.279117 |
| 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 | 57.882371 |
| 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 | 42.250421 |
| 2020/4/1 | 2448 | | .5 45.2176391 | 0.07945205 | 0.00273973 | -1.166918 | -1.294374 | 0.12 | 0.10 | 0.12139874 | 0.0006 | -390.79388 | 139.087502 | 22.175397 |
| 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 | 26.142895 |
| 2020/4/3 | 2482.75 | | .5 36.4530281 | 0.0739726 | 0.00273973 | -1.3894164 | -1.488561 | 0.08 | 0.07 | 0.08221248 | 0.0006 | -248.98256 | 102.432656 | 14.425307 |
| 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 | 40.196503 |
| 2020/4/7 | 2642 | 20 | .5 44.5517504 | 0.0630137 | 0.00273973 | -0.662265 | -0.7741012 | 0.25 | 0.22 | 0.25353138 | 0.0011 | -738.7767 | 212.172215 | 39.488958 |
| 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 | 54.862972 |
| 2020/4/9 | 2779.75 | 5 | 5 45.4563536 | 0.05753425 | 0.00273973 | -0.2151652 | -0.3241981 | 0.41 | 0.37 | 0.41426832 | 0.0013 | -1005.9265 | 259.566573 | 61.277449 |

| | Positon | | | | | |
|------|--------------------|--------------|---------------------|-------------|-----------------|--------------|
| CALL | Underlying (short) | DIV | Change in undelying | 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 |



Appendix B: Delta & Gamma hedging process

| ecurity S | | | | | , | 11144 | hedgi | 8 | proc | CBB | | | | |
|-----------|--------------------------------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------|------------------------|------------------------|
| | CJOP 2600 Ind | ex | | | | | 500 put opti | | | | | | | |
| ate s | Stock Price | Price (Avg(mid,ask)) | IVM | т | dt | d1 | d2 N(| d1) | N(-d2) | put Delta | gamma th | eta | Vega | Rho |
| 2020/3/9 | 2735.25 | 138.5 | | 0.1424658 | | -0.156906 | -0.344224 | 0.56 | 0.63 | -0.560493 | | 729.5335 | 405.49643 | |
| 2020/3/10 | 2854.25 2729 | 93.75 | 48.100913 50.148744 | | 0.0027397 | -0.171908 | | 0.47 | 0.55 | -0.472177 -0.56645 | | 749.3781 | 423.34472 | |
| 2020/3/11 | 2456 | 300.25 | 59.991141 | | 0.0027397 | -0.171908 | | 0.72 | | -0.72115 | | 696.4915 | 300.19159 | |
| 020/3/13 | 2684 | 162.75 | 52.975814 | | 0.0027397 | -0.245779 | -0.43789 | 0.60 | 0.67 | -0.595262 | 7E-04 | -780.629 | 375.60396 | -251.496 |
| 020/3/16 | 2405.25 | 343 | 66.695144 | | 0.0082192 | -0.631 | -0.865182 | 0.74 | | -0.733887 | | 770.0284 | 275.31743 | |
| 020/3/17 | 2485.5 2401.5 | 283.25 328.25 | 63.0544 62.913092 | | 0.0027397 | -0.540645 -0.710137 | -0.75957 -0.926075 | 0.71 | 0.78 | -0.703662 -0.759122 | | 706.8574 | 296.63534 254.85449 | |
| 020/3/19 | 2389 | | | 0.1150685 | | -0.868862 | | 0.81 | 0.85 | -0.805395 | | | 221.06546 | |
| 020/3/20 | 2288.5 | | | 0.1123288 | | -1.431721 | -1.580937 | 0.92 | 0.94 | -0.921494 | | | 109.51297 | -302.7378 |
| 020/3/23 | 2220.5 | | | 0.1041096 | | -1.749598 | | 0.96 | | -0.9576 | | | 61.709807 | |
| 020/3/24 | 2438 2467 | | 52.130664 | 0.1013699 | | -0.967688 | | 0.83 | 0.87 | -0.831451 -0.795172 | | | 193.43734 218.36139 | |
| 020/3/26 | 2608 | 164.25 | 52.391697 | | 0.0027397 | -0.497113 | -0.65935 | 0.69 | | -0.688918 | | 803.3718 | 284.10674 | |
| 2020/3/27 | 2524 | 208 | 53.734229 | 0.0931507 | 0.0027397 | -0.689368 | | 0.75 | | -0.753082 | | 725.9519 | 241.80404 | |
| 2020/3/30 | 2611.25 | 144.75 | 49.694532 | | 0.0082192 | -0.565499 | -0.710324 | 0.71 | | -0.712733 | | 783.8693 | 258.2257 | -184.8052 |
| 2020/3/31 | 2569.75 2448 | 146.75 218.25 | 44.399588 45.258287 | 0.0821918 | 0.0027397 | -0.787649 -1.165755 | -0.914939 -1.293326 | 0.78 | 0.82 | -0.783061 -0.876533 | | 611.8064 428.9707 | 215.11677 | -192.6238 -204.8665 |
| 2020/4/2 | 2516.5 | 164 | 41.655136 | 0.0767123 | | -1.06226 | | 0.86 | 0.88 | -0.854426 | 8E-04 - | 461.4669 | 157.88532 | |
| 2020/4/3 | 2482.75 | 169.75 | 36.482946 | | | -1.388196 | | 0.92 | | -0.915895 | | 287.7117 | 102.60646 | |
| 2020/4/6 | 2644.5 2642 | 91.25 97 | 41.828285 44.543054 | | | -0.68681 -0.662416 | -0.794068 -0.774231 | 0.75 | 0.79 | -0.752755 -0.745062 | 0.001 - | 709.5696 -780.345 | 213.36489 | |
| 2020/4/8 | 2735 | | 44.643689 | | 0.0027397 | -0.361961 | -0.471564 | 0.64 | 0.68 | -0.640417 | | | 250.54052 | |
| 2020/4/9 | 2779.75 | 48.25 | 45.414924 | 0.0575342 | 0.0027397 | -0.215461 | -0.324394 | 0.59 | 0.63 | -0.584519 | 0.001 - | 1049.905 | 259.55005 | -103.1615 |
| etla ar | nd Gam | ma Netural | with SP5 | 500 mini fu | iture (und | erlving) an | d vanila put o | ption w | ith same st | ike | | | | |
| | | Position | | | | ,g, a | a vaima part | p (10.11 11 | | | | | | |
| ALL | PI | UT(short) | Underly | ing(Sho DI | V | С | hange of put | c | hange of ur | ndel cash | | Portfol | io value | P/L |
| | 1 | -1.000425572 | | | | | | | J J. | | 2.30823 | | 2.30823 | |
| | 1 | -0.99968854 | | | -0.1725 | 75073 | -0.06909 | 6731 | -0.707079 | | 1.40982 | | 7.89318 | -26.4833 |
| | 1 | -1.000492757 | | | -0.1800 | | 0.11178 | | 1.0964018 | | 2.48829 | | 3.00756 | -0.51926 |
| | 1 | -0.999792092 | | | -0.1722 | | -0.21037 | | -0.451052 | | 741.705 | | 5.48198 | 46.2230 |
| | 1 | -1.000700805 | | | -0.1549 | | 0.14789 | | 1.0433400 | | 2.79161 | | 3.98646 | -1.19484 |
| | 1 | -0.999905779 | | | -0.1349 | | -0.27269 | | -0.254466 | | 1.90725 | | 2.60183 | 49.3054 |
| | 1 | -1.000320974 | | | | 79295 | 0.11760 | | 0.3911093 | | 42.3145 | | 5.38709 | 36.9274 |
| | 1 | -1.000320374 | | | -0.1568 | | 0.00651 | | -0.113710 | | 2.10076 | | 87.7709 | 54.3298 |
| | 1 | -0.999979195 | | | -0.1515 | | -0.11255 | | 0.351288 | | 2.23826 | | 1.78815 | 70.4501 |
| | 1 | -0.996224956 | | | -0.1513 | | -1.31679 | | -9.48212 | | 1.33887 | | 5.49945 | 115.839 |
| | | -0.988981903 | | | | | | | | | | | | |
| | 1 | | | | -0.4316 | | -2.90446 | | -15.50862 | | 2.64458 | | 1.60505 | 131.039 |
| | 1 | -1.000066025 | | | -0.1386 | | 2.75994 | | 28.423341 | | 3.73906 | | 6.97787 | 86.7611 |
| | 1 | -1.000123393 | | | -0.1539 | | 0.01376 | | -0.767068 | | 2.88214 | | 2.91404 | 69.9681 |
| | 1 | -0.999973823 | | | -0.1557 | | -0.02456 | | 0.4068394 | | 743.159 | | 6.45172 | 26.707 |
| | 1 | -1.000151057 | | | | 69277 | 0.03686 | | 0.2210547 | | 3.30258 | | 6.14511 | 47.1574 |
| | 1 | -0.99996753 | | | -0.4782 | | -0.02656 | | 0.4281947 | | 3.37705 | | 5.85099 | 27.5260 |
| | 1 | -1.000045373 | | | -0.1649 | | 0.01142 | | 0.1679264 | | 3.44182 | | 6.86203 | 46.5797 |
| | 1 | -0.999542695 | | 97531 | | 32886 | -0.10970 | | -1.381378 | | 1.83876 | | 3.60609 | 88.2326 |
| | 1 | -0.999878346 | | | -0.1545 | | 0.05504 | | 1.1715964 | | 2.96118 | | 8.68841 | 74.2727 |
| | 1 | -0.999125409 | | | -0.1589 | | -0.12781 | | -1.713706 | | 1.01107 | | 2.16381 | 98.8472 |
| | 1 | -0.998868428 | | 25057 | -0.4701 | 57277 | | 9545 | 2.4970720 | 08 2/4 | 3.16548 | -2/1 | 3.52039 | 29.6450 |
| | | | | | | | -0.02344 | | | | | | | |
| | 1 | -0.999904882 | -0.998 | 52292 | -0.1670 | 76742 | 0.10053 | 6078 | 0.7195472 | 55 274 | 3.86884 | -271 | 4.58834 | 29.2805 |
| | 1 1 | -0.999904882 -0.999450692 | 2 -0.998 2 -0.998 | 52292 37339 | -0.1670 -0.1669 | 76742 64335 | 0.10053 -0.02781 | 6078 9126 | 0.7195472 -0.408968 | 55 274 27 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| | 1 | -0.999904882 | 2 -0.998 2 -0.998 | 52292 | -0.1670 | 76742 64335 | 0.10053 | 6078 9126 | 0.7195472 | 55 274 27 274 | 3.86884 | -271 -275 | | 29.2805 |
| | 1 1 | -0.999904882 -0.999450692 | 2 -0.998 2 -0.998 | 52292 37339 82914 | -0.1670 -0.1669 | 76742 64335 15697 | 0.10053 -0.02781 | 6078 9126 | 0.7195472 -0.408968 | 55 274 27 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| | 1 1 | -0.999904882 -0.999450692 | 2 -0.998 2 -0.998 | 52292 37339 82914 | -0.1670 -0.1669 -0.1728 | 76742 64335 15697 | 0.10053 -0.02781 | 6078 9126 | 0.7195472 -0.408968 | 55 274 27 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 | -0.99904882 -0.999450692 -0.999152199 | 2 -0.998 2 -0.998 9 -0.99 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 | 76742 64335 15697 re | 0.10053 -0.02781 -0.01440 | 6078 9126 | 0.7195472 -0.408968 -0.227921 | 55 274 27 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 1 | -0.999904882 -0.999450692 | 2 -0.998 2 -0.998 9 -0.99 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu | 76742 664335 15697 re | 0.10053 -0.02781 -0.01440 Theta | 6078 9126 2308 | 0.7195472 -0.408968 -0.227921 | 55 274 27 274 14 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 | -0.99904882 -0.999450692 -0.999152199 | 2 -0.998 2 -0.998 9 -0.99 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 | 76742 664335 15697 re | 0.10053 -0.02781 -0.01440 | 6078 9126 2308 | 0.7195472 -0.408968 -0.227921 | 55 274 27 274 14 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 1 | -0.99904882 -0.999450692 -0.999152199 | 2 -0.998 2 -0.998 9 -0.99 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu | 76742 664335 15697 re | 0.10053 -0.02781 -0.01440 Theta | 6078 9126 2308 | 0.7195472 -0.408968 -0.227921 Rho 407.16 | 55 274 27 274 14 274 2457 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 | -0.99904882 -0.999450692 -0.999152199 | 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 | 76742 64335 15697 re | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 | 6078 9126 2308 35661 67069 | 0.7195472 -0.408968 -0.227921 Rho 407.16: | 2457 55 274 27 274 14 274 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 | 76742 64335 15697 re 124422 871794 803333 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 | 6078 9126 2308 35661 67069 | 0.7195472 -0.408968 -0.227921 Rho 407.16 398.75 391.21 | 274 27 274 14 274 2457 5978 5061 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 | -0.99904882 -0.999450692 -0.999152199 | 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 | 76742 64335 15697 re | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 | 35661 57069 12304 39167 | 0.7195472 -0.408968 -0.227921 Rho 407.16; 398.75; 391.21; 383.38 | 2457 278 279 274 274 2457 5978 5061 7346 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 | 76742 164335 15697 re 124422 1871794 1803333 131305 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 | 35661 57069 12304 39167 | 0.7195472 -0.408968 -0.227921 Rho 407.16 398.75 391.21 | 2457 278 279 274 274 2457 5978 5061 7346 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 | 76742 164335 15697 re 824422 871794 803333 831305 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 | 85661 67069 12304 89167 89167 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.660 | 2457 278 2457 2457 5978 5061 7346 0599 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.1308 -0.2078 -0.2949 -0.2949 | 76742 64335 15697 re 824422 871794 803333 831305 991448 17792 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 | 35661 57069 12304 39167 08216 23966 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.666 352.15: | 2457 2798 2457 2998 2061 2346 2599 2778 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 | 76742 64335 15697 re 824422 871794 803333 831305 991448 17792 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 | 35661 57069 12304 39167 08216 23966 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.660 | 2457 2798 2457 2998 2061 2346 2599 2778 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.1308 -0.2078 0.1204 -0.2949 -0.0571 -0.1616 | 76742 64335 715697 re 24422 871794 803333 331305 991448 17792 503429 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 38.9556 | 35661 57069 42304 39167 08216 23966 53863 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: | 2457 274 2457 2457 5978 5061 7346 0599 9778 2088 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.2949 -0.1616 -0.2541 | 76742 64335 15697 re 224422 871794 803333 31305 991448 17792 603429 19811 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 38.9556 37.5300 | 35661 57069 12304 39167 08216 23966 53863 07173 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: | 2457 274 274 2457 2457 5978 5061 7346 0599 9778 2088 3071 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.2949 -0.1616 -0.2541 | 76742 64335 715697 re 24422 871794 803333 331305 991448 17792 503429 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 38.9556 37.5300 | 35661 57069 12304 39167 08216 23966 53863 07173 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: | 2457 274 274 2457 2457 5978 5061 7346 0599 9778 2088 3071 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.2949 -0.1616 -0.2541 | 176742 164335 115697 re 124422 171794 1803333 131305 191448 17792 103429 119811 1557636 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 38.9556 37.5300 | 35661 57069 12304 39167 08216 23966 53863 07173 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: | 2457 5978 5978 5061 7346 0599 9778 2088 3071 3095 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.1308 -0.2078 -0.2049 -0.2949 -0.0571 -0.1616 -0.2541 -0.056 -0.3243 | 76742 64335 115697 re 824422 871794 803333 131305 991448 17792 603429 119811 557636 863225 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1200 44.4644 36.8743 43.8656 35.9482 38.9556 37.5300 35.6210 34.7215 | 6078 9126 22308 855661 67069 42304 89167 08216 63863 07173 04481 59432 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 319.6i | 2457 5978 5978 5061 7346 0599 9778 2088 3071 3095 8618 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.0571 -0.1616 -0.2541 -0.056 -0.3243 -0.2905 | 76742 64335 125697 re 824422 871794 803333 31305 991448 117792 603429 119811 557636 863225 511267 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1200 44.4644 36.8743 43.8656 35.9482 37.5300 35.6210 34.7215 32.8644 | 835661 67069 82304 99167 98216 83966 83966 63863 97173 94481 69432 8259 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 319.61: | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | 1 1 1 0 0 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | Veg 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.0571 -0.1616 -0.2541 -0.056 -0.3243 -0.2905 | 76742 64335 115697 re 824422 871794 803333 131305 991448 17792 603429 119811 557636 863225 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1200 44.4644 36.8743 43.8656 35.9482 37.5300 35.6210 34.7215 32.8644 | 835661 67069 82304 99167 98216 83966 83966 63863 97173 94481 69432 8259 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 319.6i | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.0571 -0.1616 -0.2541 -0.056 -0.3243 -0.2905 -0.1503 | 76742 64335 125697 re 824422 871794 803333 31305 991448 117792 603429 119811 557636 863225 511267 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9482 37.5300 35.6210 34.7215 32.8644 36.3285 | 835661 67069 82304 89167 98216 823966 63863 97173 98481 69432 8259 969777 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 319.6: 294.1: 289.72: | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2541 -0.2541 -0.2541 -0.3243 -0.2905 -0.1503 -0.1557 | 76742 64335 125697 re 824422 871794 803333 31305 991448 117792 503429 119811 557636 863225 511267 896242 733165 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9483 38.9556 37.5300 35.6210 34.7215 32.8644 36.3285 38.5264 | 85661 67769 82308 835661 67069 82304 89167 88216 823966 63863 877173 84481 89432 8959 89777 86983 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 294.11: 289.720: 281.81: | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 1601 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 -0.2078 -0.2078 -0.2949 -0.0571 -0.1616 -0.2541 -0.056 -0.3243 -0.2905 -0.1503 | 76742 64335 125697 re 824422 871794 803333 31305 991448 117792 503429 119811 557636 863225 511267 896242 733165 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1206 44.4644 36.8743 43.8650 35.9483 38.9556 37.5300 35.6210 34.7215 32.8644 36.3285 38.5264 | 85661 67769 82308 835661 67069 82304 89167 88216 823966 63863 877173 84481 89432 8959 89777 86983 | Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 319.6: 294.1: 289.72: | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 1601 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
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| Delta | 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 0.056 -0.3243 -0.2905 0.1503 -0.1557 0.0110 -0.0887 | 76742 64335 155697 re 224422 871794 803333 31305 991448 177792 603429 19811 657636 663225 611267 896242 733165 063122 755047 | 7.001440 Theta 44.4748 46.1206 44.4644 36.8743 38.9556 37.5300 35.6210 32.8644 36.3283 38.5264 40.9010 | 6078 9126 9126 67069 82304 89167 08216 633966 33966 33966 33966 34481 69432 99777 8983 89777 8983 89777 | Rho 407.16; 398.75; 391.21; 383.38; 375.66; 352.15; 344.39; 328.76; 294.10; 289.72(281.81; 273.95; 266.176 | 2457 5978 5061 7346 0599 9778 2088 3087 3095 8618 8383 0827 1601 7043 8444 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
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| Delta | 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | -0.99904882 -0.999450692 -0.999152199 | 0 -0.998 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 -0.2905 0.1503 -0.1557 0.0110 -0.0887 0.0140 -0.034 | 76742 64335 155697 re 224422 871794 803333 31305 991448 17792 503429 19811 557636 663225 612267 896242 733165 96242 733165 996242 733166 995302 603036 | 7.001440 Theta 44.4748 46.1206 44.4644 36.8743 38.9556 37.5300 35.6210 32.8644 36.3283 38.5264 40.9010 39.5408 40.9682 40.2854 | 6078 9126 9126 67069 12304 89167 08216 03966 63863 07173 04481 12959 99777 46983 07374 82388 8389 93889 93886 93889 93886 93889 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 93886 9388 | 0.7195472 -0.408968 -0.227921 Rho 407.16; 398.75; 391.21; 383.38; 375.66; 352.15; 344.39; 336.58; 328.76; 294.11; 289.720; 281.81; 273.95; 266.17; 242.68; 234.88; 226.94; | 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 1601 7043 8444 1556 2937 8232 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 -0.998 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 0.056 -0.3243 -0.2905 0.1503 -0.1010 -0.0887 0.0140 -0.034 -0.125 -0.0763 | 76742 64335 715697 re 824422 871794 803333 831305 991448 17792 603429 19811 557636 863225 612267 896242 733165 996242 753166 995302 603036 829907 | 7.0053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 38.9556 37.5300 35.6210 32.8644 36.3283 38.5264 40.9010 39.5408 40.9682 40.9856 37.9800 39.2808 | 6078 9126 9126 67069 42304 89167 08216 63863 377173 394481 49481 99777 46983 377374 82383 99777 82383 83383 91385 633713 82263 | Rho 407.16; 398.75; 391.21; 383.38; 375.66; 352.15; 344.39; 328.76; 319.6; 294.1; 289.72; 281.81; 273.95; 242.68; 234.88; 226.94; 219.26 | 2457 5978 5061 7346 0599 9778 2088 3071 3095 8638 30827 1601 7043 8444 1556 2937 8232 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
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| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 -0.998 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 0.056 -0.3243 -0.2905 0.1503 -0.1010 -0.0887 0.0140 -0.034 -0.125 -0.0763 | 76742 64335 715697 re 824422 871794 803333 831305 991448 17792 603429 19811 557636 863225 611267 896242 733165 996242 755047 013166 995302 603036 829907 969394 | 0.10053 -0.02781 -0.01446 Theta 44.4748 46.1200 44.4644 36.8743 43.8656 35.9482 37.5300 35.6210 34.7215 32.8644 40.9010 39.5408 40.2854 37.9806 39.2805 38.4774 | 6078 9126 9126 9126 9126 9126 912304 9167 9167 9177 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 | Rho 407.16; 398.75; 391.21; 383.38; 375.66; 352.15; 344.39; 328.76; 319.6; 294.1; 289.72; 281.81; 273.95; 242.68; 234.88; 226.94; 219.26 | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 1601 7043 8444 1556 2937 8232 0566 5258 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 -0.998 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 0.056 -0.3243 -0.2905 0.1503 -0.1010 -0.0887 0.0140 -0.034 -0.125 -0.0763 -0.0840 0.5298 | 76742 64335 715697 re 824422 871794 803333 831305 991448 17792 603429 19811 557636 863225 611267 896242 733165 996242 755046 895302 803036 829907 8069394 836205 | 7.0053 -0.02781 -0.01440 Theta 44.4748 46.1206 44.4644 36.8743 38.9556 37.5300 35.6210 32.8644 36.3283 38.5264 40.9010 39.5408 40.2854 37.9806 39.2803 38.4774 38.460 | 6078 9126 9126 12308 835661 167069 12304 89167 82366 63863 07173 169432 14295 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 94797 9479 94797 94797 94797 94797 94797 9 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 289.72: 281.81: 273.95: 266.17: 242.68: 234.88: 226.94: 211.23: 187.85: | 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 701601 7043 8444 1556 2937 8232 0566 5258 4552 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 -0.998 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 0.056 -0.3243 -0.2905 0.1503 -0.1503 -0.0100 -0.0344 -0.125 -0.0763 -0.0840 0.5298 0.0414 | 76742 64335 615697 re 224422 871794 803333 831305 91448 17792 603429 19811 557636 863225 611267 896242 733165 996242 755046 95302 603036 829907 969394 836205 817765 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1200 44.4644 36.8743 43.8650 35.9482 37.5300 35.6210 34.7215 32.8644 39.5408 40.9682 40.9010 39.5408 40.2854 37.9806 39.2805 38.4774 38.460 41.4940 | 6078 9126 9126 9126 9126 9126 912304 9167 9167 9177 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 289.72: 281.81: 273.95: 266.17: 242.68: 234.88: 226.94: 219.2(211.23: 187.85: 180.09: | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 1601 7043 8444 1556 2937 8232 0566 5258 4552 5788 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |
| Delta | | -0.99904882 -0.999450692 -0.999152199 | 0 -0.998 | 52292 37339 82914 Greek | -0.1670 -0.1669 -0.1728 exporsu -0.1824 0.1308 -0.2078 0.1204 -0.2949 0.0571 -0.1616 -0.2541 0.056 -0.3243 -0.2905 0.1503 -0.1503 -0.0100 -0.0344 -0.125 -0.0763 -0.0840 0.5298 0.0414 | 76742 64335 715697 re 824422 871794 803333 831305 991448 17792 603429 19811 557636 863225 611267 896242 733165 996242 755046 895302 803036 829907 8069394 836205 | 0.10053 -0.02781 -0.01440 Theta 44.4748 46.1200 44.4644 36.8743 43.8650 35.9482 37.5300 35.6210 34.7215 32.8644 39.5408 40.9682 40.9010 39.5408 40.2854 37.9806 39.2805 38.4774 38.460 41.4940 | 6078 9126 9126 9126 9126 9126 912304 9167 9167 9177 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 918216 | 0.7195472 -0.408968 -0.227921 Rho 407.16: 398.75: 391.21: 383.38: 375.66: 352.15: 344.39: 336.58: 328.76: 289.72: 281.81: 273.95: 266.17: 242.68: 234.88: 226.94: 211.23: 187.85: | 2457 274 2457 2978 2457 5978 5061 7346 0599 9778 2088 3071 3095 8618 8383 0827 1601 7043 8444 1556 2937 8232 0566 5258 4552 5788 | 3.86884 3.31546 | -271 -275 | 1.01758 | 29.2805 -7.70212 |

Appendix C: Delta & Gamma & Vega hedging process

| Security | SCJ0P 2950 I | ndex | | | in the money | put | | | | | | | | |
|-----------|--------------|----------------------|------------|------------|--------------|------------|------------|--------|--------|------------|--------|------------|------------|------------|
| | | 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 | 39.3311195 | 0.30958904 | | -0.2591553 | -0.4779965 | 0.60 | 0.68 | -0.5979507 | 0.0006 | -394.57676 | 582.92153 | -623.09692 |
| 2020/3/10 | 2854.25 | 213.5 | 37.3225874 | 0.30684932 | 0.00273973 | -0.0805666 | -0.2873112 | 0.53 | 0.61 | -0.5283483 | 0.0007 | -402.40209 | 624.276208 | -553.80824 |
| 2020/3/11 | 2729 | 296.5 | 38.9501907 | 0.30410959 | 0.00273973 | -0.2783527 | -0.4931479 | 0.61 | 0.69 | -0.6053616 | 0.0007 | -391.85519 | 573.526059 | -616.90094 |
| 2020/3/12 | 2456 | 522.5 | 44.7152385 | 0.30136986 | 0.00273973 | -0.6439986 | -0.8894725 | 0.74 | 0.81 | -0.7350766 | 0.0005 | -347.72121 | 434.116767 | -721.44371 |
| 2020/3/13 | 2684 | 319.25 | 37.0366926 | 0.29863014 | 0.00273973 | -0.3898952 | -0.5922898 | 0.65 | 0.72 | -0.6472128 | 0.0007 | -359.84349 | 538.583615 | -635.81115 |
| 2020/3/16 | 2405.25 | 570.75 | 49.1291291 | 0.29041096 | 0.00821918 | -0.656704 | -0.9214599 | 0.74 | 0.82 | -0.7393379 | 0.0005 | -375 06831 | 414 015282 | -702.50217 |
| 2020/3/17 | 2485.5 | 497 | 46.8311736 | 0.28767123 | 0.00273973 | -0.5753018 | -0.8264807 | 0.72 | 0.80 | -0.7127045 | 0.0005 | Plot A | rea 730205 | -673.9838 |
| 2020/3/18 | 2401.5 | 567.25 | 46.2203845 | 0.28493151 | 0.00273973 | -0.7293671 | -0.9760867 | 0.77 | 0.84 | -0.7620789 | 0.0005 | -341.62187 | 389.392174 | -700.9294 |
| 2020/3/19 | 2389 | 572.25 | 42.2045041 | 0.28219178 | 0.00273973 | -0.8493666 | -1.0735642 | 0.80 | 0.86 | -0.7969493 | 0.0005 | -289.28299 | 350.681005 | -713.31441 |
| 2020/3/20 | 2288.5 | 665.75 | 41.5897842 | 0.27945205 | 0.00273973 | -1.0657975 | -1.2856545 | 0.86 | 0.90 | -0.8512296 | 0.0004 | -229.43799 | 271.736697 | -741.14828 |
| 2020/3/23 | 2220.5 | 732.5 | 45.2338853 | 0.27123288 | 0.00821918 | -1.1069466 | -1.3425247 | 0.87 | 0.91 | -0.8604335 | 0.0004 | -233.3448 | 248.447004 | -727.03192 |
| 2020/3/24 | 2438 | 527.5 | 44.7128195 | 0.26849315 | 0.00273973 | -0.7259472 | -0.9576326 | 0.77 | 0.83 | -0.7613279 | 0.0005 | -346.92538 | 384.840121 | -656.9165 |
| 2020/3/25 | 2467 | 498.5 | 43.1329011 | 0.26575342 | 0.00273973 | -0.7125508 | -0.9349064 | 0.76 | 0.83 | -0.757275 | 0.0006 | -344.34501 | 391.201648 | -645.69077 |
| 2020/3/26 | 2608 | 368 | 38.7438043 | 0.2630137 | 0.00273973 | -0.5425077 | -0.7412048 | 0.71 | 0.77 | -0.7019876 | 0.0007 | -364.25753 | 457.781905 | -596.93781 |
| 2020/3/27 | 2524 | 440.5 | 39.2847383 | 0.26027397 | 0.00273973 | -0.6992585 | -0.8996777 | 0.76 | 0.82 | -0.7532622 | 0.0006 | -329.60089 | 399.877364 | -625.32806 |
| 2020/3/30 | 2611.25 | 354.5 | 35.0013279 | 0.25205479 | 0.00821918 | -0.6297949 | -0.8055192 | 0.74 | 0.79 | -0.7313151 | 0.0007 | -324.60874 | 426.429963 | -586.22949 |
| 2020/3/31 | 2569.75 | 385.5 | 30.0892243 | 0.24931507 | 0.00273973 | -0.8706031 | -1.0208429 | 0.81 | 0.85 | -0.8033744 | 0.0007 | -241.23155 | 348.407377 | -621.42352 |
| 2020/4/1 | 2448 | 504.75 | 35.1824925 | 0.24657534 | 0.00273973 | -1.0035121 | -1.1782155 | 0.84 | 0.88 | -0.8374097 | 0.0006 | -237.8964 | 291.438832 | -639.52111 |
| 2020/4/2 | 2516.5 | 436.5 | 31.6306794 | 0.24383562 | 0.00273973 | -0.9650798 | -1.1212712 | 0.83 | 0.87 | -0.8280702 | 0.0006 | -231.68924 | 309.430407 | -624.0025 |
| 2020/4/3 | 2482.75 | 469 | 31.8656996 | 0.24109589 | 0.00273973 | -1.0491239 | -1.2055893 | 0.85 | 0.89 | -0.8482024 | 0.0006 | -215.501 | 278.941887 | -629.14381 |
| 2020/4/6 | 2644.5 | 311.5 | 28.6480178 | 0.23287671 | 0.00821918 | -0.7492798 | -0.8875274 | 0.77 | 0.81 | -0.7690077 | 0.0008 | -266.17938 | 382.445493 | -557.37644 |
| 2020/4/7 | 2642 | 315.25 | 30.7552319 | 0.23013699 | 0.00273973 | -0.6991899 | -0.8467308 | 0.76 | 0.80 | -0.7537655 | 0.0008 | -293.37937 | 393.886668 | -543.25405 |
| 2020/4/8 | 2735 | 231 | 29.7478371 | 0.22739726 | 0.00273973 | -0.4888156 | -0.6306717 | 0.69 | 0.74 | -0.6839119 | 0.0009 | -329.10943 | 459.296783 | -492.88781 |
| 2020/4/9 | 2779.75 | 195.25 | 30.7397845 | 0.22465753 | 0.00273973 | -0.3604256 | -0.5061262 | 0.64 | 0.69 | -0.637419 | 0.0009 | -362.48728 | 490.019792 | -458.99546 |

| Delta a | nd Gamn | na and Veg | a Netural | with | vilina | in the money v | anila put option | | | | | |
|---------|---------|--------------|--------------|--------------|--------|----------------|------------------|----------------|-----------------|-------------|-----------------|-------------|
| | | Posi | | | | , | | | | | | |
| CALL | PUT | 1 | PUT2 | Underlying | DIV | | Change of put1 | Change of put2 | change of undel | cash | Portfolio value | P/L |
| | 1 | -1.001048486 | 0.000746265 | -0.996795073 | | | | | | 2741.907671 | -2741.907671 | |
| | 1 | -0.999250067 | -0.000506982 | -0.996705261 | | -0.172558266 | -0.168601768 | 0.26756828 | -0.256344659 | 2741.628066 | -2768.133926 | -26.5058608 |
| | 1 | -1.00121837 | 0.000863066 | -0.996934751 | | -0.180049375 | 0.273594068 | -0.406219363 | 0.626276554 | 2741.991994 | -2742.548389 | -0.55639503 |
| | 1 | -0.999196956 | -0.000688953 | -0.996939792 | | -0.172188098 | -0.60692942 | 0.810929933 | 0.012382191 | 2742.086521 | -2695.852994 | 46.233527 |
| | 1 | -1.002037403 | 0.00147985 | -0.997089116 | | -0.154963762 | 0.462282785 | -0.692390352 | 0.400784126 | 2742.152569 | -2743.296332 | -1.1437630 |
| | 1 | -0.999624333 | -0.00032512 | -0.997179295 | | -0.508157203 | -0.827683237 | 1.030186888 | 0.216903867 | 2742.214829 | -2692.772208 | 49.4426214 |
| | 1 | -1.001026313 | 0.000828249 | -0.997208851 | | -0.151798099 | 0.397110865 | -0.573224364 | 0.073460535 | 2742.010715 | -2704.941662 | 37.0690534 |
| | 1 | -1.00162508 | 0.001493154 | -0.997092496 | | -0.156867419 | 0.196545206 | -0.377167604 | -0.279426148 | 2741.444133 | -2686.954069 | 54.490063 |
| | 1 | -0.999682383 | -0.00034844 | -0.99744116 | | -0.15154824 | -0.604664308 | 1.053852247 | 0.832957782 | 2742.625053 | -2671.987467 | 70.637586 |
| | 1 | -0.998462026 | 0.002095232 | -0.993537065 | | -0.150812137 | -0.428040319 | -1.62687457 | -8.934519716 | 2731.535151 | -2615.525229 | 116.00992 |
| | 1 | -0.991726157 | 0.001850933 | -0.987310144 | | -0.431734336 | -2.701083292 | 0.178949224 | -13.82687858 | 2714.904829 | -2583.648556 | 131.25627 |
| | 1 | -0.999527016 | -0.000661732 | -0.997988951 | | -0.138751356 | 1.942413743 | 1.325430353 | 26.0349312 | 2744.118689 | -2657.328353 | 86.790336 |
| | 1 | -1.000704341 | 0.000722362 | -0.997537311 | | -0.15398992 | 0.282558118 | -0.689970818 | -1.114194925 | 2742.493463 | -2672.483491 | 70.009971 |
| | 1 | -0.999935957 | -4.76673E-05 | -0.997785756 | | -0.155751112 | -0.12620715 | 0.283370915 | 0.647944792 | 2743.193163 | -2716.482275 | 26.710887 |
| | 1 | -1.000503059 | 0.00043481 | -0.997803523 | | -0.164693988 | 0.117957257 | -0.212531056 | 0.044842993 | 2743.029093 | -2695.869195 | 47.159898 |
| | 1 | -0.999918547 | -6.25235E-05 | -0.998040756 | | -0.478207059 | -0.08460805 | 0.176304563 | 0.619473751 | 2743.413115 | -2715.894298 | 27.518817 |
| | 1 | -1.000199289 | 0.000195355 | -0.998058874 | | -0.164941366 | 0.041198921 | -0.099412033 | 0.046558562 | 2743.286878 | -2696.715727 | 46.57115 |
| | 1 | -1.000178231 | 0.000732728 | -0.997474477 | | -0.162322937 | -0.004595918 | -0.271239306 | -1.430602865 | 2741.468474 | -2653.236574 | 88.231899 |
| | 1 | -1.000220337 | 0.000421178 | -0.997940009 | | -0.154541835 | 0.006905359 | 0.135991609 | 1.171511504 | 2742.678664 | -2668.418324 | 74.260339 |
| | 1 | -0.999570023 | 0.000464934 | -0.997319184 | | -0.158940373 | -0.110390882 | -0.020521597 | -1.541354588 | 2740.897802 | -2642.05316 | 98.844641 |
| | 1 | -0.997126626 | -0.002357135 | -0.998752079 | | -0.47016334 | -0.222959991 | 0.879074548 | 3.78929155 | 2745.023986 | -2715.421925 | 29.602060 |
| | 1 | -0.999777423 | -0.000173803 | -0.998558965 | | -0.167160679 | 0.257127392 | -0.688295498 | -0.51020727 | 2743.965838 | -2714.725987 | 29.239851 |
| | 1 | -0.999014003 | -0.00059949 | -0.998503727 | | -0.166970361 | -0.04675953 | 0.098333741 | -0.151077048 | 2743.749734 | -2751.485782 | -7.7360474 |
| | 1 | -0.998597438 | -0.000776623 | -0.998462165 | | -0.172838257 | -0.020099258 | 0.034585329 | -0.115531569 | 2743.526216 | -2766.309164 | -22.782948 |

| | I | Greek exporsure | I | I |
|-------|--------------|-----------------|-------------|-----------|
| Delta | Gamma | Vega | Theta | Rho |
| C | 1.83129E-18 | -2.32087E-12 | 44.6348346 | 406.85839 |
| C | -2.08048E-10 | -6.43929E-15 | 45.99609947 | 398.94128 |
| C | -2.20931E-10 | 4.10783E-15 | 44.66892791 | 390.86430 |
| C | -1.83511E-10 | 2.63678E-14 | 36.69944837 | 383.70361 |
| C | 2.46529E-18 | 4.94904E-12 | 44.37595511 | 375.05584 |
| C | -1.85216E-10 | 4.67404E-14 | 35.85346061 | 352.30820 |
| C | 7.98937E-18 | 2.90185E-12 | 39.19811555 | 344.02247 |
| C | -2.03009E-10 | 8.99281E-15 | 37.92777543 | 335.89222 |
| C | -2.27202E-10 | 3.90382E-14 | 35.5548461 | 328.92820 |
| C | -1.52696E-17 | -1.06437E-12 | 34.79495321 | 318.81054 |
| C | 1.16751E-17 | 3.93857E-12 | 32.86927631 | 293.63067 |
| C | 2.43239E-17 | -8.47028E-12 | 36.29253865 | 290.01981 |
| C | -3.18919E-10 | -3.8911E-07 | 38.62995665 | 281.48274 |
| C | -2.69054E-17 | 0.000000000 | 40.88801606 | 273.97776 |
| C | 2.56658E-17 | 5.04854E-12 | 39.65306607 | 265.98182 |
| C | -3.70116E-10 | -3.76504E-14 | 40.95013759 | 242.70915 |
| C | -2.16844E-17 | 5.52601E-12 | 40.33247984 | 234.79118 |
| C | -1.21735E-17 | 2.1376E-12 | 38.07895016 | 226.60983 |
| C | -2.20486E-17 | -2.99921E-12 | 39.34115787 | 219.00887 |
| C | -3.81569E-10 | -9.3342E-14 | 38.50519768 | 211.03032 |
| C | 4.90568E-17 | 6.99818E-12 | 37.85187495 | 188.91088 |
| C | -5.48465E-10 | -2.92042E-07 | 41.44555823 | 180.17228 |
| C | -5.92865E-10 | -3.32512E-14 | 42.47769013 | 172.4541 |
| C | -3.24396E-17 | -1.60971E-12 | 42.78748001 | 164.65068 |

Appendix D: Gamma with in-the-money put

| Security | SCJ0P 2950 I | ndex | | | in-the-mo | oney, E-m | ini S&P 50 | 0 put option | on. | | | | | |
|-----------|--------------|----------------------|-----------|-----------|-----------|------------|------------|--------------|--------|------------|-------|------------|-----------|------------|
| | | 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 | | -0.4506416 | -0.5990955 | 0.67 | 0.73 | -0.671662 | 9E-04 | -540.06795 | 370.8816 | -304.59493 |
| 2020/3/10 | 2854.25 | 213.5 | 37.322587 | 0.139726 | 0.0027397 | -0.1831806 | -0.3226922 | 0.57 | 0.63 | -0.5708264 | 1E-03 | -582.47207 | 417.20794 | -258.0112 |
| 2020/3/11 | 2729 | 296.5 | 38.950191 | 0.1369863 | 0.0027397 | -0.4836622 | -0.6278233 | 0.69 | 0.73 | -0.6835208 | 9E-04 | -536.59921 | 357.33934 | -296.7239 |
| 2020/3/12 | 2456 | 522.5 | 44.715239 | 0.1342466 | 0.0027397 | -1.0501519 | -1.2139871 | 0.85 | 0.89 | -0.8505342 | 6E-04 | -374.1188 | 206.19074 | -351.2072 |
| 2020/3/13 | 2684 | 319.25 | 37.036693 | 0.1315068 | 0.0027397 | -0.6524797 | -0.7867891 | 0.74 | 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 | -0.8638059 | 5E-04 | -392.17357 | 181.66135 | -327.0508 |
| 2020/3/17 | 2485.5 | 497 | 46.831174 | 0.1205479 | 0.0027397 | -0.9845715 | -1.1471694 | 0.84 | 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 | -0.8881471 | 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 | -0.9190102 | 4E-04 | -249.45618 | 118.49828 | -318.973 |
| 2020/3/20 | 2288.5 | 665.75 | 41.589784 | 0.1123288 | 0.0027397 | -1.7650883 | -1.9044785 | 0.96 | 0.97 | -0.9587346 | 3E-04 | -150.48538 | 64.276075 | -321.7088 |
| 2020/3/23 | 2220.5 | 732.5 | 45.233885 | 0.1041096 | 0.0082192 | -1.8850699 | -2.0310216 | 0.97 | 0.98 | -0.9679591 | 2E-04 | -135.11935 | 48.242693 | -300.4252 |
| 2020/3/24 | 2438 | 527.5 | 44.712819 | 0.1013699 | 0.0027397 | -1.2795527 | -1.4219122 | 0.90 | 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 | -0.8948738 | 5E-04 | -336.11595 | 138.69711 | -267.2691 |
| 2020/3/26 | 2608 | 368 | 38.743804 | 0.0958904 | 0.0027397 | -0.9801826 | -1.1001573 | 0.84 | 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 | -0.8930736 | 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 | -0.8749406 | 8E-04 | -354.23745 | 154.89239 | -224.4249 |
| 2020/3/31 | 2569.75 | 385.5 | 30.089224 | 0.0821918 | 0.0027397 | -1.572211 | -1.6584741 | 0.94 | 0.95 | -0.9402623 | 5E-04 | -193.04416 | 85.238484 | -230.55221 |
| 2020/4/1 | 2448 | 504.75 | 35.182492 | 0.0794521 | 0.0027397 | -1.8445093 | -1.943679 | 0.97 | 0.97 | -0.9656716 | 3E-04 | -146.38241 | 50.14129 | -228.1758 |
| 2020/4/2 | 2516.5 | 436.5 | 31.630679 | 0.0767123 | 0.0027397 | -1.7847415 | -1.8723489 | 0.96 | 0.97 | -0.9611437 | 4E-04 | -153.10844 | 56.453442 | -219.2685 |
| 2020/4/3 | 2482.75 | 469 | 31.8657 | 0.0739726 | 0.0027397 | -1.9603058 | -2.0469738 | 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 | -0.9272853 | 7E-04 | -238.98688 | 92.210679 | -181.89933 |
| 2020/4/7 | 2642 | 315.25 | 30.755232 | 0.0630137 | 0.0027397 | -1.4030754 | -1.4802788 | 0.92 | 0.93 | -0.9183651 | 7E-04 | -278.59846 | 98.72967 | -172.916 |
| 2020/4/8 | 2735 | 231 | 29.747837 | 0.060274 | 0.0027397 | -1.0131736 | -1.0862068 | 0.84 | 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 | -0.7818925 | 0.001 | -556.97127 | 195.64343 | -136.40114 |

| Detla ar | ıd Gam | ma Netural | with SP500 mini fu | uture (underlying) a | nd vanila put option wi | th same strike | | | |
|----------|--------|--------------|--------------------|----------------------|-------------------------|----------------|-------------|-----------------|--------------|
| | | Position | | | | | | | |
| CALL | P | UT(short) | Underlying(Sho D | IV | Change of put | change of unde | cash | Portfolio value | P/L |
| | 1 | -0.866860643 | -1.018398061 | | | | 2919.597477 | -2919.597477 | (|
| | 1 | -0.78709057 | -0.973906352 | -0.176298026 | -17.03091052 | -126.9904595 | 2775.453402 | -2777.316043 | -1.862640793 |
| | 1 | -0.860683217 | -1.018612232 | -0.175930877 | 21.82021979 | 122.0023454 | 2919.150984 | -2917.985355 | 1.165628751 |
| | 1 | -1.084944433 | -1.198644536 | -0.175932179 | 117.1764853 | 442.1593392 | 3478.364461 | -3457.754447 | 20.6100136 |
| | 1 | -0.839822616 | -1.023628861 | -0.186316634 | -78.2551403 | -469.7420719 | 2930.244782 | -2920.033233 | 10.21154887 |
| | 1 | -1.116285026 | -1.227581478 | -0.521682938 | 157.7909209 | 490.5570311 | 3578.23242 | -3541.010028 | 37.22239174 |
| | 1 | -1.042283737 | -1.163986524 | -0.186871645 | -36.77864064 | -158.065258 | 3383.267332 | -3354.353522 | 28.91381042 |
| | 1 | -1.216232174 | -1.318067974 | -0.183102628 | 98.67225093 | 370.0266032 | 3851.845188 | -3819.747941 | 32.09724763 |
| | 1 | -1.4148166 | -1.492255107 | -0.200333352 | 113.6399379 | 416.1330597 | 4381.488558 | -4352.376249 | 29.1123088 |
| | 1 | -1.585596143 | -1.595409683 | -0.225627526 | 113.6964806 | 236.0692481 | 4731.109088 | -4699.705692 | 31.40339547 |
| | 1 | -1.318576273 | -1.315553343 | -0.693273723 | -195.5920546 | -621.4210025 | 3913.663299 | -3882.043319 | 31.61997986 |
| | 1 | -1.309224237 | -1.341514922 | -0.184880922 | -4.933199284 | 63.29432893 | 3971.911388 | -3936.229165 | 35.68222331 |
| | 1 | -1.302799033 | -1.36819278 | -0.206996054 | -3.202963953 | 65.81427463 | 4034.388613 | -3996.526905 | 37.86170711 |
| | 1 | -1.056556265 | -1.190734673 | -0.213623636 | -90.61733888 | -462.8107417 | 3480.820965 | -3444.248733 | 36.57223198 |
| | 1 | -1.264931678 | -1.374347486 | -0.196542034 | 91.78936955 | 463.4387396 | 4035.916427 | -3995.555459 | 40.36096841 |
| | 1 | -1.174170606 | -1.312649438 | -0.658669422 | -32.17480016 | -161.1090291 | 3842.196187 | -3808.899323 | 33.29686309 |
| | 1 | -1.7103709 | -1.823196073 | -0.216935221 | 206.7052136 | 1311.977217 | 5360.732211 | -5329.756091 | 30.97611939 |
| | 1 | -2.158297589 | -2.205605328 | -0.296522129 | 226.090996 | 936.1378546 | 6522.762942 | -6482.22255 | 40.540392 |
| | 1 | -2.123432411 | -2.184598327 | -0.341721319 | -15.21865011 | -52.86411761 | 6454.458187 | -6417.669937 | 36.78825089 |
| | 1 | -2.274285617 | -2.295900457 | -0.347937621 | 70.75015346 | 276.335364 | 6801.314247 | -6763.286814 | 38.02743362 |
| | 1 | -1.582976732 | -1.714218733 | -1.082349807 | -215.3427177 | -1538.25732 | 5047.006409 | -5008.848691 | 38.15771796 |
| | 1 | -1.483525644 | -1.615949492 | -0.286908005 | -31.35195545 | -259.6273342 | 4755.832856 | -4716.520017 | 39.3128385 |
| | 1 | -1.04210907 | -1.237156657 | -0.270205045 | -101.9672285 | -1035.998404 | 3617.684318 | -3583.600652 | 34.08366592 |
| | 1 | -0.897200932 | -1.115782982 | -0.214148425 | -28.29331405 | -337.3884716 | 3251.854791 | -3219.276228 | 32.57856378 |
| | | | | | | | | | |

| | | Greek exporsure | | |
|-------|-------|-----------------|--------------|-----------|
| 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 |
| n | n | 84 U3E1U41E | 506 2112466 | 102 65660 |

Appendix E: Gamma with at-the-money put

| Security | SCIOP 2700 In | dex | | almost at | t-the-mone | y, E-mini | S&P 500 | out opti | on. | | | | | | |
|-----------|---------------|----------------------|------------|------------|------------|-------------|-------------|----------|--------|------|-------------|--------|-------------|------------|-------------|
| | | 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 | 175.5 | 47.1824233 | 0.14246575 | | 0.14875963 | -0.0293287 | | .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 | 0.22725693 | | .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 | | .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 | | .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 | | .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 | | .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 | | .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 | | .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 | C | .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 | -1.26583487 | | .87 | 0.90 | -0.8676692 | 0.0007 | -330.261885 | 161.900883 | -271.909197 |
| 2020/3/23 | 2220.5 | 491 | 42.7845289 | 0.10410959 | 0.00821918 | -1.35965169 | -1.49770033 | | .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 | C | .73 | 0.78 | -0.73154934 | 0.0009 | -613.789801 | 254.49365 | -213.285681 |
| 2020/3/25 | 2467 | 298.75 | 48.1245742 | 0.09863014 | 0.00273973 | -0.53226579 | -0.68340311 | | .70 | 0.75 | -0.70112979 | 0.0009 | -679.330155 | 267.654932 | -200.345609 |
| 2020/3/26 | 2608 | 208.25 | 48.2946734 | 0.09589041 | 0.00273973 | -0.16755658 | -0.31710672 | | .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 | | .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 | | .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 | | .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 | | .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 | | .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 | -0.9332002 | -1.02032291 | | .82 | 0.85 | -0.82323378 | 0.0012 | -408.639651 | 173.992682 | -168.926883 |
| 2020/4/6 | 2644.5 | 130.75 | 36.8327115 | 0.06575342 | 0.00821918 | -0.18410023 | -0.27854825 | | .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 | | .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 | | .43 | 0.47 | -0.43195185 | 0.0015 | -897.497605 | 263.670289 | -76.7173905 |
| 2020/4/9 | 2779.75 | 73 | 41.3150841 | 0.05753425 | 0.00273973 | 0.33376551 | 0.23466592 | | .37 | 0.41 | -0.36878779 | 0.0014 | -918.435939 | 251.253285 | -63.2363557 |

| | | | | | | | | | - |
|----------|---------|--------------|-----------------|--------------|---------------|------------------|-------------|-----------------|-------------|
| Detla ar | nd Gamn | na Netural | | | | | | | |
| | | Position | | | | | | | |
| CALL | PU | T(short) | Underlying(Shor | DIV | Change of put | change of undely | cash | Portfolio value | P/L |
| | 1 | -0.949950051 | -0.853590743 | | | | 2378.500314 | -2378.500314 | |
| | 1 | -1.023513907 | -0.87701723 | -0.147767723 | 8.91961754 | 66.86504884 | 2454.180873 | -2456.827489 | -2.64661535 |
| | 1 | -0.943490431 | -0.84972352 | -0.158428384 | -14.08413176 | -74.48453385 | 2365.498829 | -2367.949802 | -2.45097237 |
| | 1 | -0.843628212 | -0.816196652 | -0.146762139 | -35.52598432 | -82.34198681 | 2247.527518 | -2251.699714 | -4.17219668 |
| | 1 | -0.910972545 | -0.839360264 | -0.12686915 | 13.5362108 | 62.17113473 | 2323.149251 | -2340.448431 | -17.2991803 |
| | 1 | -0.839077755 | -0.820342999 | -0.42777216 | -28.72196838 | -45.74127857 | 2248.386167 | -2259.59156 | -11.2053930 |
| | 1 | -0.843786749 | -0.818167122 | -0.124878754 | 1.572804103 | -5.40814017 | 2244.467225 | -2258.629157 | -14.1619323 |
| | 1 | -0.812374807 | -0.797399208 | -0.128702994 | -12.10145081 | -49.87414563 | 2182.404125 | -2192.421593 | -10.0174678 |
| | 1 | -0.767084372 | -0.75528526 | -0.121196827 | -16.87068693 | -100.6102213 | 2064.842081 | -2067.865416 | -3.0233348 |
| | 1 | -0.631369239 | -0.623063461 | -0.1141984 | -58.52715126 | -302.5895883 | 1703.649046 | -1691.158715 | 12.4903315 |
| | 1 | -0.531774786 | -0.523585445 | -0.270747714 | -48.90087631 | -220.8909342 | 1433.680308 | -1418.722901 | 14.9574070 |
| | 1 | -0.732705848 | -0.702438318 | -0.073581934 | 63.79561224 | 436.0433052 | 1933.47196 | -1920.178727 | 13.2932333 |
| | 1 | -0.753230372 | -0.730464252 | -0.108386391 | 6.131701506 | 69.13997828 | 2008.670745 | -1998.832883 | 9.83786186 |
| | 1 | -0.82615233 | -0.775886512 | -0.114051493 | 15.18599776 | 118.4612541 | 2142.240818 | -2145.558246 | -3.31742864 |
| | 1 | -0.777023134 | -0.748342528 | -0.128067416 | -12.74902642 | -69.52101564 | 2059.882032 | -2059.954044 | -0.07201229 |
| | 1 | -0.78969939 | -0.741499474 | -0.358650447 | 2.383136117 | -17.86892432 | 2044.151031 | -2049.703987 | -5.55295650 |
| | 1 | -0.702589068 | -0.672960702 | -0.12254403 | -16.96473525 | -176.1275087 | 1850.973766 | -1851.419986 | -0.44622011 |
| | 1 | -0.630597677 | -0.619934731 | -0.109449413 | -20.40955921 | -129.8075781 | 1700.681156 | -1689.874663 | 10.8064933 |
| | 1 | -0.618964876 | -0.603790463 | -0.096048423 | -2.573757386 | -40.62705017 | 1657.415519 | -1649.634679 | 7.78083949 |
| | 1 | -0.517332463 | -0.508098037 | -0.09616478 | -24.11228992 | -237.5803721 | 1395.657116 | -1380.717527 | 14.9395889 |
| | 1 | -0.70664524 | -0.650663853 | -0.239531209 | 24.75264567 | 377.0153022 | 1797.262391 | -1795.574425 | 1.68796643 |
| | 1 | -0.721554609 | -0.665441828 | -0.108901312 | 2.038856122 | 39.04340831 | 1838.268746 | -1836.269901 | 1.99884446 |
| | 1 | -0.854623438 | -0.727464373 | -0.111269405 | 12.00946184 | 169.6316626 | 2019.832345 | -2025.994826 | -6.16248172 |
| | 1 | -0.938968583 | -0.760548474 | -0.125922088 | 6.157195608 | 91.96552936 | 2117.866224 | -2125.179328 | -7.31310350 |
| | | | | | | | | | |

| | | Greek exporsure | | |
|-------|-------|-----------------|--------------|-----------|
| Delta | Gamma | Vega | Theta | Rho |
| 0 | 0 | 19.80533325 | -29.12116235 | 335.50444 |
| 0 | 0 | 22.12154911 | -32.65311194 | 339.31890 |
| 0 | 0 | 20.27972493 | -34.43129705 | 320.61241 |
| 0 | 0 | 17.79378414 | -45.7936231 | 298.55370 |
| 0 | 0 | 23.27263362 | -54.18137979 | 302.92942 |
| 0 | 0 | 18.1394087 | -64.28299355 | 274.88227 |
| 0 | 0 | 20.9082353 | -73.40293703 | 268.41701 |
| 0 | 0 | 19.30093204 | -69.33968929 | 254.96325 |
| 0 | 0 | 18.52977828 | -57.926309 | 235.6630 |
| 0 | 0 | 6.555950333 | -3.509420345 | 189.7663 |
| 0 | 0 | 0.572190448 | 14.97350796 | 147.92061 |
| 0 | 0 | 7.131525917 | -6.788757179 | 194.18836 |
| 0 | 0 | 16.6267745 | -56.15635617 | 195.88497 |
| 0 | 0 | 22.22759017 | -84.16189701 | 203.20860 |
| 0 | 0 | 20.42684999 | -82.82933423 | 189.66549 |
| 0 | 0 | 23.63603108 | -100.8077946 | 171.80429 |
| 0 | 0 | 24.34684481 | -96.37003209 | 150.35544 |
| 0 | 0 | 14.6270656 | -55.06937616 | 133.47215 |
| 0 | 0 | 19.41311723 | -74.75397948 | 125.5850 |
| 0 | 0 | 12.42059296 | -37.57999803 | 101.81666 |
| 0 | 0 | 25.98328087 | -127.7679001 | 116.65248 |
| 0 | 0 | 24.62641765 | -135.559546 | 114.35379 |
| 0 | 0 | 25.23002052 | -145.0154517 | 120.42745 |
| 0 | 0 | 23.64763213 | -143.5439923 | 120.654 |

Appendix F: Simulation

| | | 11.36246452 | | | 10.53968 | | | -23.7755 |
|---------------------|----------|----------------------------|---------------|-------------|----------------------|-------------------------|-----------------------------------------------------------------------|----------------------|
| | | 25.32948656 | | | 12.37463 | | | -25.1440 |
| | | 27.58191873 | | | 6.234397 | | | -23.5588 |
| Out of money put op | otion | 14.90739755 | Almost at the | e money opt | 9.157435 | in the money PUT option | | -23.0529 |
| 50 | 2,735.25 | 11.9077443 | SO SO | 2,735.25 | 8.074617 | SO | 2,735.25 | -25.725 |
| 00 | 123 | 35.81720879 | CO | 123 | 9.97708 | CO | 123 | -23.2397 |
| K1(strike of call) | 2860 | 23.95273176 | K1(strike of | 2860 | 11.12879 | K1(strike of c | 2860 | -23.4301 |
| 20 | 138.5 | 19.91508201 | | | 4.658493 | PO | 296.5 | -24.252 |
| ((strike of put) | 2600 | 25.15149136 | K(strike of p | 2700 | 13.76815 | K(strike of pu | 2950 | -24.799 |
| | 0.67% | 21.10994172 | r | 0.67% | 9.593012 | r | | |
| igma | 0.4 | 24.80583044 | sigma | 0.4 | 4.909537 | sigma | | -24.8572 |
| 1 | 2.31% | 22.18770067 | q | 2.31% | 8.698676 | q | 2.31% | -26.2712 |
| | 0.25 | 24.27718347 | T | 0.25 | 10.65097 | Ť | 0.25 | -26.2728 |
| nu | 0.12 | 20.30012773 | mu | 0.12 | 5.454164 | mu | | |
| И | 500 | 12.93712385 | M | 500 | 15.10058 | M | 500 | -21.8833 |
| 1 | 90 | 24.46705103 | N | 90 | 10.32653 | N | 90 | -25.6487 |
| | | 20.02914855 | | | 12.75438 | | 123 2860 296.5 2950 0.67% 0.4 2.31% 0.25 0.12 | -25.2860 |
| | | 12.51556886 | | | 9.769791 | | | -23.0699 |
| | | 19.93020231 | | | 8.014958 | | | -24.2511 |
| | | 20.14852467 | | | 8.09877 | | | -25.9935 |
| | | 21.53567861 | | | 9.036025 | | | -25.6897 |
| | | 15.13471833 | | | 8.279958 | | | -24.3260 |
| | | 21.99003816 | | | 7.775889 | | | -25.2670 |
| | | 18.87190838 | | | 11.56805 | | | -24.316 |
| | | 8.752702156 | | | 7.287524 | | | -20.625 |
| | | 25.10694963 | | | 9.570024 | | | -22.7066 |
| | | 17.41356655 | | | 11.24149 | | | -24.1766 |
| | | 16.3239364 | | | 11.14569 | | | -24.3941 |
| | | 18.89446962 | | | 16.47378 | | | -22.473 |
| | | 17.66581061 | | | 9.569738 | | | -25.3444 |
| | | 22.09010892 | | | 20.24146 | | | -24.7741 |
| | | 15.85053491 | | | 7.706389 | | | -23.5006 |
| | | 16.76029774 | | | 7.260746 | | | -21.117 |
| | | 19.78742899 | | | 15.77283 | | | -22.1615 |
| | | 15.38801087 | | | 5.405372 | | | -22.1226 |
| | | 24.389308 | | | 7.702305 | | | -22.8331 |
| | | 23.65845134 | | | 6.032193 | | | -22.3167 |
| | | 18.50366255 | | | 9.463932 | | | -23.3745 |
| | | 20.6160988 | | | 12.07274 | | | -23.3346 |
| | | 17.17135491 | | | 11.90359 | | | -25.2260 |
| | - | 22.90400705 | | | 6.230773 | | | -24.5434 |
| | | 25.66975292 | | | 5.211599 | | | -21.9990 |
| | | 16.73490447 | | | 11.79439 | | | -23.6370 |
| | - | 18.24489164 | | | 10.3186 | | | -21.9431 |
| | | 16.35329304 | | | 14.64002 | | | -22.7026 |
| | - | 19.30603235 | | | 7.399856 | | | -25.2823 |
| | | 17.66026498 | | | 10.36492 | | | -23.4884 |
| | | 18.06061873 | | | 6.576963 9.674989 | | | -22.4998 -23.7388 |
| | | 20.60175347 | | | 7.698946 | | | -23.7388 |
| | | 15.43463177 | | | | | | -26.7859 |
| | | 24.85462526 22.40816884 | | | 11.31468 | | | -26.2308 |
| | | 21.82532866 | | | 7.477562 | | | -22.3586 |
| | | 27.22879375 | | | 8.529653 | | | -24.1044 |
| | | 24.94379659 | | | 7.678924 | | | -23.4404 |
| | | 19.53215029 | | | 10.57904 | | | -24.3062 |
| | 1 | 22.29893196 | | | 1.918362 | | | -23.2017 |
| | | 21.18202197 | | | 12.2039 | | | -23.2017 |
| | | 16.98431694 | | | 7.985906 | | | -24.8128 |
| | + | 17.45196861 | - | | 10.59486 | | | -24.8128 |
| | | 8.739099386 | | | 8.371875 | | | -24.2972 |