Level 9 Homework Group A&B

#### European Option Pricing

* Design Decisions:

I designed two classes, one is option base class, the other is European Option class. Option base class is used to store basic data of an option, including different kinds of getter and setter functions. European Option class inherit option base class and includes functions to get price and greeks with different formats of input. I built two classes because later when we create American Option class, the basic initializers, getters and setters, can also directly inherit basic option class.

* Program outputs:

A1(a) Outputs:

Option1 Call price: 2.13337

Option1 Put price: 5.84628

Option2 Call price: 7.96557

Option2 Put price: 7.96557

Option3 Call price: 0.204058

Option3 Put price: 4.07326

Option4 Call price: 92.1757

Option4 Put price: 1.2475

A1(b) Outputs:

Put-call parity satisfied for Option1? Yes.

Put-call parity satisfied for Option2? Yes.

Put-call parity satisfied for Option3? Yes.

Put-call parity satisfied for Option4? Yes.

A1(c) Outputs:

S of option, Call Price, Put Price

55, 0.76652, 9.47943

56, 0.965684, 8.6786

57, 1.19971, 7.91263

58, 1.47106, 7.18397

59, 1.78175, 6.49466

60, 2.13337, 5.84628

61, 2.52699, 5.2399

62, 2.96317, 4.67608

63, 3.44196, 4.15487

64, 3.96293, 3.67584

65, 4.5252, 3.23811

A1(d) Outputs:

Input Parameter Matrix:

T K sig r b S

1 60 0.1 0.01 0.01 55

2 61 0.15 0.02 0.02 56

3 62 0.2 0.03 0.03 57

4 63 0.25 0.04 0.04 58

5 64 0.3 0.05 0.05 59

6 65 0.35 0.06 0.06 60

7 66 0.4 0.07 0.07 61

8 67 0.45 0.08 0.08 62

9 68 0.5 0.09 0.09 63

10 69 0.1 0.1 64

70 65

Call Price depending on each parameter range:

T K sig r b S

7.15299 4.1771 0.173097 2.17103 1.76826 0.76652

12.1667 3.6858 0.556628 2.16561 1.8173 0.965684

16.347 3.23714 1.04145 2.1602 1.86736 1.19971

20.0025 2.82995 1.57454 2.15481 1.91845 1.47106

23.265 2.46266 2.13337 2.14943 1.97059 1.78175

26.2087 2.13337 2.7072 2.14406 2.02378 2.13337

28.8826 1.83988 3.29033 2.13871 2.07804 2.52699

31.3219 1.57982 3.87943 2.13337 2.13337 2.96317

33.554 1.3507 4.47244 2.12804 2.18979 3.44196

35.6009 1.14994 2.12273 2.2473 3.96293

0.97498 4.5252

Put Price depending on each parameter range:

T K sig r b S

7.15556 2.98903 3.88601 5.94949 6.52204 9.47943

7.55609 3.47792 4.26954 5.93464 6.4235 8.6786

7.47778 4.00945 4.75437 5.91982 6.32561 7.91263

7.20216 4.58246 5.28745 5.90504 6.22838 7.18397

6.83576 5.19538 5.84628 5.89029 6.13182 6.49466

6.42963 5.84628 6.42012 5.87559 6.03595 5.84628

6.01115 6.53299 7.00325 5.86092 5.94076 5.2399

5.59588 7.25313 7.59235 5.84628 5.84628 4.67608

5.19285 8.0042 8.18535 5.83168 5.75251 4.15487

4.80725 8.78364 5.81712 5.65946 3.67584

9.58889 3.23811

A2(a) Outputs:

Delta for call: 0.594629

Delta for put: -0.356601

Gamma: 0.0134936

A2(b) Outputs:

S, Delta for Call

55, 0.012525

56, 0.0149907

57, 0.0178071

58, 0.021001

59, 0.0245987

60, 0.028625

61, 0.0331031

62, 0.0380544

63, 0.0434978

64, 0.0494499

65, 0.0559246

A2(c) Outputs:

Input Parameter Matrix:

T K sig r b S

1 60 0.1 0.01 0.01 55

2 61 0.15 0.02 0.02 56

3 62 0.2 0.03 0.03 57

4 63 0.25 0.04 0.04 58

5 64 0.3 0.05 0.05 59

6 65 0.35 0.06 0.06 60

7 66 0.4 0.07 0.07 61

8 67 0.45 0.08 0.08 62

9 68 0.5 0.09 0.09 63

10 69 0.1 0.1 64

70 65

Call Deltas depending on each parameter range:

T K sig r b S

0.564455 0.9417 0.72853 0.621998 0.604706 0.012525

0.521513 0.939921 0.662089 0.618896 0.614823 0.0149907

0.482819 0.937897 0.628942 0.615809 0.624975 0.0178071

0.446157 0.935609 0.610894 0.612738 0.635162 0.021001

0.411443 0.933035 0.600786 0.609682 0.645379 0.0245987

0.378755 0.930159 0.595328 0.606641 0.655626 0.028625

0.348138 0.92696 0.592815 0.603615 0.665899 0.0331031

0.319584 0.923421 0.592277 0.600605 0.676195 0.0380544

0.293049 0.919526 0.593124 0.597609 0.686513 0.0434978

0.268461 0.915258 0.594629 0.696851 0.0494499

0.910605 0.0559246

Gamma depending on each parameter range:

T K sig r b S

0.00908594 0.000950031 0.0392891 0.0141147 0.013474 0.00229961

0.00574625 0.00110257 0.0298728 0.0140443 0.0134492 0.00263648

0.00418349 0.00127127 0.0234404 0.0139743 0.0134192 0.00300071

0.00322802 0.00145662 0.0191315 0.0139046 0.0133842 0.00339158

0.00257167 0.00165902 0.0161018 0.0138352 0.0133441 0.00380799

0.00209071 0.0018787 0.0138706 0.0137662 0.013299 0.00424848

0.00172365 0.00211574 0.0121636 0.0136976 0.0132489 0.00471129

0.00143569 0.00237009 0.0108171 0.0136293 0.0131939 0.00519433

0.00120524 0.00264153 0.00972826 0.0135613 0.0131341 0.00569522

0.00101806 0.00292967 0.0134936 0.0130695 0.00621136

0.00323398 0.00673992

A2(d) Outputs:

Gamma and Delta from the exact formula:

Gamma: 0.0134936

Delta for call: 0.594629

Delta for put: -0.356601

Gamma and Delta from divided difference approximation with step size 0.1:

Gamma: 0.0134936

Delta for call: 0.594628

Delta for put: -0.356601

S, Delta for Call

55, 0.0125255

56, 0.0149913

57, 0.0178077

58, 0.0210017

59, 0.0245995

60, 0.0286258

61, 0.0331039

62, 0.0380552

63, 0.0434986

64, 0.0494508

65, 0.0559255

#### American Option Pricing

* Design Decisions:

I added American Option class that inherits from Option base class. It has less functions than European option class since there is no calculation for Greeks. All other required functionality is impelemented.

* Program outputs:

B(b) Outputs:

Price, call, 18.5035

Price, put, 3.03106

B(c) Outputs:

S of option, Call Price, Put Price

105, 15.9316, 4.04761

106, 16.4249, 3.81598

107, 16.9286, 3.5996

108, 17.4429, 3.39733

109, 17.9678, 3.20813

110, 18.5035, 3.03106

111, 19.0501, 2.86523

112, 19.6078, 2.70985

113, 20.1765, 2.56416

114, 20.7566, 2.42748

115, 21.3481, 2.29919

B(d) Outputs:

Input Parameter Matrix:

K sig r b S

95 0.1 0.05 0.01 105

96 0.15 0.06 0.02 106

97 0.2 0.07 0.03 107

98 0.25 0.08 0.04 108

99 0.3 0.09 0.05 109

100 0.35 0.1 110

101 0.4 0.11 111

102 0.45 0.12 112

103 0.5 0.13 113

104 0.14 114

105 0.15 115

Call Price depending on each parameter range:

K sig r b S

20.732 18.5035 30.25 15.4417 15.9316

20.2562 22.5052 26.0963 18.5035 16.4249

19.7962 26.5984 23.292 22.456 16.9286

19.3511 30.6563 21.2616 27.3822 17.4429

18.9204 34.6188 19.7185 33.4204 17.9678

18.5035 38.4512 18.5035 18.5035

18.0998 42.1321 17.5205 19.0501

17.7087 45.6484 16.7079 19.6078

17.3298 48.9929 16.0246 20.1765

16.9625 15.4417 20.7566

16.6065 14.9385 21.3481

Put Price depending on each parameter range:

K sig r b S

2.09327 3.03106 4.15891 4.15891 4.04761

2.2576 6.85143 3.85799 3.03106 3.81598

2.43291 10.9261 3.6046 2.1912 3.5996

2.61983 15.0293 3.38721 1.58538 3.39733

2.81899 19.0713 3.1979 1.15397 3.20813

3.03106 23.0055 3.03106 3.03106

3.25673 26.8039 2.88254 2.86523

3.49673 30.4492 2.74921 2.70985

3.75181 33.9308 2.62864 2.56416

4.02276 2.51894 2.42748

4.3104 2.41857 2.29919