MA374-Financial Engineering Laboratory
Assignment 2

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1 Question 1

Here we need to determine the price of an European Call and an European Put option in the Binomial model with the following data:
$S(0) = 100; K = 100; T = 1; M = 100; r = 0.08\%; \sigma = 0.2$
We also need to determine the above for two sets of (u,d) given by:
(a)Set1: $u = e^{\sigma\sqrt{\Delta t}}; d = e^{-\sigma\sqrt{\Delta t}};$
(b)Set2: $u = e^{\sigma\sqrt{\Delta t}+(r-\frac{1}{2}\sigma^2)}; d = e^{-\sigma\sqrt{\Delta t}+(r-\frac{1}{2}\sigma^2)};$
where $\Delta t = \frac{T}{M}$ M being the number of subintervals in the time interval $[0, T]$. We will also we use the compounding convention in our calculations.

1.1 The Call/Put Option Prices

The following table gives the European Call/Put Option Values at t=0.

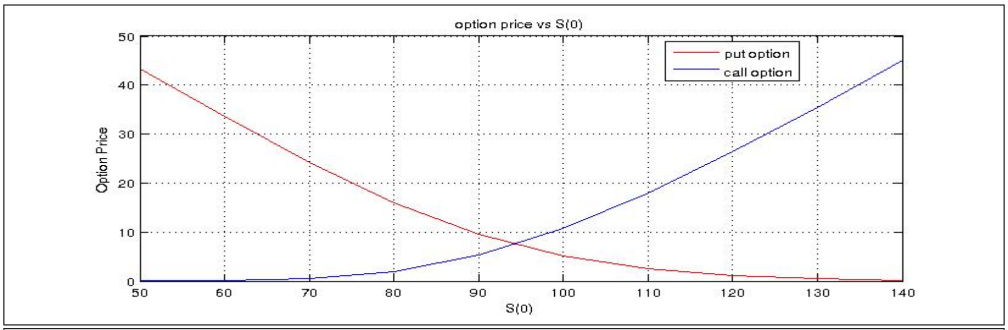
Option	Set1	Set2
Call	12.08538001	12.12304707
Put	4.39701465	4.43468171

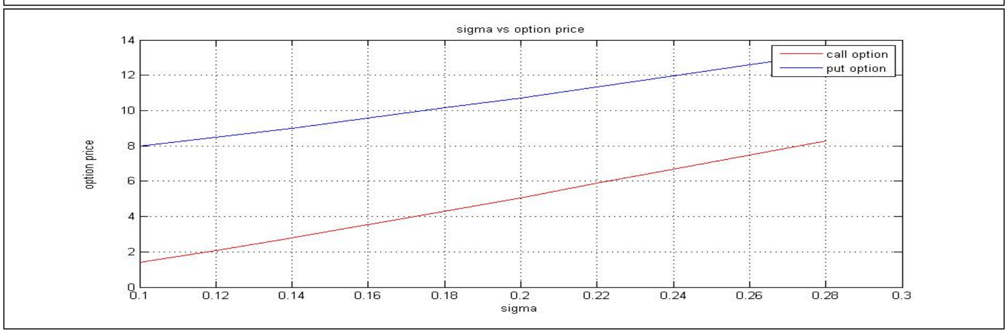
1.2 Varying the Parameters

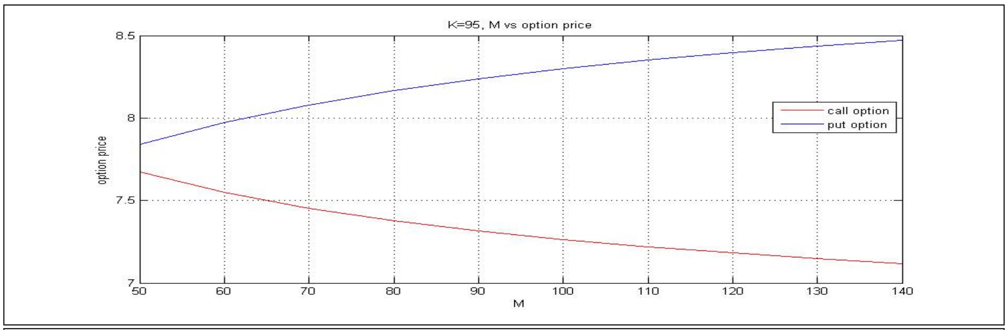
The following plots show the variation of option prices with respect to the parameters S(0), K, r, M and σ.

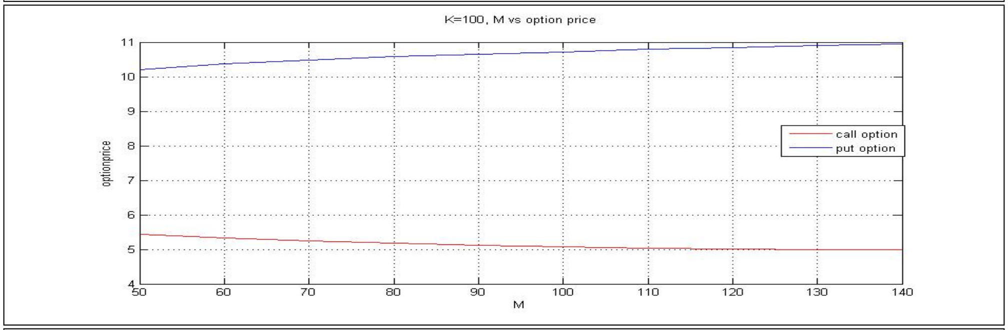
1.3 Set 1

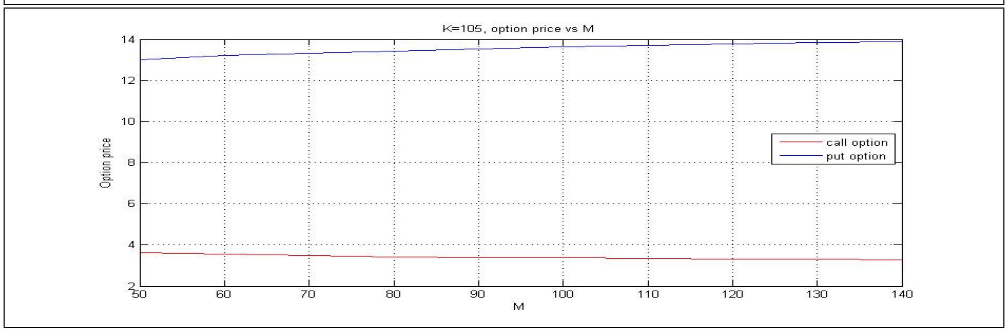
(a) Set1: $u = e^{\sigma\sqrt{\Delta t}}; d = e^{-\sigma\sqrt{\Delta t}};$





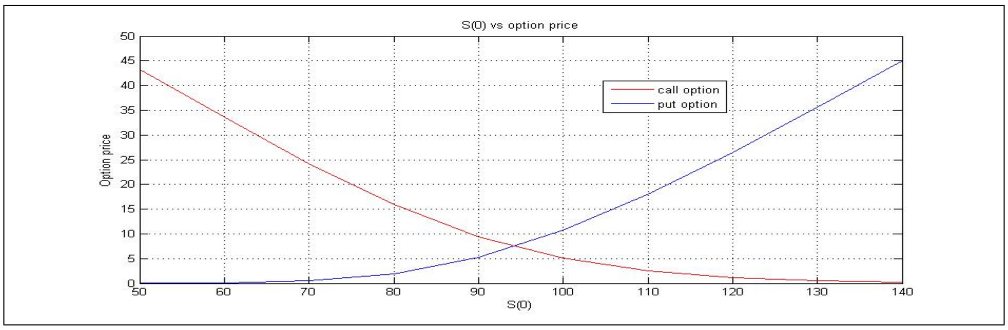


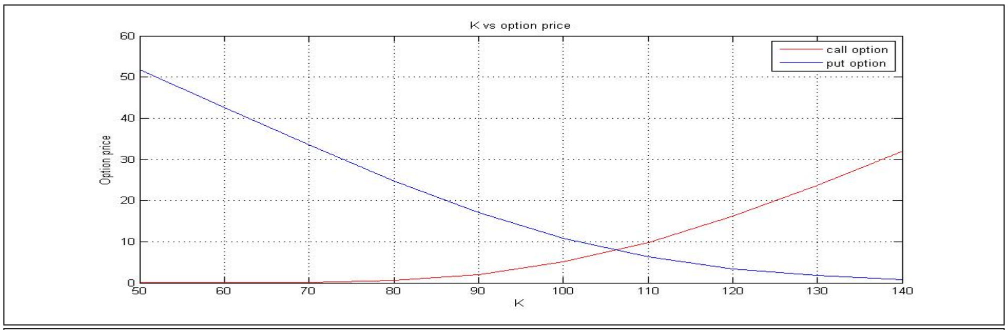




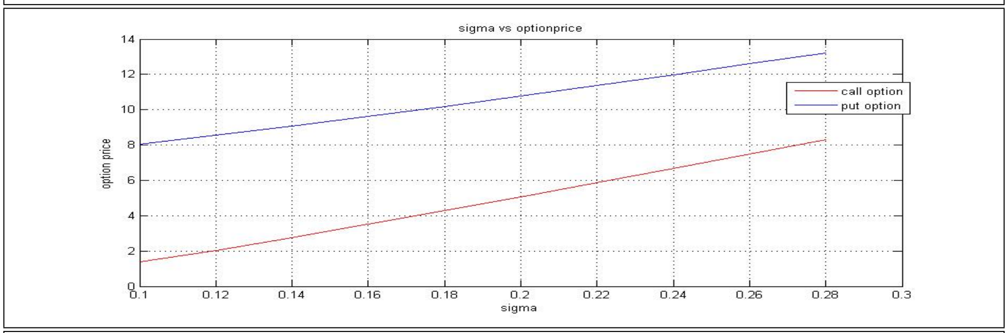
1.4 Set 2

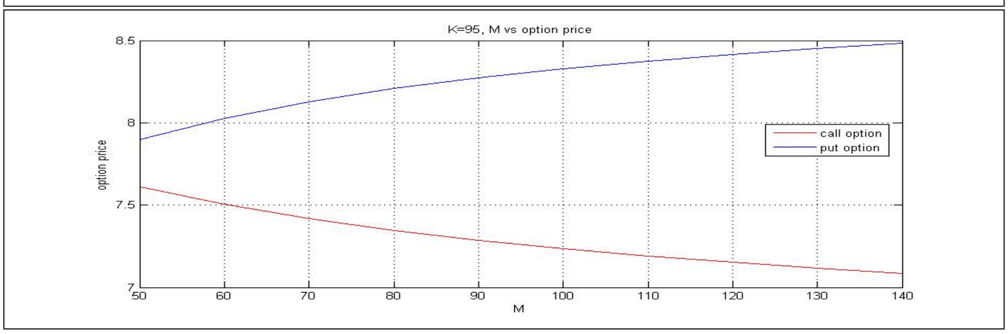
(b) Set2: $u = e^{\sigma\sqrt{\Delta t}+(r-\frac{1}{2}\sigma^2)}; d = e^{-\sigma\sqrt{\Delta t}+(r-\frac{1}{2}\sigma^2)};$

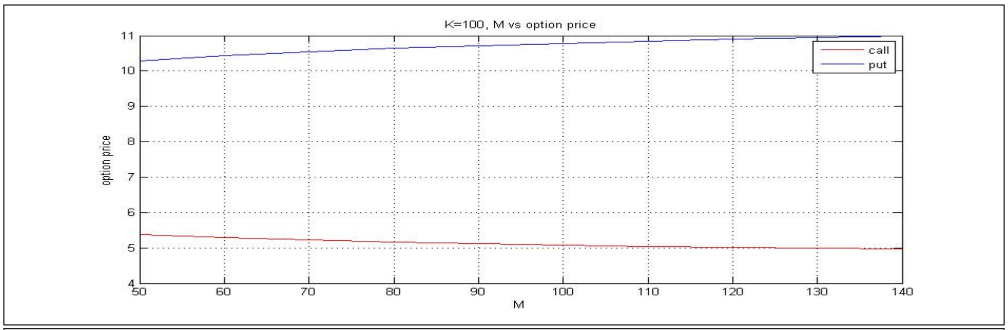


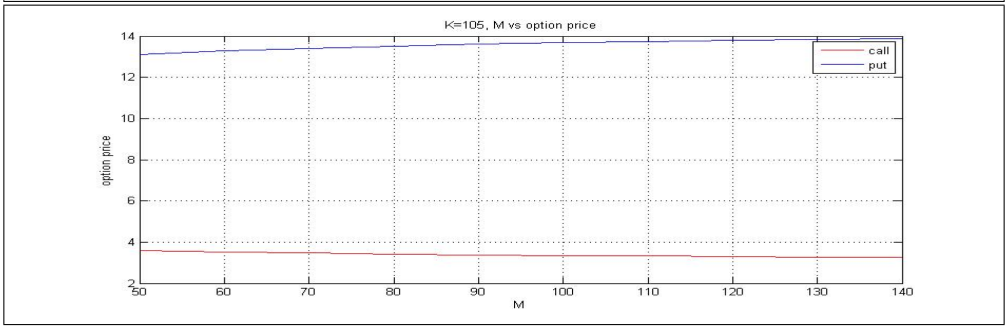

K vs option price
call option
put option
Option price
K
0
10
20
30
40
50
60
50
60
70
80
90
100
110
120
130
140


rate vs option price
call option
put option
option price
Rate
2
4
6
8
10
12
14
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
0.13


sigma vs optionprice
call option
put option
option price
sigma
0
2
4
6
8
10
12
14
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.26
0.28
0.3


K=95, M vs option price
call option
put option
option price
M
7
7.5
8
8.5
50
60
70
80
90
100
110
120
130
140





2 Question 2

Here we have to choose a path-dependent derivative. Some of the available path-dependent options are:
a) Asian Options
b) Russian Options
c) Barrier Options
d) Look back Options
For this question we choose to work with Asian Options and (u,d) set 1.

2.1 Call/Put Option Prices

The following table gives the Asian Call/Put Option Values at t=0.

Option	Set1	Set2
Call	6.08538001	6.47098877
Put	2.39701465	2.43468171

2.2 Varying Parameters

3 Matlab Codes

3.1 Question 1

3.1.1 Driver Script

```
%driver to run the entire process
i=1;
S=100;K=100;T=1;M=100;r=0.08;sigma=0.2;%fixed parameters
display('displaying put option value');
optionvalueput(S,K,r,sigma,M)
display('displaying call option value');
optionvaluecall(S,K,r,sigma,M)
V=10;% varying upto V values each parameters
X=zeros(1,V);
X1=zeros(1,V);
Y=zeros(1,V);
%varying S
s1=50;
while(i<=V)
    X(i)=optionvalueput(s1,K,r,sigma,M);
    X1(i)=optionvaluecall(s1,K,r,sigma,M);
    Y(i)=s1;
    s1=s1+10;
    i=i+1;
end
plot(Y,X,'r');
hold on
plot(Y,X1);
figure
%varying K
k1=50;i=1;
while(i<=V)
    X(i)=optionvalueput(S,k1,r,sigma,M);
    X1(i)=optionvaluecall(S,k1,r,sigma,M);
    Y(i)=k1;
    k1=k1+10;
    i=i+1;
end
plot(Y,X,'r');
hold on
plot(Y,X1);
figure
%varying r
r1=0.04;i=1;
while(i<=V)
    X(i)=optionvalueput(S,K,r1,sigma,M);
    X1(i)=optionvaluecall(S,K,r1,sigma,M);
    Y(i)=r1;
```

```
    r1=r1+0.01;
    i=i+1;
end
plot(Y,X,'r');
hold on
plot(Y,X1);
figure
%varying sigma
sigma1=0.1;i=1;
while(i<=V)
    X(i)=optionvalueput(S,K,r,sigma1,M);
    X1(i)=optionvaluecall(S,K,r,sigma1,M);
    Y(i)=sigma1;
    sigma1=sigma1+0.02;
    i=i+1;
end
plot(Y,X,'r');
hold on
plot(Y,X1);
figure
%varying M, k=100
M1=50;i=1;
while(i<=V)
    X(i)=optionvalueput(S,K,r,sigma,M1);
    X1(i)=optionvaluecall(S,K,r,sigma,M1);
    Y(i)=M1;
    M1=M1+10;
    i=i+1;
end
plot(Y,X,'r');
hold on
plot(Y,X1);
figure
%varying M, k=95
M1=50;i=1;K=95;
while(i<=V)
    X(i)=optionvalueput(S,K,r,sigma,M1);
    X1(i)=optionvaluecall(S,K,r,sigma,M1);
    Y(i)=M1;
    M1=M1+10;
    i=i+1;
end
plot(Y,X,'r');
```

```
hold on
plot(Y,X1);
figure
%varying M, k=105
K=105;
M1=50;i=1;
while(i<=V)
    X(i)=optionvalueput(S,K,r,sigma,M1);
    X1(i)=optionvaluecall(S,K,r,sigma,M1);
    Y(i)=M1;
    M1=M1+10;
    i=i+1;
end
plot(Y,X,'r');
hold on
plot(Y,X1);
```

3.1.2 Member Function:optionvalueput

```
function [P]=optionvalueput(S,K,r,sigma,M)
U=zeros(M+1,M+1);
%defining a 2-d matrix containing only zeros
i=1;
T=1;
t=T/M;
u=exp(sigma*sqrt(t));
d=1/u;
%u=exp(sigma*sqrt(t)+t*(r-(sigma*sigma)/2));
%d=exp(-1*sigma*sqrt(t)+t*(r-(sigma*sigma)/2));
while(i<=M+1)
    U(i,M+1)=S*(u^(M+1-i-1))*(d^(i-1));
    i=i+1;
end
%call/put option
i=1;
while(i<=M+1)
    U(i,M+1)=max((-1*U(i,M+1))+K,0);%the formula
    i=i+1;
end
%claculate the option value by backtracking
p=(exp(r*t)-d)/(u-d);
%risk-neutral probability p
i=M;
while(i>0)
```

```
    j=1;
    while(j<=M-(M-i))
        U(j,i)=((U(j,i+1)*p)+(U(j+1,i+1)*(1-p)))*exp(-1*r*t);
        j=j+1;
    end
    i=i-1;
end
%view the final option tree
%U
%option value at t=0
P=U(1,1);
end
```

3.1.3 Member Function:optionvaluecall

```
function[P]=optionvaluecall(S,K,r,sigma,M)
U=zeros(M+1,M+1);
%defining a 2-d matrix containing only zeros
i=1;
T=1;% this is fixed
t=T/M;
u=exp(sigma*sqrt(t));
d=1/u;
%u=exp(sigma*sqrt(t)+t*(r-(sigma*sigma)/2));
%d=exp(-1*sigma*sqrt(t)+t*(r-(sigma*sigma)/2));
while(i<=M+1)
    U(i,M+1)=S*(u^(M+1-i-1))*(d^(i-1));
    i=i+1;
end
%call/put option
i=1;
while(i<=M+1)
    U(i,M+1)=max(+U(i,M+1)-K,0);%the formula
    i=i+1;
end
%calculate the option value by backtracking
p=(exp(r*t)-d)/(u-d);
%risk-neutral probability p
i=M;
while(i>0)
    j=1;
    while(j<=M-(M-i))
        U(j,i)=((U(j,i+1)*p)+(U(j+1,i+1)*(1-p)))*exp(-1*r*t);
        j=j+1;
```

```
    end
    i=i-1;
end
%view the final option tree
%U
%option value at t=0
P=U(1,1);
end
```

3.2 Question 2