Financial Engineering II
Lab Assignment 3

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January 24, 2014

Contents

1 Question 1

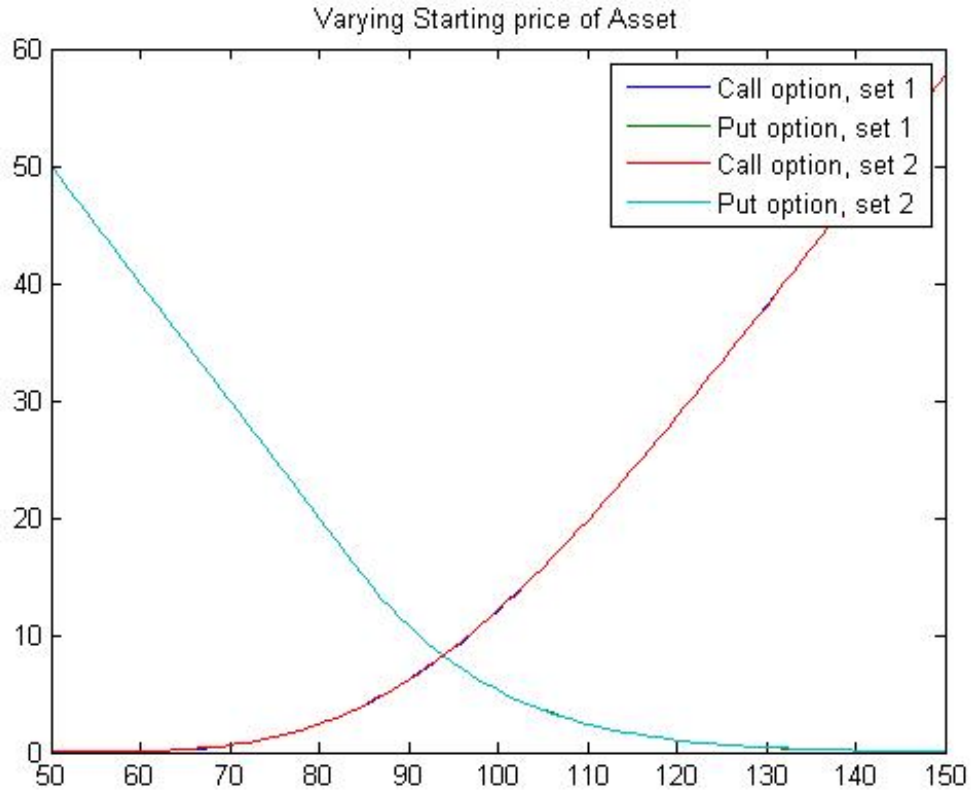
Initial Price of Options

The initial prices of American call and put options for the given values are tabulated below:

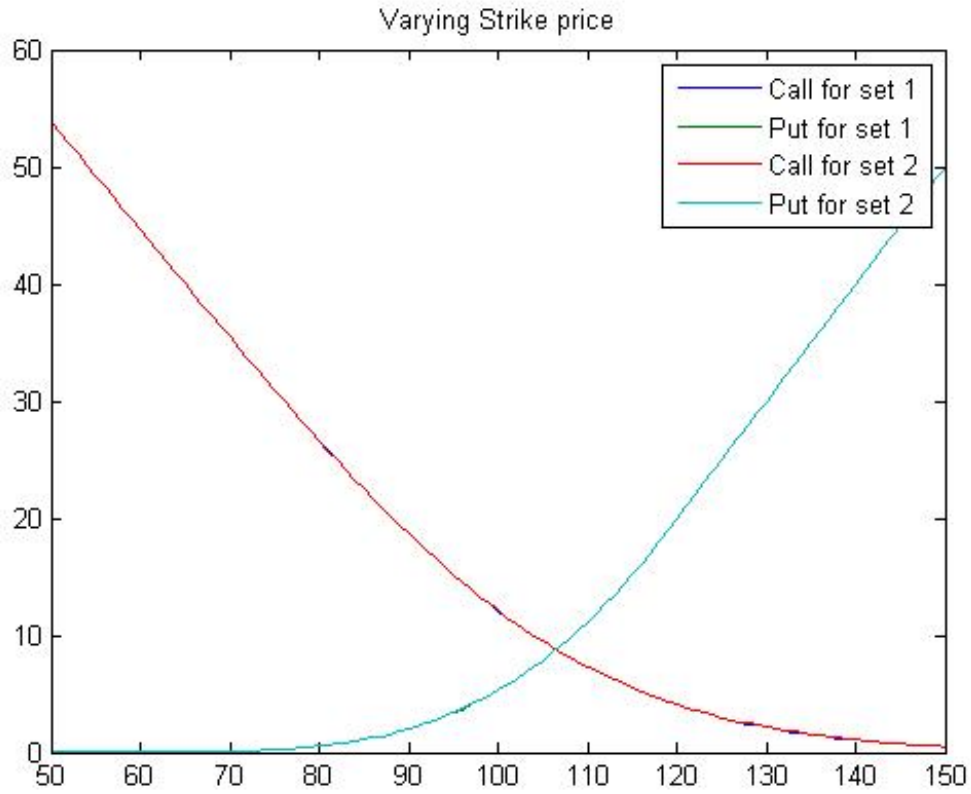
	Set 1	Set 2
Call option	12.0853	12.1230
Put option	5.2667	5.2798

Dependence of Option Prices on Variables

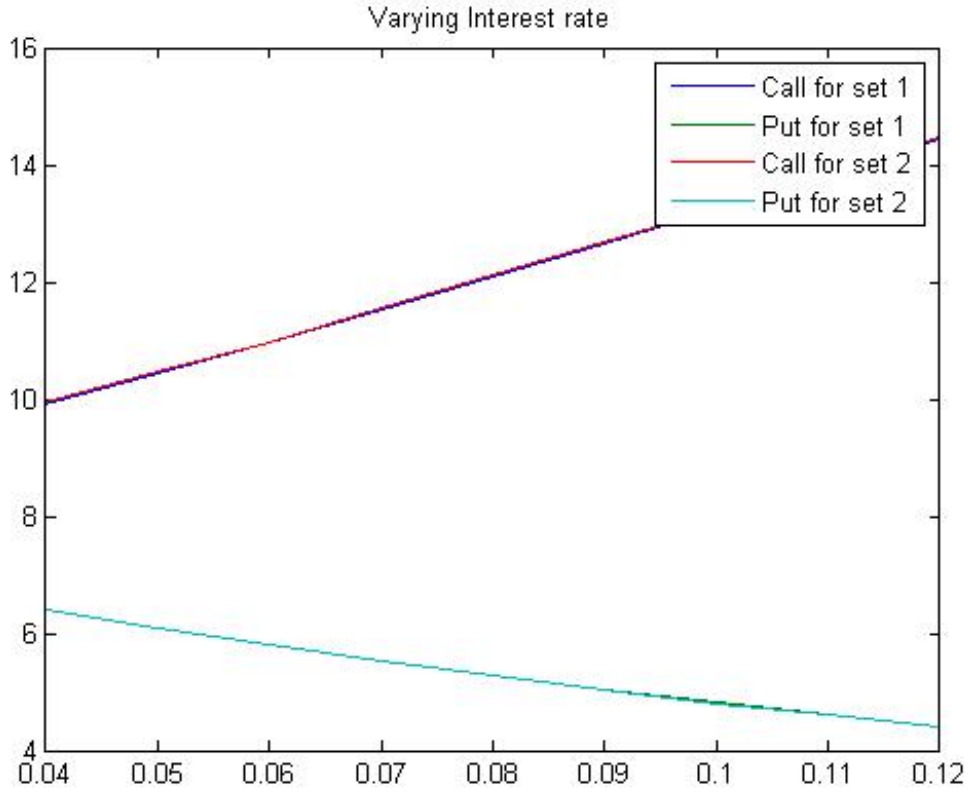
Dependence on Starting Price of Asset



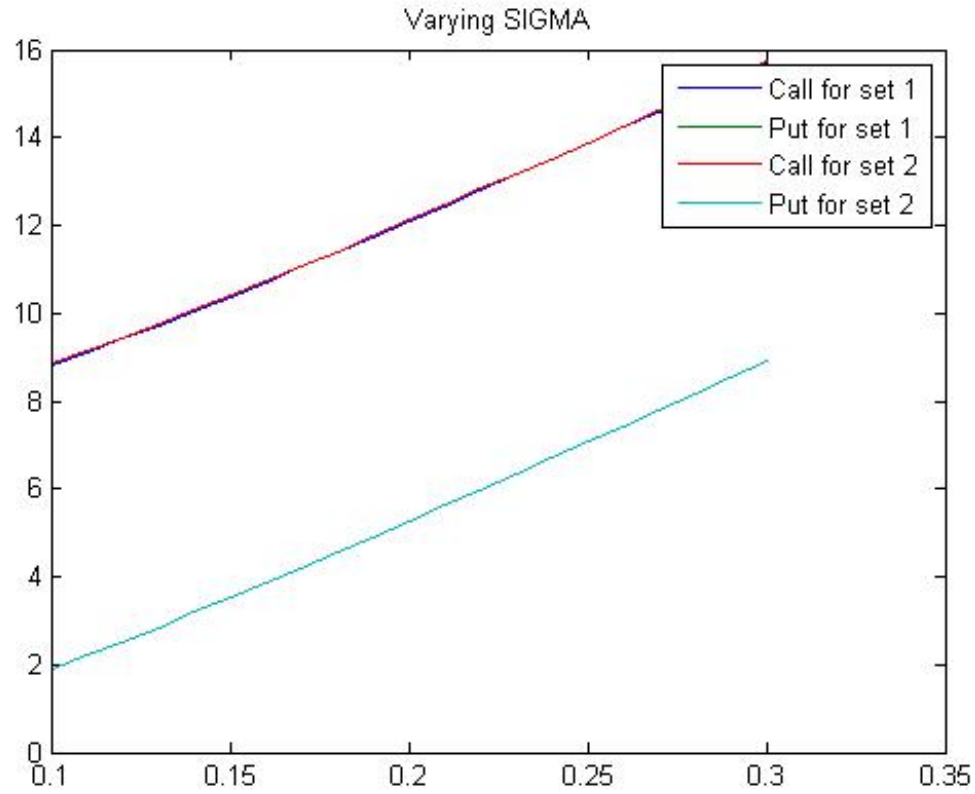
Dependence on Strike Price



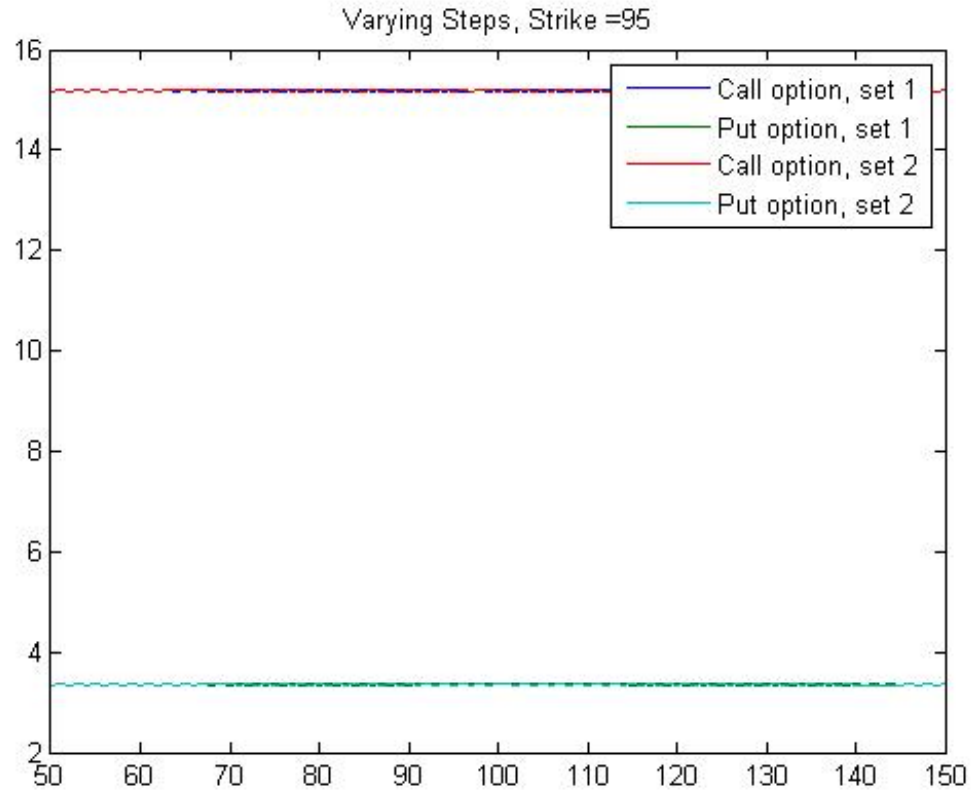
Dependence on Rate

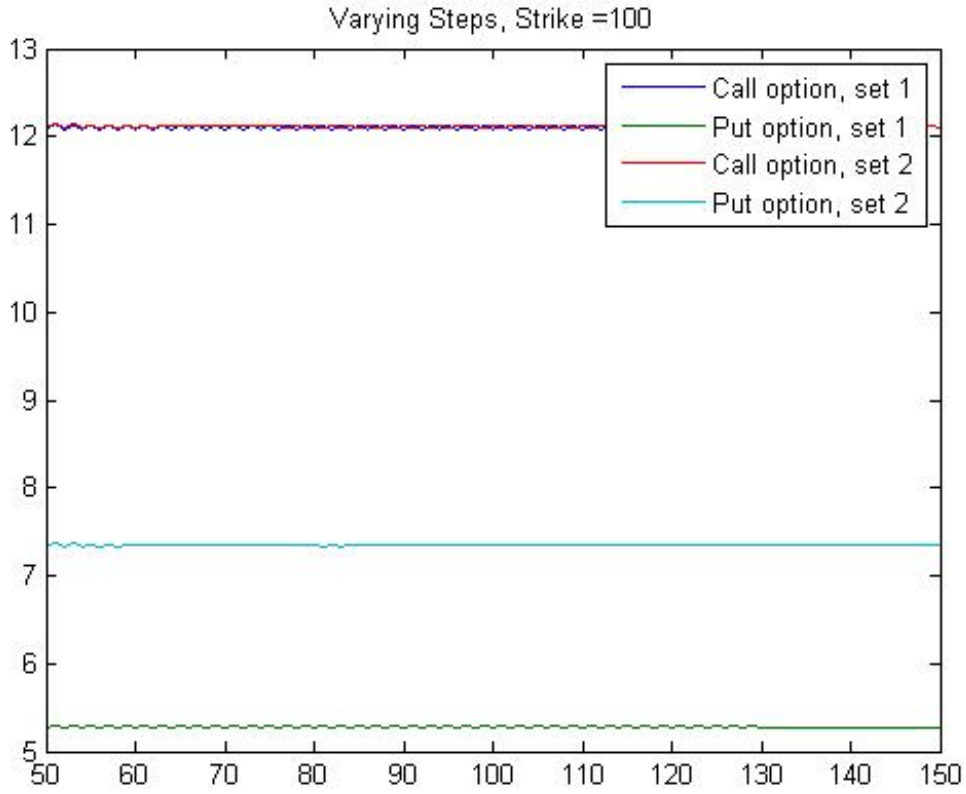


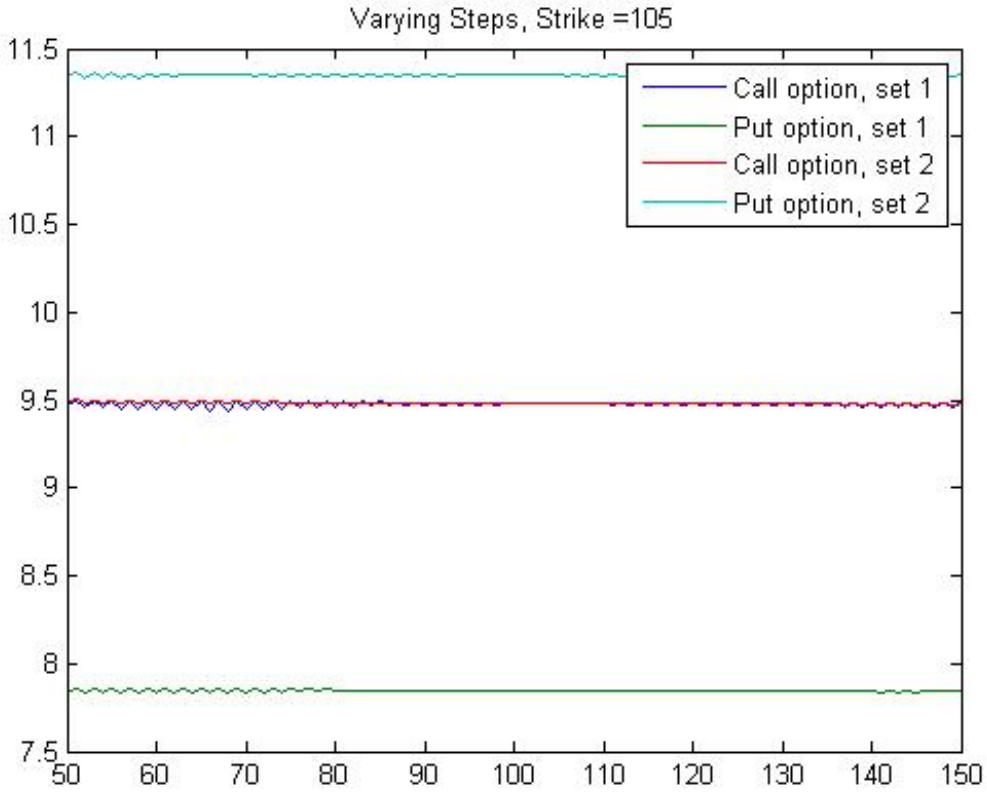
Dependence on Volatility



Dependence on Number of Steps




Varying Steps, Strike =100
Call option, set 1
Put option, set 1
Call option, set 2
Put option, set 2
13
12
11
10
9
8
7
6
5
50
60
70
80
90
100
110
120
130
140
150



2 Question 2

Initial Prices of Lookback Put Option with Floating Strike

M↓	Option price
5	9.1193
10	10.0806
15	10.5192

Comparison

The value of option at time $t = 0$ increases with increasing steps; probably to converge to greater accuracy. Accurate conclusions cannot be drawn because the algorithm takes a long time to compute values for more time steps.

3 Code

Function for Valuating an American Call Option

```
function [ price ] = americancallWD( start, strike, rate, steps,
   sigma, T, set )
%AMERICANCALLWD computes american call option price; no dividends
    on asset
%   start = price of asset at t = 0
%   strike = strike price for the option
%   rate = risk free interest rate
%   steps = number of time steps
%   sigma = volatility
%   T = total time
%   set = set number of up-down pair to use

dt = T/steps;
switch set
    case 1
        up = exp(sigma*sqrt(dt));
        down = 1/up;
    case 2
        up = exp(sigma*sqrt(dt) + (rate-sigma*sigma*0.5)*dt);
        down = exp(-sigma*sqrt(dt) + (rate-sigma*sigma*0.5)*dt);
end

price = european(start, strike, rate, steps, sigma, T, 0, up,
   down);

end
```

Function for Valuating an American Put Option

```
function [ price ] = americanputWD( start, strike, rate, steps,
   sigma, T, set)
%AMERICANPUTWD computes american option price; no dividends on
   asset
%   start = price of asset at t = 0
%   strike = strike price for the option
%   rate = risk free interest rate
%   steps = number of time steps
```

```
%   sigma = volatility
%   T = total time
%   set = set number of up-down pair to use


asset = zeros(steps+1);
option = zeros(steps+1, steps+1);
dt = T/steps;
switch set
    case 1
        up = exp(sigma*sqrt(dt));
        down = 1/up;
    case 2
        up = exp(sigma*sqrt(dt) + (rate-sigma*sigma*0.5)*dt);
        down = exp(-sigma*sqrt(dt) + (rate-sigma*sigma*0.5)*dt);
end

p = (exp(rate*dt)-down)/(up-down);
asset(1,1) = start;

%create asset price tree
for i=2:steps+1
    asset(1,i) = asset(1,i-1)*up;
    for j=2:i
        asset(j,i) = asset(j-1,i)*down/up;
    end
end

%create option price tree
for i=1:steps+1
    option(i, steps+1) = max(strike-asset(i,steps+1), 0);
end
for i=1:steps
    for j=1:steps+1-i
        option(j, steps+1-i) = max(strike-asset(j, steps+1-i), (
           option(j, steps+2-i)*p + option(j+1, steps+2-i)*(1-p))
           *exp(-rate*dt));
    end
end

price = option(1,1);
```

end

Code for Analysing European Options

```
format long; clear all; clc;

%initial values
start = 100;
K = 100;
T = 1;
M = 100;
r = 0.08;
sigma = 0.2;

%initial price of American call and put
disp(['American Call; Set 1']);
disp(americancallWD(start, K, r, M, sigma, T, 1));
disp(['American Call; Set 2']);
disp(americancallWD(start, K, r, M, sigma, T, 2));
disp(['American Put; Set 1']);
disp(americanputWD(start, K, r, M, sigma, T, 1));
disp(['American Put; Set 2']);
disp(americanputWD(start, K, r, M, sigma, T, 2));

%varying starting price S(0)
range = 50;
optiondata = zeros(2*range+1, 5);
for i=start-range:start+range
    optiondata(i-start+range+1, 1) = i;
    optiondata(i-start+range+1, 2) = americancallWD(i, K, r, M,
       sigma, T, 1);
    optiondata(i-start+range+1, 3) = americanputWD(i, K, r, M,
       sigma, T, 1);
    optiondata(i-start+range+1, 4) = americancallWD(i, K, r, M,
       sigma, T, 2);
    optiondata(i-start+range+1, 5) = americanputWD(i, K, r, M,
       sigma, T, 2);
end
figure
```

```
plot(optiondata(:,1), optiondata(:,2), optiondata(:,1),
   optiondata(:,3), optiondata(:,1), optiondata(:,4), optiondata
   (:,1), optiondata(:,5))
title('Varying Starting price of Asset')
legend('Call option, set 1', 'Put option, set 1', 'Call option,
   set 2', 'Put option, set 2')


%varying strike price K
range = 50;
strikedata = zeros(2*range+1, 5);
for i=K-range:K+range
    strikedata(i-K+range+1, 1) = i;
    strikedata(i-K+range+1, 2) = americancallWD(start, i, r, M,
       sigma, T, 1);
    strikedata(i-K+range+1, 3) = americanputWD(start, i, r, M,
       sigma, T, 1);
    strikedata(i-K+range+1, 4) = americancallWD(start, i, r, M,
       sigma, T, 2);
    strikedata(i-K+range+1, 5) = americanputWD(start, i, r, M,
       sigma, T, 2);
end
figure
plot(strikedata(:,1), strikedata(:,2), strikedata(:,1),
   strikedata(:,3), strikedata(:,1), strikedata(:,4), strikedata
   (:,1), strikedata(:,5))
title('Varying Strike price')
legend('Call for set 1', 'Put for set 1', 'Call for set 2', 'Put
   for set 2')


%varying interest rate
range = 4;
r = 8;
ratedata = zeros(2*range+1, 5);
for i=r-range:r+range
    ratedata(i-r+range+1, 1) = i/100;
    ratedata(i-r+range+1, 2) = americancallWD(start, K, i/100, M,
        sigma, T, 1);
    ratedata(i-r+range+1, 3) = americanputWD(start, K, i/100, M,
       sigma, T, 1);
```

```
    ratedata(i-r+range+1, 4) = americancallWD(start, K, i/100, M,
        sigma, T, 2);
    ratedata(i-r+range+1, 5) = americanputWD(start, K, i/100, M,
       sigma, T, 2);
end
figure
x = plot(ratedata(:,1), ratedata(:,2), ratedata(:,1), ratedata
   (:,3), ratedata(:,1), ratedata(:,4), ratedata(:,1), ratedata
   (:,5));
title('Varying Interest rate')
legend('Call for set 1', 'Put for set 1', 'Call for set 2', 'Put
   for set 2')


%varying sigma
s = 20;
r = 0.08;
range = 10;
sigmadata = zeros(2*range+1, 5);
for i=s-range:s+range
    sigmadata(i-s+range+1, 1) = i/100;
    sigmadata(i-s+range+1, 2) = americancallWD(start, K, r, M, i
       /100, T, 1);
    sigmadata(i-s+range+1, 3) = americanputWD(start, K, r, M, i
       /100, T, 1);
    sigmadata(i-s+range+1, 4) = americancallWD(start, K, r, M, i
       /100, T, 2);
    sigmadata(i-s+range+1, 5) = americanputWD(start, K, r, M, i
       /100, T, 1);
end
figure
plot(sigmadata(:,1), sigmadata(:,2), sigmadata(:,1), sigmadata
   (:,3), sigmadata(:,1), sigmadata(:,4), sigmadata(:,1),
   sigmadata(:,5))
title('Varying SIGMA')
legend('Call for set 1', 'Put for set 1', 'Call for set 2', 'Put
   for set 2')


%varying steps and strike prices
range = 50;
```

```
K = [95, 100, 105];
stepdata = zeros(2*range+1, 13);
for i=M-range:M+range
    stepdata(i-M+range+1, 1) = i;
    for j=1:3
        stepdata(i-M+range+1, 2+(j-1)*4) = americancallWD(start,
            K(j), r, i, sigma, T, 1);
        stepdata(i-M+range+1, 3+(j-1)*4) = americanputWD(start, K
            (j), r, i, sigma, T, 1);
        stepdata(i-M+range+1, 4+(j-1)*4) = americancallWD(start,
            K(j), r, i, sigma, T, 2);
        stepdata(i-M+range+1, 5+(j-1)*4) = americanputWD(start, K
            (j), r, i, sigma, T, 2);
    end
end
for i=1:3
    figure
    plot(stepdata(:,1), log10(stepdata(:,2+(i-1)*4)), stepdata
        (:,1), log10(stepdata(:,3+(i-1)*4)), stepdata(:,1), log10(
        stepdata(:,4+(i-1)*4)), stepdata(:,1), log10(stepdata
        (:,5+(i-1)*4)))
    title(['Varying Steps, Strike =', num2str(K(i))])
    legend('Call option, set 1', 'Put option, set 1', 'Call
        option, set 2', 'Put option, set 2')
end
```

Function for Valuating a Lookback Option

```
function [ price ] = lookback( start, rate, steps, sigma, T)
%LOOKBACK compute initial price of a lookback put option with
    floating
%strike
%   start = initial asset price
%   rate = risk-free interest rate
%   steps = number of time steps
%   sigma = volatility
%   T = total time


dt = T/steps;
up = exp(sigma*sqrt(dt) + (rate-sigma*sigma*0.5)*dt);
```

```
down = exp(-sigma*sqrt(dt) + (rate-sigma*sigma*0.5)*dt);
p = (exp(rate*dt) - down)/(up - down);

option = zeros(2^steps,1);

for i=0:2^steps-1
    assetpath = de2bi(i, steps);
    d = sum(assetpath);
    u = steps-d;
    option(i+1) = start*(up^u)*(down^d);
    strike = start;
    temp = start;
    for j=1:steps
        switch assetpath(steps-j+1)
            case 0
                temp = temp*up;
            case 1
                temp = temp*down;
        end
        strike = max(strike, temp);
    end
    option(i+1) = (max(strike-option(i+1), 0))*(p^u)*((1-p)^d);
end

disp(option)

price = sum(option)*exp(-rate);

end
```