MA374-Financial Engineering Laboratory
Assignment 5

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Contents

1 Question 1

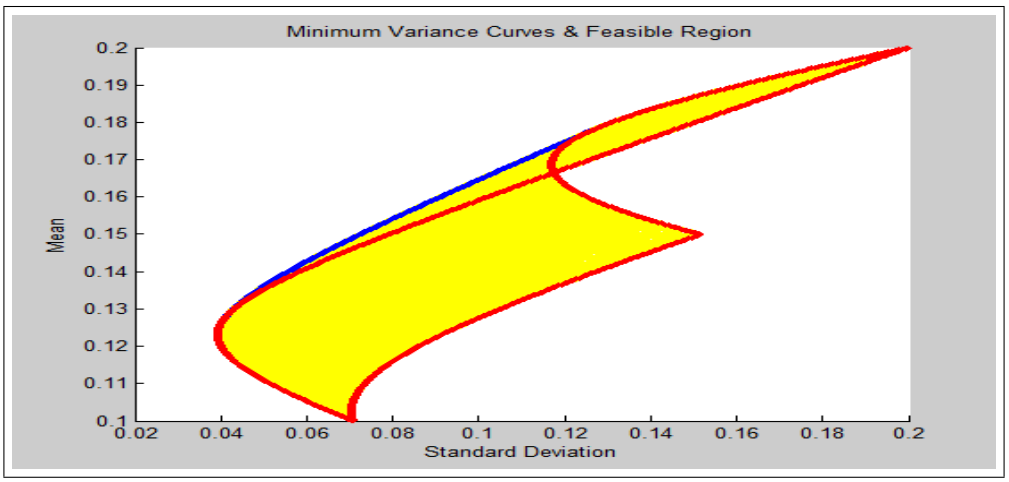
We are given three assets with the following mean return vector and covariance matrix:

$$M = \begin{pmatrix} 0.1 & 0.2 & 0.15 \end{pmatrix}$$

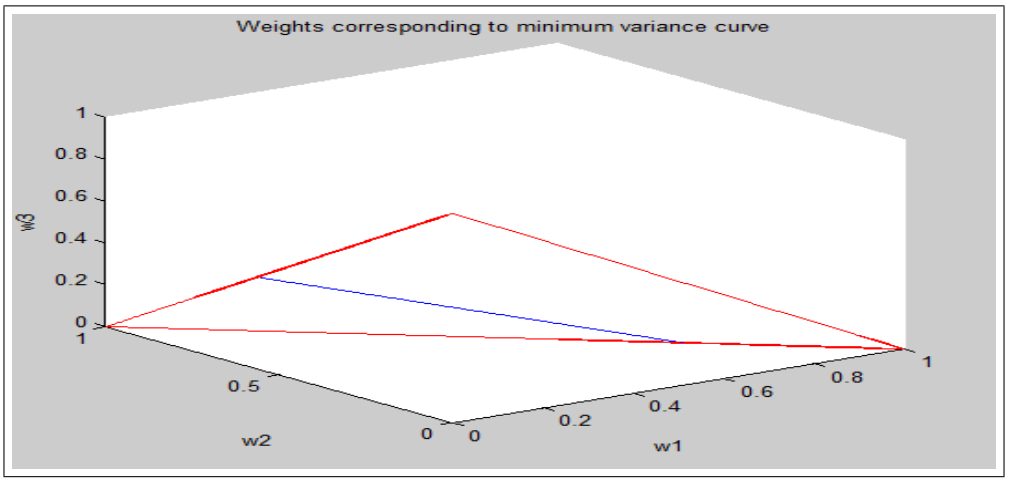
$$C = \begin{pmatrix} 0.005 & -0.010 & 0.004 \\ -0.010 & 0.040 & -0.002 \\ 0.004 & -0.002 & 0.023 \end{pmatrix}$$

There is no short selling allowed.

1.1 The Markowitz Efficient Frontier and the Feasible Region



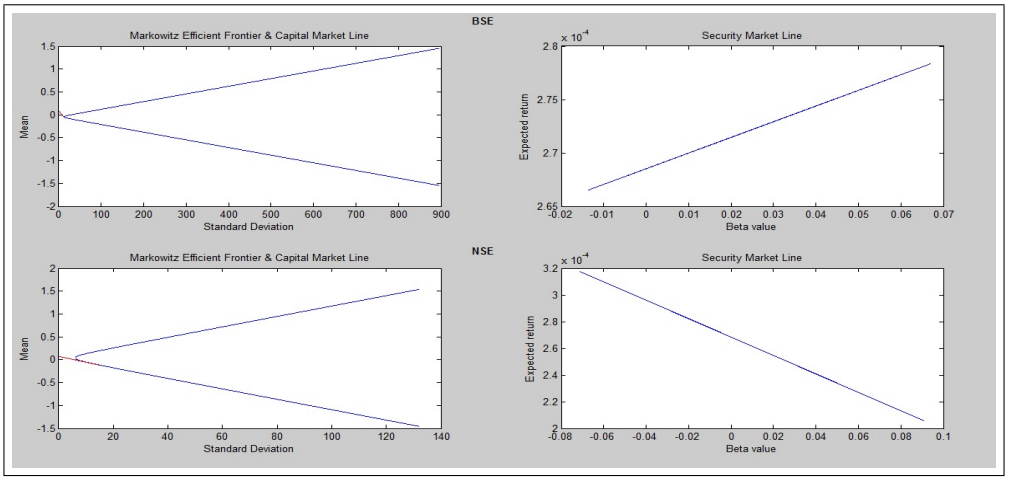
1.2 The weights corresponding to the minimum variance curve



2 Question 2

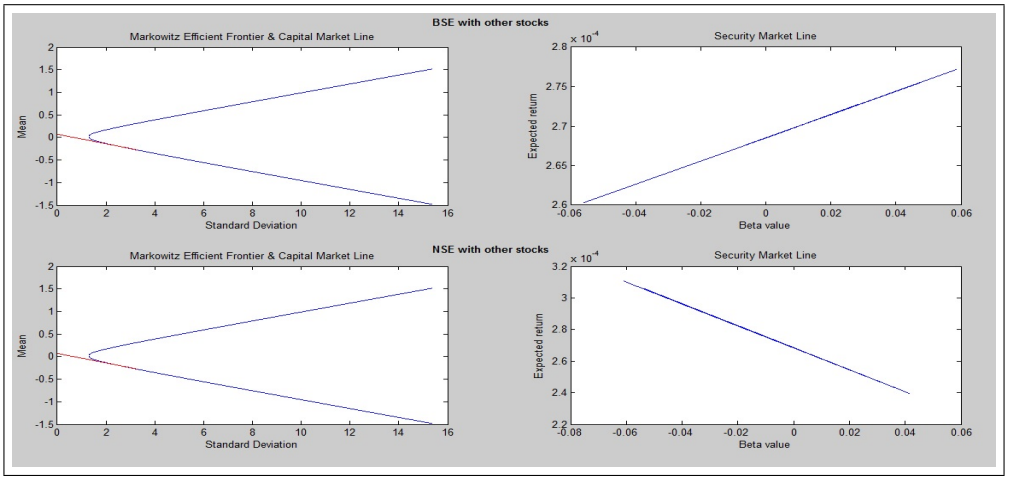
Here we had to calculate the following using data from online resources. The data has been enclosed in csv format for both BSE and NSE.

2.1 The Markov Efficient Frontier and The SML for BSE and NSE



2.2 The Markov Efficient Frontier and The SML for BSE and NSE

The Market Portfolio is the Portfolio with the following mean and standard deviation:



2.3 Comparison of Beta Values

	GAIL	Tata Motors	NTPC	ITC	Tata Steel	Infosys	HDFC	Bharti Airtel	BHEL	ICICI
Actual beta	0.83	1.52	0.71	0.49	1.5	0.87	1	0.88	1.63	1.68
Calculated beta	0.01489	0.040223252	0.022909	-0.01368	0.0319611	0.010876	0.05999	0.037429604	0.067	0.013108

	Axis Bank	Bharti Airtel	BHEL	Canara Bank	Cipla	GAIL	ITC	Mahindra & Mahindra	HDFC	ICICI
Actual beta	1.46	0.79	1.15	1.4	0.46	0.56	0.49	0.99	0.98	1.51
Calculated beta	0.050297	0.014797145	-0.01782	0.090776013	-0.02821	-0.01322	0.032107	-0.071156512	-0.00456	-0.04541

3 Matlab Codes

3.1 Question 1

```
 clear;
clc;

m = [0.1  0.2  0.15];
c = [0.005  -0.010  0.004; -0.010  0.040  -0.002; 0.004  -0.002
    0.023];
u = ones(1,3);

w_opt = (u*inv(c))/(u*inv(c)*u');
m_opt = w_opt*m';
sig_opt = sqrt(w_opt*c*w_opt');
p = zeros(250,2);
k = zeros(250,3);
p(:,2) = m_opt;
j = 0;
for i = 1:250
    w_temp=[0  0  -1];
    while(min(w_temp)<0)
        p(i,2) = m_opt+((-1)^j)*j*0.0001;
        w_temp = (det([1  u*inv(c)*m';p(i,2)  m*inv(c)*m'])*u*inv
            (c) + det([u*inv(c)*u'  1;m*inv(c)*u'  p(i,2)])*m*inv(
            c))/det([u*inv(c)*u'  u*inv(c)*m';m*inv(c)*u'  m*inv(c
            )*m']);
        j = j+1;
    end
    k(i,:) = w_temp;
```

```
    p(i,1) = sqrt(w_temp*c*w_temp');
end

q = zeros(100000,2);
w_temp = [0 0 -1];
qq = rand(100000,3);
for i = 1:100000
    qq(i,:) = qq(i,:)/sum(qq(i,:));
    q(i,1) = sqrt(qq(i,:)*c*qq(i,:)');
    q(i,2) = qq(i,:)*m';
end
scatter(q(:,1),q(:,2),'yellow','*');
hold on;
scatter(p(:,1),p(:,2),'blue','.');
title('Minimum Variance Curves & Feasible Region');
xlabel('Standard Deviation');
ylabel('Mean');

mm = m;
mm(:,3)=[];
cc = c;
cc(:,3)=[];
cc(3,:)=[];
uu = ones(1,2);
w_opt = (uu*inv(cc))/(uu*inv(cc)*uu');
m_opt = w_opt*mm';
sig_opt = sqrt(w_opt*cc*w_opt');
p = zeros(500,2);
k3 = zeros(500,2);
p(:,2) = m_opt;
j = 0;
for i = 1:500
    w_temp=[0 0 -1];
    while(min(w_temp)<0)
        p(i,2) = m_opt+((-1)^j)*j*0.0001;
        w_temp = (det([1 uu*inv(cc)*mm';p(i,2) mm*inv(cc)*mm'])
            *uu*inv(cc) + det([uu*inv(cc)*uu' 1;mm*inv(cc)*uu' p
            (i,2)])*mm*inv(cc))/det([uu*inv(cc)*uu' uu*inv(cc)*
            mm';mm*inv(cc)*uu' mm*inv(cc)*mm']);
    j = j+1;
    end
    k3(i,:) = w_temp;
    p(i,1) = sqrt(w_temp*cc*w_temp');
```

```
end
scatter(p(:,1),p(:,2),'red','.');

mm = m;
mm(:,2)=[];
cc = c;
cc(:,2)=[];
cc(2,:)=[];
uu = ones(1,2);
w_opt = (uu*inv(cc))/(uu*inv(cc)*uu');
m_opt = w_opt*mm';
sig_opt = sqrt(w_opt*cc*w_opt');
p = zeros(250,2);
k2 = zeros(250,2);
p(:,2) = m_opt;
j = 0;
for i = 1:250
    w_temp=[0 0 -1];
    while(min(w_temp)<0)
        p(i,2) = m_opt+((-1)^j)*j*0.0001;
        w_temp = (det([1 uu*inv(cc)*mm';p(i,2) mm*inv(cc)*mm'])
            *uu*inv(cc) + det([uu*inv(cc)*uu' 1;mm*inv(cc)*uu' p
            (i,2)])*mm*inv(cc))/det([uu*inv(cc)*uu' uu*inv(cc)*
            mm';mm*inv(cc)*uu' mm*inv(cc)*mm']);
    j = j+1;
    end
    k2(i,:) = w_temp;
    p(i,1) = sqrt(w_temp*cc*w_temp');
end
scatter(p(:,1),p(:,2),'red','.');

mm = m;
mm(:,1)=[];
cc = c;
cc(:,1)=[];
cc(1,:)=[];
uu = ones(1,2);
w_opt = (uu*inv(cc))/(uu*inv(cc)*uu');
m_opt = w_opt*mm';
sig_opt = sqrt(w_opt*cc*w_opt');
p = zeros(250,2);
k1 = zeros(250,2);
p(:,2) = m_opt;
```

```
j = 0;
for i = 1:250
    w_temp=[0 0 -1];
    while(min(w_temp)<0)
        p(i,2) = m_opt+((-1)^j)*j*0.0001;
        w_temp = (det([1 uu*inv(cc)*mm';p(i,2) mm*inv(cc)*mm'])
            *uu*inv(cc) + det([uu*inv(cc)*uu' 1;mm*inv(cc)*uu' p
            (i,2)])*mm*inv(cc))/det([uu*inv(cc)*uu' uu*inv(cc)*
            mm';mm*inv(cc)*uu' mm*inv(cc)*mm']);
    j = j+1;
    end
    k1(i,:) = w_temp;
    p(i,1) = sqrt(w_temp*cc*w_temp');
end
scatter(p(:,1),p(:,2),'red','.');
hold off;

figure();
plot3(k(:,1),k(:,2),k(:,3));
title('Weights corresponding to minimum variance curve');
xlabel('w1');
ylabel('w2');
zlabel('w3');
hold on;
plot3(zeros(250,1),k1(:,1),k1(:,2),'red');
plot3(k2(:,1),zeros(250,1),k2(:,2),'red');
plot3(k3(:,1),k3(:,2),zeros(500,1),'red');
hold off;
```

3.2 Question 2

```
clear;
clc;

[num,data] = xlsread('bsedata1.xlsx');
[n1 n2] = size(num);

for i = 1:(n1-1)
    m_temp(i,:) = (num(i+1,:)-num(i,:))./num(i,:);
end
for i = 1:n2
    m(i) = geomean(1+m_temp(:,i))-1;
end
m = ((1+m).^252)-1;
```

```
c = cov(num);
u = ones(1,n2);

w_opt = (u*inv(c))/(u*inv(c)*u');
m_opt = w_opt*m';
sig_opt = sqrt(w_opt*c*w_opt');

p1 = zeros(1500,2);
p1(1,1) = sig_opt;
p1(1,2) = m_opt;
for i = 2:1500
    p1(i,2) = m_opt+(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p1(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p1(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p1(i,1) = sqrt(w_temp*c*w_temp');
end
p2 = zeros(1500,2);
p2(1,1) = sig_opt;
p2(1,2) = m_opt;
for i = 2:1500
    p2(i,2) = m_opt-(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p2(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p2(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p2(i,1) = sqrt(w_temp*c*w_temp');
end

subplot(2,2,1);
plot(p1(:,1),p1(:,2));
hold on;
plot(p2(:,1),p2(:,2));
title('Markowitz Efficient Frontier & Capital Market Line');
xlabel('Standard Deviation');
ylabel('Mean');

r = 0.07;
w_temp = ((m-r*u)*inv(c))/((m-r*u)*inv(c)*u');
m_m = w_temp*m';
sig_m = sqrt(w_temp*c*w_temp');
x=[0,sig_m];
y=[0.07,m_m];
plot(x,y,'red');
```

```
rf = ((1+r)^(1/252))-1;
[num]=xlsread('sensex.xlsx');
for i = 1:(n1-1)
    mr(i)=(num(i+1)-num(i))/num(i);
end
for i = 1:n2
    temp = cov(m_temp(:,i),mr');
    beta(i) = temp(1,2)/var(mr);
end
temp = geomean(1+mr)-1;
er = rf+beta*(temp-rf);
subplot(2,2,2);
plot(beta,er);
title('Security Market Line');
xlabel('Beta value');
ylabel('Expected return');
rowhead = {'Actual beta';'Calculated beta'};
[num]=xlsread('bsebeta1.xlsx');
xlswrite('comparison_bsebeta.xlsx',data,'B1:K1');
xlswrite('comparison_bsebeta.xlsx',rowhead,'A2:A3');
xlswrite('comparison_bsebeta.xlsx',num,'B2:K2');
xlswrite('comparison_bsebeta.xlsx',beta,'B3:K3');

clear;
clc;

[num,data] = xlsread('nsedata1.xlsx');
[n1 n2] = size(num);

for i = 1:(n1-1)
    m_temp(i,:) = (num(i+1,:)-num(i,:))./num(i,:);
end
for i = 1:n2
    m(i) = geomean(1+m_temp(:,i))-1;
end
m = ((1+m).^252)-1;
c = cov(num);
u = ones(1,n2);

w_opt = (u*inv(c))/(u*inv(c)*u');
m_opt = w_opt*m';
sig_opt = sqrt(w_opt*c*w_opt');
```

```
p1 = zeros(1500,2);
p1(1,1) = sig_opt;
p1(1,2) = m_opt;
for i = 2:1500
    p1(i,2) = m_opt+(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p1(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p1(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p1(i,1) = sqrt(w_temp*c*w_temp');
end
p2 = zeros(1500,2);
p2(1,1) = sig_opt;
p2(1,2) = m_opt;
for i = 2:1500
    p2(i,2) = m_opt-(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p2(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p2(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p2(i,1) = sqrt(w_temp*c*w_temp');
end

subplot(2,2,3);
plot(p1(:,1),p1(:,2));
hold on;
plot(p2(:,1),p2(:,2));
title('Markowitz Efficient Frontier & Capital Market Line');
xlabel('Standard Deviation');
ylabel('Mean');

r = 0.07;
w_temp = ((m-r*u)*inv(c))/((m-r*u)*inv(c)*u');
m_m = w_temp*m';
sig_m = sqrt(w_temp*c*w_temp');
x=[0,sig_m];
y=[0.07,m_m];
plot(x,y,'red');

rf = ((1+r)^(1/252))-1;
[num]=xlsread('nifty.xlsx');
for i = 1:(n1-1)
    mr(i)=(num(i+1)-num(i))/num(i);
end
```

```
for i = 1:n2
    temp = cov(m_temp(:,i),mr');
    beta(i) = temp(1,2)/var(mr);
end
temp = geomean(1+mr)-1;
er = rf+beta*(temp-rf);
subplot(2,2,4);
plot(beta,er);
title('Security Market Line');
xlabel('Beta value');
ylabel('Expected return');
rowhead = {'Actual beta';'Calculated beta'};
[num]=xlsread('nsebeta1.xlsx');
xlswrite('comparison_nsebeta.xlsx',data,'B1:K1');
xlswrite('comparison_nsebeta.xlsx',rowhead,'A2:A3');
xlswrite('comparison_nsebeta.xlsx',num,'B2:K2');
xlswrite('comparison_nsebeta.xlsx',beta,'B3:K3');

ha = axes('Position',[0 0 1 1],'Xlim',[0 1],'Ylim',[0 1],'Box',
    'off','Visible','off','Units','normalized', 'clipping' , '
    off');
text(0.5, 0.99,'\bf BSE','HorizontalAlignment','center','
    VerticalAlignment', 'top')
ha = axes('Position',[0 0 1 1],'Xlim',[0 1],'Ylim',[0 1],'Box',
    'off','Visible','off','Units','normalized', 'clipping' , '
    off');
text(0.5, 0.5,'\bf NSE','HorizontalAlignment','center','
    VerticalAlignment', 'top')

clear;
clc;

[num,data] = xlsread('otherdata1.xlsx');
[n1 n2] = size(num);

for i = 1:(n1-1)
    m_temp(i,:) = (num(i+1,:)-num(i,:))./num(i,:);
end
for i = 1:n2
    m(i) = geomean(1+m_temp(:,i))-1;
end
m = ((1+m).^252)-1;
c = cov(num);
```

```
u = ones(1,n2);

w_opt = (u*inv(c))/(u*inv(c)*u');
m_opt = w_opt*m';
sig_opt = sqrt(w_opt*c*w_opt');

p1 = zeros(1500,2);
p1(1,1) = sig_opt;
p1(1,2) = m_opt;
for i = 2:1500
    p1(i,2) = m_opt+(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p1(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p1(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p1(i,1) = sqrt(w_temp*c*w_temp');
end
p2 = zeros(1500,2);
p2(1,1) = sig_opt;
p2(1,2) = m_opt;
for i = 2:1500
    p2(i,2) = m_opt-(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p2(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p2(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p2(i,1) = sqrt(w_temp*c*w_temp');
end

figure();
subplot(2,2,1);
plot(p1(:,1),p1(:,2));
hold on;
plot(p2(:,1),p2(:,2));
title('Markowitz Efficient Frontier & Capital Market Line');
xlabel('Standard Deviation');
ylabel('Mean');

r = 0.07;
w_temp = ((m-r*u)*inv(c))/((m-r*u)*inv(c)*u');
m_m = w_temp*m';
sig_m = sqrt(w_temp*c*w_temp');
x=[0,sig_m];
y=[0.07,m_m];
plot(x,y,'red');
```

```
rf = ((1+r)^(1/252))-1;
[num]=xlsread('sensex.xlsx');
for i = 1:(n1-1)
    mr(i)=(num(i+1)-num(i))/num(i);
end
for i = 1:n2
    temp = cov(m_temp(:,i),mr');
    beta(i) = temp(1,2)/var(mr);
end
temp = geomean(1+mr)-1;
er = rf+beta*(temp-rf);
subplot(2,2,2);
plot(beta,er);
title('Security Market Line');
xlabel('Beta value');
ylabel('Expected return');

clear;
clc;

[num,data] = xlsread('otherdata1.xlsx');
[n1 n2] = size(num);

for i = 1:(n1-1)
    m_temp(i,:) = (num(i+1,:)-num(i,:))./num(i,:);
end
for i = 1:n2
    m(i) = geomean(1+m_temp(:,i))-1;
end
m = ((1+m).^252)-1;
c = cov(num);
u = ones(1,n2);

w_opt = (u*inv(c))/(u*inv(c)*u');
m_opt = w_opt*m';
sig_opt = sqrt(w_opt*c*w_opt');

p1 = zeros(1500,2);
p1(1,1) = sig_opt;
p1(1,2) = m_opt;
for i = 2:1500
    p1(i,2) = m_opt+(i-1)*0.001;
```

```
    w_temp = (det([1 u*inv(c)*m';p1(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p1(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p1(i,1) = sqrt(w_temp*c*w_temp');
end
p2 = zeros(1500,2);
p2(1,1) = sig_opt;
p2(1,2) = m_opt;
for i = 2:1500
    p2(i,2) = m_opt-(i-1)*0.001;
    w_temp = (det([1 u*inv(c)*m';p2(i,2) m*inv(c)*m'])*u*inv(c)
        + det([u*inv(c)*u' 1;m*inv(c)*u' p2(i,2)])*m*inv(c))/
       det([u*inv(c)*u' u*inv(c)*m';m*inv(c)*u' m*inv(c)*m']);
    p2(i,1) = sqrt(w_temp*c*w_temp');
end

subplot(2,2,3);
plot(p1(:,1),p1(:,2));
hold on;
plot(p2(:,1),p2(:,2));
title('Markowitz Efficient Frontier & Capital Market Line');
xlabel('Standard Deviation');
ylabel('Mean');

r = 0.07;
w_temp = ((m-r*u)*inv(c))/((m-r*u)*inv(c)*u');
m_m = w_temp*m';
sig_m = sqrt(w_temp*c*w_temp');
x=[0,sig_m];
y=[0.07,m_m];
plot(x,y,'red');

rf = ((1+r)^(1/252))-1;
[num]=xlsread('nifty.xlsx');
for i = 1:(n1-1)
    mr(i)=(num(i+1)-num(i))/num(i);
end
for i = 1:n2
    temp = cov(m_temp(:,i),mr');
    beta(i) = temp(1,2)/var(mr);
end
temp = geomean(1+mr)-1;
er = rf+beta*(temp-rf);
```

```
subplot(2,2,4);
plot(beta,er);
title('Security Market Line');
xlabel('Beta value');
ylabel('Expected return');


ha = axes('Position',[0 0 1 1],'Xlim',[0 1],'Ylim',[0 1],'Box',
    'off','Visible','off','Units','normalized', 'clipping' , '
    off');
text(0.5, 0.99,'\bf BSE with other stocks','HorizontalAlignment
    ','center','VerticalAlignment', 'top')
ha = axes('Position',[0 0 1 1],'Xlim',[0 1],'Ylim',[0 1],'Box',
    'off','Visible','off','Units','normalized', 'clipping' , '
    off');
text(0.5, 0.5,'\bf NSE with other stocks','HorizontalAlignment'
    ,'center','VerticalAlignment', 'top')
```

4 References

- www.bseindia.com
- www.nseindia.com
- https://www.aaii.com/computerizedinvesting/article/mean-variance-optimization-multi-asset-portfolio.mobile
- http://www.calculatinginvestor.com/2011/06/07/efficient-frontier-1/...