In [2]:

```
import pandas as pd
import numpy as np
from gurobipy import *
import math
import os
import matplotlib.pyplot as plt
```

In [3]:

```
table = pd.read_csv("C:/Users/NGDRS-1/Downloads/Adjusted.csv", encoding = "ISO-8859-1", eng
table['Date'] = table.Date.apply(lambda x: pd.to_datetime(x).strftime('%d/%m/%Y'))
#table = table.iloc[::-1]
table = table.set_index('Date')
l = list(a for a in range(50))
data = table.iloc[:,l]
table = data.loc['22/11/2018':'20/11/2020']
```

In [4]:

```
returns_daily = table.pct_change()
for column in returns_daily:
    returns_daily[column] = returns_daily[column].mask(returns_daily[column]<-0.475, np.nan
avg = returns_daily.mean() * 250/4
cov_daily = returns_daily.cov()
cov = cov_daily * 250/4
#std_daily = returns_daily.std()
#std = std_daily * math.sqrt(125/2)
```

In [5]:

```
cov
```

Out[5]:

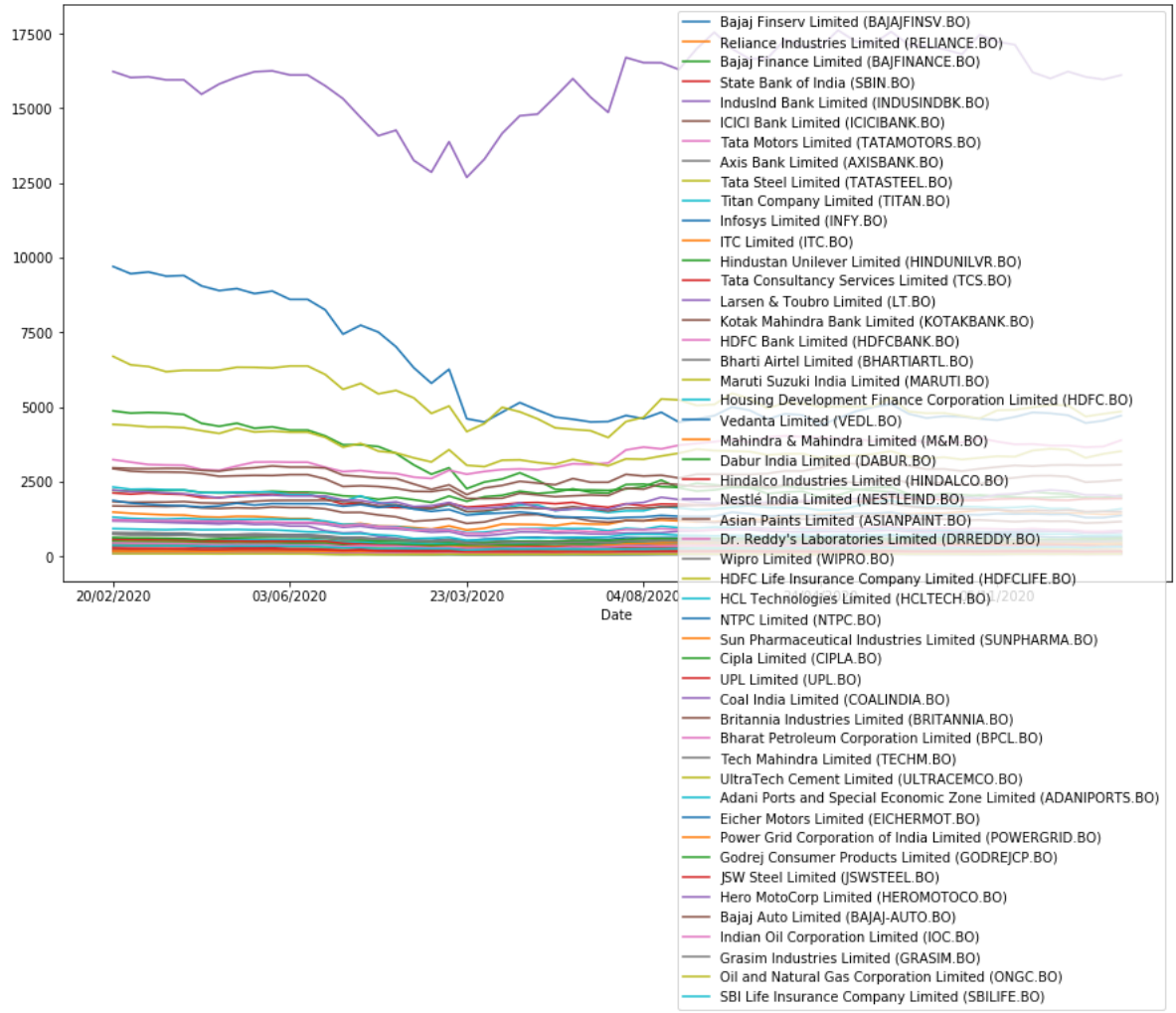
	Bajaj Finserv Limited (BAJAJFINSV.BO)	Reliance Industries Limited (RELIANCE.BO)	Bajaj Finance Limited (BAJFINANCE.BO)	State Bank of India (SBIN.BO)	IndusInd Bank Limited (INDUSINDBK.BO)	(ICI
Bajaj Finserv Limited (BAJAJFINSV.BO)	0.049449	0.017487	0.047125	0.027874	0.040995	
Reliance Industries Limited (RELIANCE.BO)	0.017487	0.035990	0.017833	0.016079	0.017074	
Bajaj Finance Limited (BAJFINANCE.BO)	0.047125	0.017833	0.060500	0.029923	0.043995	
State Bank of India (SBIN.BO)	0.027874	0.016079	0.029923	0.043528	0.036125	

In [51]:

```
tb1 = data.loc['20/02/2020':'20/05/2020']
tb1.plot(figsize=(15,8))
```

Out[51]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1b36c8eb188>
```



In [6]:

```
def ann_risk_return(table):
    summary = table.agg(["mean","std"]).T
    summary.columns = ["Returns","Risk"]
    summary.Returns =summary.Returns*250
    summary.Risk = summary.Risk*np.sqrt(250)
    return summary
```

In [7]:

```
ret=table.pct_change().dropna()
```

In [8]:

```
summary=ann_risk_return(table)
```

In [9]:

```
summary
```

Out[9]:

	Returns	Risk
Bajaj Finserv Limited (BAJAJFINSV.BO)	1.766661e+06	22679.307790
Reliance Industries Limited (RELIANCE.BO)	3.709570e+05	5445.133800
Bajaj Finance Limited (BAJFINANCE.BO)	8.220306e+05	10940.176710
State Bank of India (SBIN.BO)	6.675036e+04	965.083893
IndusInd Bank Limited (INDUSINDBK.BO)	2.818815e+05	7368.675261
ICICI Bank Limited (ICICIBANK.BO)	1.020523e+05	1024.635169
Tata Motors Limited (TATAMOTORS.BO)	3.649165e+04	585.336676
Axis Bank Limited (AXISBANK.BO)	1.546971e+05	2238.742989
Tata Steel Limited (TATASTEEL.BO)	1.013505e+05	1155.706337
Titan Company Limited (TITAN.BO)	2.743519e+05	2049.542919
Infosys Limited (INFY.BO)	1.884470e+05	2095.341230
ITC Limited (ITC.BO)	5.584915e+04	629.607689
Hindustan Unilever Limited (HINDUNILVR.BO)	4.842769e+05	3223.337062
Tata Consultancy Services Limited (TCS.BO)	5.209220e+05	3658.911975
Larsen & Toubro Limited (LT.BO)	2.902661e+05	3353.891007
Kotak Mahindra Bank Limited (KOTAKBANK.BO)	3.563117e+05	2645.075129
HDFC Bank Limited (HDFCBANK.BO)	2.807021e+05	1827.692643
Bharti Airtel Limited (BHARTIARTL.BO)	1.038833e+05	1528.719477
Maruti Suzuki India Limited (MARUTI.BO)	1.625847e+06	11704.639404
Housing Development Finance Corporation Limited (HDFC.BO)	4.921693e+05	3510.090808
Vedanta Limited (VEDL.BO)	3.128401e+04	454.283601
Mahindra & Mahindra Limited (M&M.BO)	1.436750e+05	1587.738939
Dabur India Limited (DABUR.BO)	1.123094e+05	633.620179
Hindalco Industries Limited (HINDALCO.BO)	4.547397e+04	476.507291
Nestlé India Limited (NESTLEIND.BO)	3.411875e+06	40760.287768
Asian Paints Limited (ASIANPAINT.BO)	4.104834e+05	3745.795375
Dr. Reddy's Laboratories Limited (DRREDDY.BO)	8.139513e+05	12940.206667
Wipro Limited (WIPRO.BO)	6.424140e+04	617.223139
HDFC Life Insurance Company Limited (HDFCLIFE.BO)	1.270195e+05	1409.268331
HCL Technologies Limited (HCLTECH.BO)	1.426039e+05	1649.041965
NTPC Limited (NTPC.BO)	2.584179e+04	223.365274
Sun Pharmaceutical Industries Limited (SUNPHARMA.BO)	1.105473e+05	690.060256
Cipla Limited (CIPLA.BO)	1.392229e+05	1703.180744
UPL Limited (UPL.BO)	1.298048e+05	1373.368177

	Returns	Risk
Coal India Limited (COALINDIA.BO)	4.100109e+04	560.031185
Britannia Industries Limited (BRITANNIA.BO)	7.640300e+05	6072.812368
Bharat Petroleum Corporation Limited (BPCL.BO)	9.299511e+04	968.973295
Tech Mahindra Limited (TECHM.BO)	1.716117e+05	1408.776755
UltraTech Cement Limited (ULTRACEMCO.BO)	1.016297e+06	5984.290714
Adani Ports and Special Economic Zone Limited (ADANIPORTS.BO)	8.914556e+04	584.108124
Eicher Motors Limited (EICHERMOT.BO)	4.871302e+05	4176.938869
Power Grid Corporation of India Limited (POWERGRID.BO)	4.385605e+04	182.880386
Godrej Consumer Products Limited (GODREJCP.BO)	1.666803e+05	1019.015495
JSW Steel Limited (JSWSTEEL.BO)	6.193819e+04	690.202063
Hero MotoCorp Limited (HEROMOTOCO.BO)	6.283175e+05	5331.900871
Bajaj Auto Limited (BAJAJ-AUTO.BO)	6.928005e+05	3757.552833
Indian Oil Corporation Limited (IOC.BO)	2.826182e+04	399.655744
Grasim Industries Limited (GRASIM.BO)	1.826897e+05	1749.541205
Oil and Natural Gas Corporation Limited (ONGC.BO)	2.738557e+04	470.478320
SBI Life Insurance Company Limited (SBILIFE.BO)	1.934133e+05	2074.337447

In [10]:

```
noa=50
nop=100000
```

In [11]:

```
matrix=np.random.random(50*50).reshape(50,50)
```

In [12]:

```
np.random.seed(123)
matrix=np.random.random(noa*nop).reshape(nop,noa)
matrix
```

Out[12]:

```
array([[0.69646919, 0.28613933, 0.22685145, ..., 0.98555979, 0.51948512,
        0.61289453],
       [0.12062867, 0.8263408 , 0.60306013, ..., 0.39887629, 0.2408559 ,
        0.34345601],
       [0.51312815, 0.66662455, 0.10590849, ..., 0.04857903, 0.7086974 ,
        0.83924335],
       ...,
       [0.771363  , 0.66399452, 0.70980034, ..., 0.42080155, 0.18014488,
        0.02020186],
       [0.00555788, 0.05765405, 0.66167542, ..., 0.42020726, 0.05788854,
        0.58869437],
       [0.60038571, 0.05553236, 0.03331703, ..., 0.7533014 , 0.86757063,
        0.89091337]])
```

In [13]:

```
matrix.sum(axis=1,keepdims=True)
```

Out[13]:

```
array([[25.09289335],
       [25.04999465],
       [26.01579807],
       ...,
       [23.99961788],
       [23.50694082],
       [24.48699498]])
```

In [14]:

```
w=matrix/matrix.sum(axis=1,keepdims=True)
```

In [15]:

```
w.sum(axis=1,keepdims=True)
```

Out[15]:

```
array([[1.],
       [1.],
       [1.],
       ...,
       [1.],
       [1.],
       [1.]])
```

In [16]:

```
port_ret=ret.dot(w.T)
port_ret
```

Out[16]:

Date	0	1	2	3	4	5	6	7
26/11/2018	0.007291	0.007718	0.006313	0.007552	0.006554	0.007322	0.006797	0.00503
27/11/2018	0.001259	0.000681	0.000012	0.000965	0.003069	0.001739	-0.000603	0.00131
28/11/2018	-0.005058	-0.002140	-0.002731	-0.003834	-0.002574	-0.004331	-0.003971	-0.00247
29/11/2018	0.012058	0.012215	0.011260	0.011317	0.010556	0.012394	0.008232	0.01244
30/11/2018	0.000992	0.001542	-0.001507	-0.000282	0.001242	-0.000371	0.001277	0.00349
...	...	...	...	...	...	...	...	...
13/11/2020	0.005674	0.005512	0.004157	0.004223	0.004312	0.003810	0.003950	0.00505
17/11/2020	0.012795	0.011331	0.013553	0.012931	0.013622	0.010695	0.008955	0.01176
18/11/2020	0.013195	0.008809	0.006611	0.007659	0.011459	0.007995	0.004247	0.00496
19/11/2020	-0.010148	-0.008445	-0.007706	-0.008812	-0.009546	-0.012205	-0.009010	-0.00739
20/11/2020	0.011452	0.007921	0.009719	0.010568	0.010721	0.009641	0.008493	0.01112

491 rows × 100000 columns

In [17]:

```
port_summary=ann_risk_return(port_ret)
port_summary
```

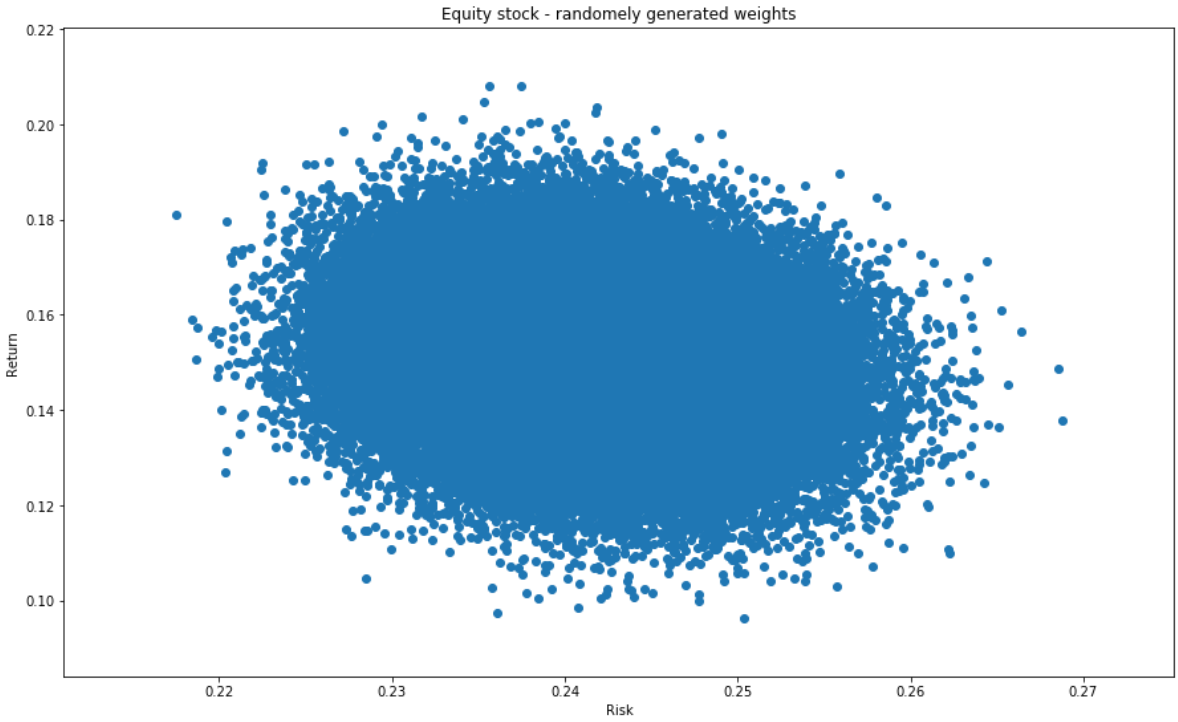
Out[17]:

	Returns	Risk
0	0.136387	0.253552
1	0.147636	0.236920
2	0.144254	0.239222
3	0.137245	0.249108
4	0.121209	0.246982
...	...	...
99995	0.148680	0.242511
99996	0.147342	0.236842
99997	0.159729	0.231583
99998	0.165464	0.235063
99999	0.140038	0.236858

100000 rows × 2 columns

In [19]:

```
plt.figure(figsize=(15,9))
plt.scatter(port_summary.loc[:,"Risk"], port_summary.loc[:,"Returns"])
plt.xlabel("Risk")
plt.ylabel("Return")
plt.title("Equity stock - randomely generated weights")
plt.show()
```



Optimized portfolio

In [ ]:

```
```

In [21]:

```
model = Model('min_risk')
```

```
Using license file C:\Users\NGDRS-1\gurobi.lic
Academic license - for non-commercial use only - expires 2021-01-24
```

In [22]:

```
tickers = table.columns
variables = pd.Series(model.addVars(tickers),index=tickers)
```

In [23]:

```
variables
```

Out[23]:

```
Bajaj Finserv Limited (BAJAJFINSV.BO)                                <gurobi.Var
*Awaiting Model Update*>
Reliance Industries Limited (RELIANCE.BO)                            <gurobi.Var
*Awaiting Model Update*>
Bajaj Finance Limited (BAJFINANCE.BO)                                <gurobi.Var
*Awaiting Model Update*>
State Bank of India (SBIN.BO)                                        <gurobi.Var
*Awaiting Model Update*>
IndusInd Bank Limited (INDUSINDBK.BO)                                <gurobi.Var
*Awaiting Model Update*>
ICICI Bank Limited (ICICIBANK.BO)                                    <gurobi.Var
*Awaiting Model Update*>
Tata Motors Limited (TATAMOTORS.BO)                                  <gurobi.Var
*Awaiting Model Update*>
Axis Bank Limited (AXISBANK.BO)                                      <gurobi.Var
*Awaiting Model Update*>
Tata Steel Limited (TATASTEEL.BO)                                    <gurobi.Var
*Awaiting Model Update*>
Titan Company Limited (TITAN.BO)                                     <gurobi.Var
*Awaiting Model Update*>
Infosys Limited (INFY.BO)                                            <gurobi.Var
*Awaiting Model Update*>
ITC Limited (ITC.BO)                                                 <gurobi.Var
*Awaiting Model Update*>
Hindustan Unilever Limited (HINDUNILVR.BO)                           <gurobi.Var
*Awaiting Model Update*>
Tata Consultancy Services Limited (TCS.BO)                           <gurobi.Var
*Awaiting Model Update*>
Larsen & Toubro Limited (LT.BO)                                      <gurobi.Var
*Awaiting Model Update*>
Kotak Mahindra Bank Limited (KOTAKBANK.BO)                           <gurobi.Var
*Awaiting Model Update*>
HDFC Bank Limited (HDFCBANK.BO)                                      <gurobi.Var
*Awaiting Model Update*>
Bharti Airtel Limited (BHARTIARTL.BO)                                <gurobi.Var
*Awaiting Model Update*>
Maruti Suzuki India Limited (MARUTI.BO)                              <gurobi.Var
*Awaiting Model Update*>
Housing Development Finance Corporation Limited (HDFC.BO)            <gurobi.Var
*Awaiting Model Update*>
Vedanta Limited (VEDL.BO)                                            <gurobi.Var
*Awaiting Model Update*>
Mahindra & Mahindra Limited (M&M.BO)                                 <gurobi.Var
*Awaiting Model Update*>
Dabur India Limited (DABUR.BO)                                       <gurobi.Var
*Awaiting Model Update*>
Hindalco Industries Limited (HINDALCO.BO)                            <gurobi.Var
*Awaiting Model Update*>
Nestlé India Limited (NESTLEIND.BO)                                  <gurobi.Var
*Awaiting Model Update*>
Asian Paints Limited (ASIANPAINT.BO)                                 <gurobi.Var
*Awaiting Model Update*>
Dr. Reddy's Laboratories Limited (DRREDDY.BO)                        <gurobi.Var
*Awaiting Model Update*>
Wipro Limited (WIPRO.BO)                                             <gurobi.Var
```

```
*Awaiting Model Update*>
HDFC Life Insurance Company Limited (HDFCLIFE.BO)                <gurobi.Var
*Awaiting Model Update*>
HCL Technologies Limited (HCLTECH.BO)                            <gurobi.Var
*Awaiting Model Update*>
NTPC Limited (NTPC.BO)                                           <gurobi.Var
*Awaiting Model Update*>
Sun Pharmaceutical Industries Limited (SUNPHARMA.BO)             <gurobi.Var
*Awaiting Model Update*>
Cipla Limited (CIPLA.BO)                                         <gurobi.Var
*Awaiting Model Update*>
UPL Limited (UPL.BO)                                             <gurobi.Var
*Awaiting Model Update*>
Coal India Limited (COALINDIA.BO)                                <gurobi.Var
*Awaiting Model Update*>
Britannia Industries Limited (BRITANNIA.BO)                      <gurobi.Var
*Awaiting Model Update*>
Bharat Petroleum Corporation Limited (BPCL.BO)                   <gurobi.Var
*Awaiting Model Update*>
Tech Mahindra Limited (TECHM.BO)                                 <gurobi.Var
*Awaiting Model Update*>
UltraTech Cement Limited (ULTRACEMCO.BO)                         <gurobi.Var
*Awaiting Model Update*>
Adani Ports and Special Economic Zone Limited (ADANIPORTS.BO)    <gurobi.Var
*Awaiting Model Update*>
Eicher Motors Limited (EICHERMOT.BO)                             <gurobi.Var
*Awaiting Model Update*>
Power Grid Corporation of India Limited (POWERGRID.BO)           <gurobi.Var
*Awaiting Model Update*>
Godrej Consumer Products Limited (GODREJCP.BO)                   <gurobi.Var
*Awaiting Model Update*>
JSW Steel Limited (JSWSTEEL.BO)                                  <gurobi.Var
*Awaiting Model Update*>
Hero MotoCorp Limited (HEROMOTOCO.BO)                            <gurobi.Var
*Awaiting Model Update*>
Bajaj Auto Limited (BAJAJ-AUTO.BO)                               <gurobi.Var
*Awaiting Model Update*>
Indian Oil Corporation Limited (IOC.BO)                          <gurobi.Var
*Awaiting Model Update*>
Grasim Industries Limited (GRASIM.BO)                            <gurobi.Var
*Awaiting Model Update*>
Oil and Natural Gas Corporation Limited (ONGC.BO)                <gurobi.Var
*Awaiting Model Update*>
SBI Life Insurance Company Limited (SBILIFE.BO)                  <gurobi.Var
*Awaiting Model Update*>
dtype: object
```

In [24]:

```
port_risk = cov.dot(variables).dot(variables)
```

In [25]:

```
model.setObjective(port_risk,GRB.MINIMIZE)
```

In [26]:

```
model.addConstr(variables.sum() == 1,'weights')
model.update()
```

In [27]:

```
model.setParam('OutputFlag',0)
model.update()
```

In [28]:

```
model.optimize()
```

In [29]:

```
n = 0
weights = {}
for v in variables:
    weights.update({tickers[n]:v.x})
    n = n + 1
weights = pd.DataFrame([weights])
weights = weights.transpose()
weights.columns = ['Weights']

print('\nMin Risk, Optimal Weights Per Stock')
print(weights['Weights'])
```

```
Min Risk, Optimal Weights Per Stock
Bajaj Finserv Limited (BAJAJFINSV.BO)                                1.002528e-0
9
Reliance Industries Limited (RELIANCE.BO)                            2.152221e-0
9
Bajaj Finance Limited (BAJFINANCE.BO)                                1.096568e-0
9
State Bank of India (SBIN.BO)                                        1.534637e-0
9
IndusInd Bank Limited (INDUSINDBK.BO)                                4.771230e-1
0
ICICI Bank Limited (ICICIBANK.BO)                                    1.203805e-0
9
Tata Motors Limited (TATAMOTORS.BO)                                  6.935419e-1
0
Axis Bank Limited (AXISBANK.BO)                                      6.562343e-1
0
Tata Steel Limited (TATASTEEL.BO)                                    8.920722e-1
0
Titan Company Limited (TITAN.BO)                                     9.332683e-0
9
Infosys Limited (INFY.BO)                                            4.001331e-0
7
ITC Limited (ITC.BO)                                                 6.688211e-0
2
Hindustan Unilever Limited (HINDUNILVR.BO)                           5.338318e-0
2
Tata Consultancy Services Limited (TCS.BO)                           1.379921e-0
1
Larsen & Toubro Limited (LT.BO)                                      3.805840e-0
9
Kotak Mahindra Bank Limited (KOTAKBANK.BO)                           4.574176e-0
9
HDFC Bank Limited (HDFCBANK.BO)                                      3.466614e-0
2
Bharti Airtel Limited (BHARTIARTL.BO)                                1.961138e-0
6
Maruti Suzuki India Limited (MARUTI.BO)                              1.223135e-0
9
Housing Development Finance Corporation Limited (HDFC.BO)            2.734705e-0
9
Vedanta Limited (VEDL.BO)                                            7.207923e-1
0
Mahindra & Mahindra Limited (M&M.BO)                                 1.361930e-0
9
Dabur India Limited (DABUR.BO)                                       7.379489e-0
```

```
2
Hindalco Industries Limited (HINDALCO.BO)                          5.494724e-1
0
Nestlé India Limited (NESTLEIND.BO)                                7.778221e-0
2
Asian Paints Limited (ASIANPAINT.BO)                               5.926722e-0
2
Dr. Reddy's Laboratories Limited (DRREDDY.BO)                      1.180732e-0
1
Wipro Limited (WIPRO.BO)                                           1.442046e-0
2
HDFC Life Insurance Company Limited (HDFCLIFE.BO)                  3.420643e-0
9
HCL Technologies Limited (HCLTECH.BO)                              5.170507e-0
4
NTPC Limited (NTPC.BO)                                             1.413838e-0
8
Sun Pharmaceutical Industries Limited (SUNPHARMA.BO)               6.471203e-0
3
Cipla Limited (CIPLA.BO)                                           6.786587e-0
2
UPL Limited (UPL.BO)                                               1.831145e-0
9
Coal India Limited (COALINDIA.BO)                                  9.023214e-0
2
Britannia Industries Limited (BRITANNIA.BO)                        1.695131e-0
8
Bharat Petroleum Corporation Limited (BPCL.BO)                     1.280441e-0
9
Tech Mahindra Limited (TECHM.BO)                                   5.060378e-0
9
UltraTech Cement Limited (ULTRACEMCO.BO)                           1.793656e-0
9
Adani Ports and Special Economic Zone Limited (ADANIPORTS.BO)      2.011598e-0
8
Eicher Motors Limited (EICHERMOT.BO)                               1.639624e-0
7
Power Grid Corporation of India Limited (POWERGRID.BO)             1.648383e-0
1
Godrej Consumer Products Limited (GODREJCP.BO)                     1.629266e-0
2
JSW Steel Limited (JSWSTEEL.BO)                                    6.679570e-1
0
Hero MotoCorp Limited (HEROMOTOCO.BO)                              2.070724e-0
9
Bajaj Auto Limited (BAJAJ-AUTO.BO)                                 1.014335e-0
8
Indian Oil Corporation Limited (IOC.BO)                            1.751865e-0
2
Grasim Industries Limited (GRASIM.BO)                              8.227978e-1
0
Oil and Natural Gas Corporation Limited (ONGC.BO)                  1.083425e-0
9
SBI Life Insurance Company Limited (SBILIFE.BO)                    5.062407e-0
9
Name: Weights, dtype: float64
```

In [30]:

```
print('\nMinimized Portfolio Variance : '+str(port_risk.getValue()))
```

```
Minimized Portfolio Variance : 0.007861859090797441
```

In [31]:

```
min_vol = math.sqrt(port_risk.getValue())
print('Volatility : '+str(min_vol))
```

```
Volatility : 0.08866712519754681
```

In [32]:

```
port_return = avg.dot(variables)
Rmin = port_return.getValue()
print('Expected Return (Rmin) : '+str(Rmin))
```

```
Expected Return (Rmin) : 0.040752730159228485
```

In [33]:

```
Rmax = avg.max()
```

In [34]:

```
target = model.addConstr(port_return == Rmin, 'target')
```

In [35]:

```
eff = {}
iterations = 50
diff = (Rmax-Rmin)/(iterations-1)
Rrange = np.arange(Rmin,Rmax+diff,diff)
for r in Rrange:
    target.rhs = r
    model.optimize()
    temp = math.sqrt(port_risk.getValue())
    eff.update({temp:r})
```

In [36]:

```
frontier = pd.DataFrame([eff]).transpose()
frontier.columns = ['Returns']
frontier['Risk'] = frontier.index
frontier = frontier.reset_index(drop=True)
```

In [37]:

```
print('\nEfficient Frontier')
print(frontier)
```

```
Efficient Frontier
     Returns      Risk
0   0.040753  0.088667
1   0.042344  0.088679
2   0.043935  0.088714
3   0.045527  0.088773
4   0.047118  0.088855
5   0.048709  0.088959
6   0.050301  0.089087
7   0.051892  0.089239
8   0.053483  0.089414
9   0.055075  0.089614
10  0.056666  0.089840
11  0.058258  0.090090
12  0.059849  0.090365
13  0.061440  0.090667
14  0.063032  0.090996
15  0.064623  0.091351
16  0.066214  0.091743
17  0.067806  0.092225
18  0.069397  0.092801
19  0.070988  0.093470
20  0.072580  0.094231
21  0.074171  0.095080
22  0.075762  0.096014
23  0.077354  0.097030
24  0.078945  0.098129
25  0.080536  0.099318
26  0.082128  0.100597
27  0.083719  0.101963
28  0.085310  0.103416
29  0.086902  0.104962
30  0.088493  0.106677
31  0.090084  0.108583
32  0.091676  0.110733
33  0.093267  0.113255
34  0.094858  0.116298
35  0.096450  0.120017
36  0.098041  0.124464
37  0.099632  0.129688
38  0.101224  0.135602
39  0.102815  0.142120
40  0.104406  0.149366
41  0.105998  0.157444
42  0.107589  0.166235
43  0.109181  0.175630
44  0.110772  0.185538
45  0.112363  0.195890
46  0.113955  0.207086
47  0.115546  0.219264
48  0.117137  0.232268
49  0.118729  0.245967
```

In [38]:

```
frontier['Sharpe'] = frontier['Returns']/frontier['Risk']
idx = frontier['Sharpe'].max()
sharpeMax = frontier.loc[frontier['Sharpe'] == idx]
sharpeMax = sharpeMax.reset_index(drop=True)
```

In [39]:

```
target.rhs = sharpeMax['Returns'][0]
model.optimize()
n = 0
sharpe_weights = {}
for v in variables:
    sharpe_weights.update({tickers[n]:v.x})
    n = n + 1
sharpe_weights = pd.DataFrame([sharpe_weights])
sharpe_weights = sharpe_weights.transpose()
sharpe_weights.columns = ['Weights']
```

In [40]:

```
print('\nMaximum Sharpe Ratio')
print(sharpeMax)
print(sharpe_weights)
```

```
Maximum Sharpe Ratio
    Returns      Risk    Sharpe
0  0.090084  0.108583  0.829634
                                                    Weights
Bajaj Finserv Limited (BAJAJFINSV.BO)              2.484757e-11
Reliance Industries Limited (RELIANCE.BO)          1.445125e-02
Bajaj Finance Limited (BAJFINANCE.BO)              1.121958e-01
State Bank of India (SBIN.BO)                      9.326079e-12
IndusInd Bank Limited (INDUSINDBK.BO)              5.038330e-12
ICICI Bank Limited (ICICIBANK.BO)                  2.162615e-11
Tata Motors Limited (TATAMOTORS.BO)                1.318703e-11
Axis Bank Limited (AXISBANK.BO)                    9.452994e-12
Tata Steel Limited (TATASTEEL.BO)                  1.194007e-11
Titan Company Limited (TITAN.BO)                   1.908272e-10
Infosys Limited (INFY.BO)                          1.829915e-01
ITC Limited (ITC.BO)                               9.883605e-12
Hindustan Unilever Limited (HINDUNILVR.BO)         2.252618e-11
Tata Consultancy Services Limited (TCS.BO)         1.956992e-02
Larsen & Toubro Limited (LT.BO)                    9.419782e-12
Kotak Mahindra Bank Limited (KOTAKBANK.BO)         1.518004e-10
HDFC Bank Limited (HDFCBANK.BO)                    4.606345e-11
Bharti Airtel Limited (BHARTIARTL.BO)              5.700317e-02
Maruti Suzuki India Limited (MARUTI.BO)            9.530653e-12
Housing Development Finance Corporation Limited...  2.674650e-11
Vedanta Limited (VEDL.BO)                          6.467916e-12
Mahindra & Mahindra Limited (M&M.BO)               1.130592e-11
Dabur India Limited (DABUR.BO)                     2.901144e-11
Hindalco Industries Limited (HINDALCO.BO)          8.442361e-12
Nestlé India Limited (NESTLEIND.BO)                2.179800e-01
Asian Paints Limited (ASIANPAINT.BO)               5.563677e-02
Dr. Reddy's Laboratories Limited (DRREDDY.BO)      2.934738e-01
Wipro Limited (WIPRO.BO)                           1.592416e-10
HDFC Life Insurance Company Limited (HDFCLIFE.BO)  9.114685e-10
HCL Technologies Limited (HCLTECH.BO)              4.669784e-02
NTPC Limited (NTPC.BO)                             1.143688e-11
Sun Pharmaceutical Industries Limited (SUNPHARM...  1.373288e-11
Cipla Limited (CIPLA.BO)                           8.132539e-09
UPL Limited (UPL.BO)                               8.544153e-12
Coal India Limited (COALINDIA.BO)                  7.392791e-12
Britannia Industries Limited (BRITANNIA.BO)        1.751780e-11
Bharat Petroleum Corporation Limited (BPCL.BO)     5.370823e-11
Tech Mahindra Limited (TECHM.BO)                   2.086865e-11
UltraTech Cement Limited (ULTRACEMCO.BO)           1.641260e-11
Adani Ports and Special Economic Zone Limited (...  1.492028e-11
Eicher Motors Limited (EICHERMOT.BO)               1.894341e-11
Power Grid Corporation of India Limited (POWERG...  7.129484e-11
Godrej Consumer Products Limited (GODREJCP.BO)     1.335122e-11
JSW Steel Limited (JSWSTEEL.BO)                    1.056568e-11
Hero MotoCorp Limited (HEROMOTOCO.BO)              1.564208e-11
Bajaj Auto Limited (BAJAJ-AUTO.BO)                 2.365075e-11
Indian Oil Corporation Limited (IOC.BO)            8.699925e-12
Grasim Industries Limited (GRASIM.BO)              1.016842e-11
Oil and Natural Gas Corporation Limited (ONGC.BO)  5.444682e-12
SBI Life Insurance Company Limited (SBILIFE.BO)    7.195355e-11
```

In [41]:

```
sharpe_weights
```

Out[41]:

	Weights
Bajaj Finserv Limited (BAJAJFINSV.BO)	2.484757e-11
Reliance Industries Limited (RELIANCE.BO)	1.445125e-02
Bajaj Finance Limited (BAJFINANCE.BO)	1.121958e-01
State Bank of India (SBIN.BO)	9.326079e-12
IndusInd Bank Limited (INDUSINDBK.BO)	5.038330e-12
ICICI Bank Limited (ICICIBANK.BO)	2.162615e-11
Tata Motors Limited (TATAMOTORS.BO)	1.318703e-11
Axis Bank Limited (AXISBANK.BO)	9.452994e-12
Tata Steel Limited (TATASTEEL.BO)	1.194007e-11
Titan Company Limited (TITAN.BO)	1.908272e-10
Infosys Limited (INFY.BO)	1.829915e-01
ITC Limited (ITC.BO)	9.883605e-12
Hindustan Unilever Limited (HINDUNILVR.BO)	2.252618e-11
Tata Consultancy Services Limited (TCS.BO)	1.956992e-02
Larsen & Toubro Limited (LT.BO)	9.419782e-12
Kotak Mahindra Bank Limited (KOTAKBANK.BO)	1.518004e-10
HDFC Bank Limited (HDFCBANK.BO)	4.606345e-11
Bharti Airtel Limited (BHARTIARTL.BO)	5.700317e-02
Maruti Suzuki India Limited (MARUTI.BO)	9.530653e-12
Housing Development Finance Corporation Limited (HDFC.BO)	2.674650e-11
Vedanta Limited (VEDL.BO)	6.467916e-12
Mahindra & Mahindra Limited (M&M.BO)	1.130592e-11
Dabur India Limited (DABUR.BO)	2.901144e-11
Hindalco Industries Limited (HINDALCO.BO)	8.442361e-12
Nestlé India Limited (NESTLEIND.BO)	2.179800e-01
Asian Paints Limited (ASIANPAINT.BO)	5.563677e-02
Dr. Reddy's Laboratories Limited (DRREDDY.BO)	2.934738e-01
Wipro Limited (WIPRO.BO)	1.592416e-10
HDFC Life Insurance Company Limited (HDFCLIFE.BO)	9.114685e-10
HCL Technologies Limited (HCLTECH.BO)	4.669784e-02
NTPC Limited (NTPC.BO)	1.143688e-11
Sun Pharmaceutical Industries Limited (SUNPHARMA.BO)	1.373288e-11
Cipla Limited (CIPLA.BO)	8.132539e-09
UPL Limited (UPL.BO)	8.544153e-12

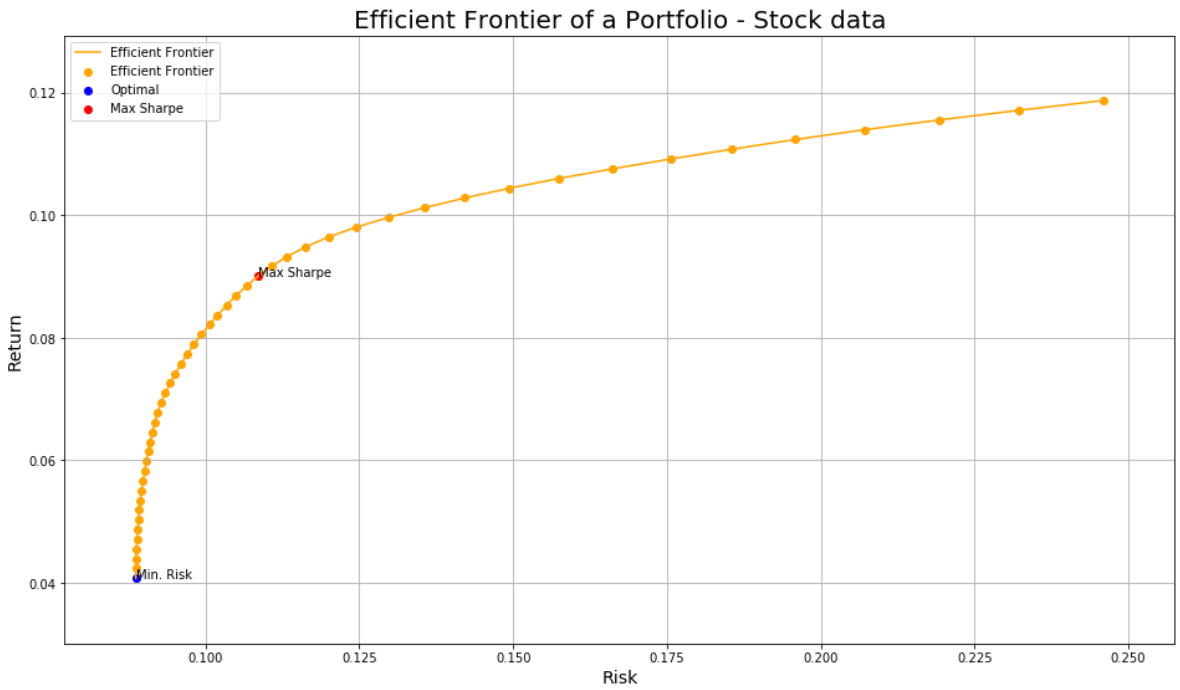
	Weights
Coal India Limited (COALINDIA.BO)	7.392791e-12
Britannia Industries Limited (BRITANNIA.BO)	1.751780e-11
Bharat Petroleum Corporation Limited (BPCL.BO)	5.370823e-11
Tech Mahindra Limited (TECHM.BO)	2.086865e-11
UltraTech Cement Limited (ULTRACEMCO.BO)	1.641260e-11
Adani Ports and Special Economic Zone Limited (ADANIPORTS.BO)	1.492028e-11
Eicher Motors Limited (EICHERMOT.BO)	1.894341e-11
Power Grid Corporation of India Limited (POWERGRID.BO)	7.129484e-11
Godrej Consumer Products Limited (GODREJCP.BO)	1.335122e-11
JSW Steel Limited (JSWSTEEL.BO)	1.056568e-11
Hero MotoCorp Limited (HEROMOTOCO.BO)	1.564208e-11
Bajaj Auto Limited (BAJAJ-AUTO.BO)	2.365075e-11
Indian Oil Corporation Limited (IOC.BO)	8.699925e-12
Grasim Industries Limited (GRASIM.BO)	1.016842e-11
Oil and Natural Gas Corporation Limited (ONGC.BO)	5.444682e-12
SBI Life Insurance Company Limited (SBILIFE.BO)	7.195355e-11

In [42]:

```
fig, ax = plt.subplots(nrows=1,ncols=1)
fig.set_size_inches(16,9)
ax.set_title('Efficient Frontier of a Portfolio - Stock data',fontsize=20)
ax.set_xlabel('Risk',fontsize=14)
ax.set_ylabel('Return',fontsize=14)

ax.scatter(x=frontier['Risk'],y=frontier['Returns'],color='orange',label='Efficient Frontie
ax.plot()#x=frontier['Risk'],y=frontier['Returns'],color='orange')
temp = pd.DataFrame([eff]).transpose()
temp.columns = ['Efficient Frontier']
temp.plot(color='orange',label='Efficient Frontier',ax=ax)

#ax.scatter(x=std,y=avg,color='green',label='Stocks')
i = 0
#for stock in tickers:
#    ax.annotate(stock,(std[i],avg[i]))
#    i = i + 1

ax.scatter(x=min_vol,y=Rmin,color='blue',label='Optimal')
ax.annotate('Min. Risk',(min_vol,Rmin))

ax.scatter(x=sharpeMax['Risk'],y=sharpeMax['Returns'],color='red',label='Max Sharpe')
ax.annotate('Max Sharpe',(sharpeMax['Risk'],sharpeMax['Returns']))

ax.grid()
ax.legend(loc='upper left')
```

Out[42]:

```
<matplotlib.legend.Legend at 0x1b378a81548>
```



In [31]:

```
# Calculate mean returns for each stock
avg_rets = returns_daily.mean()

# Calculate mean returns for portfolio overall,
# using dot product to
# normalize individual means against investment weights
 # https://en.wikipedia.org/wiki/Dot_product#:~:targetText=In%20mathematics%2C%20the%20dot%
port_mean = avg_rets.dot(sharpe_weights)

# Calculate portfolio standard deviation
port_stdev = np.sqrt(sharpe_weights.T.dot(cov).dot(sharpe_weights))
```

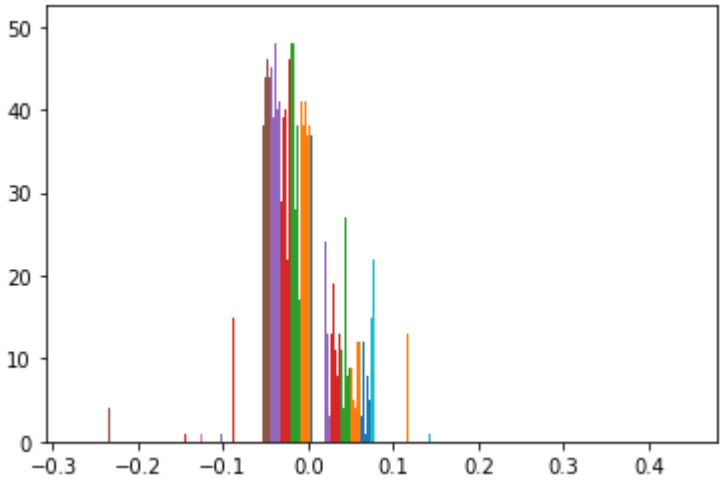
In [32]:

```
import matplotlib.pyplot as plt
plt.hist(returns_daily)
plt.show
```

```
C:\Users\NGDRS-1\anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6743:
RuntimeWarning: All-NaN slice encountered
  xmin = min(xmin, np.nanmin(xi))
C:\Users\NGDRS-1\anaconda3\lib\site-packages\matplotlib\axes\_axes.py:6744:
RuntimeWarning: All-NaN slice encountered
  xmax = max(xmax, np.nanmax(xi))
```

Out[32]:

```
<function matplotlib.pyplot.show(*args, **kw)>
```



In [33]:

```
initial_investment = 10000
# Calculate mean of investment
mean_investment = (1+port_mean) * initial_investment

# Calculate standard deviation of investmnet
stdev_investment = initial_investment * port_stdev
```

In [34]:

```
# Select our confidence interval (I'll choose 95% here)
conf_level1 = 0.05

# Using SciPy ppf method to generate values for the
# inverse cumulative distribution function to a normal distribution
# Plugging in the mean, standard deviation of our portfolio
# as calculated above
# https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.norm.html
from scipy.stats import norm
cutoff1 = norm.ppf(conf_level1, mean_investment, stdev_investment)
cutoff1
```

Out[34]:

```
array([[8228.37855592]])
```

In [35]:

```
#Finally, we can calculate the VaR at our confidence interval
var_1d1 = initial_investment - cutoff1
var_1d1
#output
```

Out[35]:

```
array([[1771.62144408]])
```

In [ ]: