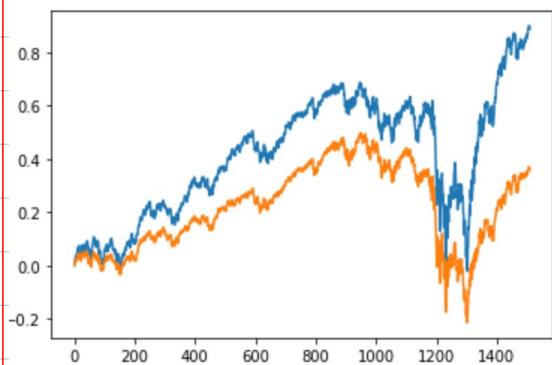


Econ 139 Final Project

Haoliang Jiang
Elena Zhou
Binhan Ge

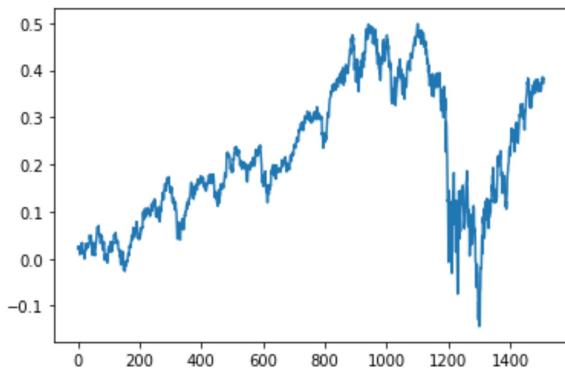
Problem 1
1(a).



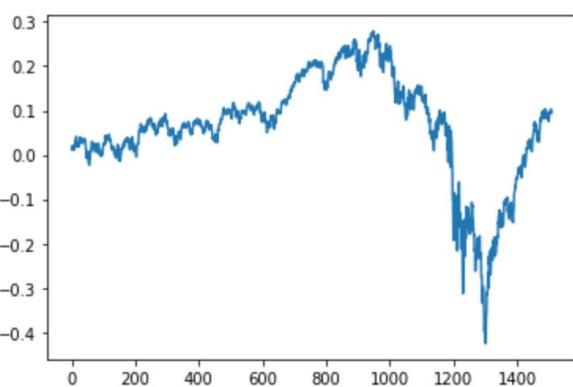
The orange curve is the cumulative market returns from fffdata.
The blue curve is the cumulative market returns from our calculation using the benchmark method provided.

The similarity of the two plots is that both of them are showing very similar pattern of seasonality. The difference is that the benchmark cumsum curve is sitting above the orange curve.

1(b)



Cumulative Returns of Randomly Selected 50 stocks
We found that the RMSE is 0.00941



Cumulative Returns of 50 stocks with biggest market cap. (a different portfolio).
We found that the RMSE is 0.00618
The RMSE decreases because the stocks with larger market caps have greater weights, so the curve of cumulative returns should have similar variance to that of the return curve of the entire market.

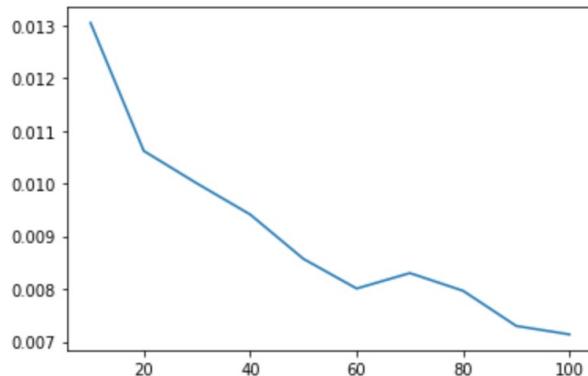
1 (C) .

```
N = [10, 20, 30, 40, 50, 60, 70, 80, 90, 100]

def mean_rmse_25(n):
    rmse = []
    for i in np.arange(25):
        random_num_arr = np.random.randint(1877, size = n)
        seadata_n = seadata.loc[seadata['Ticker'].isin(random_num_arr)]
        benchmark_n = benchmark_50(seadata_n, equalw = 0)
        rmse.append(RMSE(benchmark_n, a))
    return np.mean(rmse)

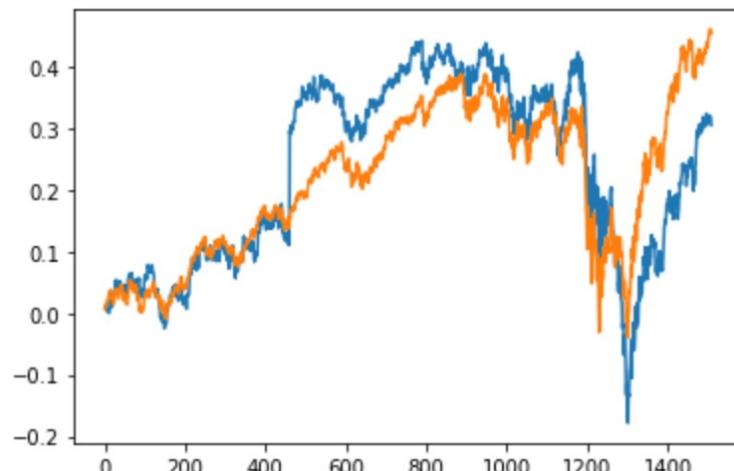
RMSE_result = []
for i in N:
    RMSE_result.append(mean_rmse_25(i))
```

4]: [0.013048874623342904, 25 10-stock
0.010619402230173746, 25 20-stock
0.010002261292308261, 25 30-stock
0.009412900716445731, 25 40-stock
0.008571121917512293, 25 50-stock
0.008007531665750238, 25 60-stock
0.008301732765943662, 25 70-stock
0.007965239859548582, 25 80-stock
0.007297700725015985, 25 90-stock
0.007137555064368531] 25 100-stock



The RMSE decreases as the number of securities increases. I choose n = 90 to do the additional testing.

The decrease of RMSE with the increase of the size of each portfolio is expected because more variance of the returns can be explained when each portfolio contains more stocks,

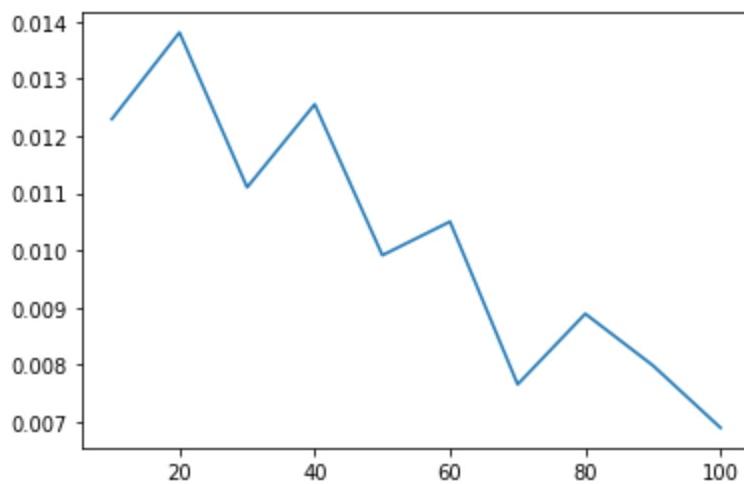


Now, as the RMSE is a lot smaller than before, the two curves have more overlaps.

I (d). My heuristic approach is to find the stocks whose variance over the time window is similar to the overall variance of the market.

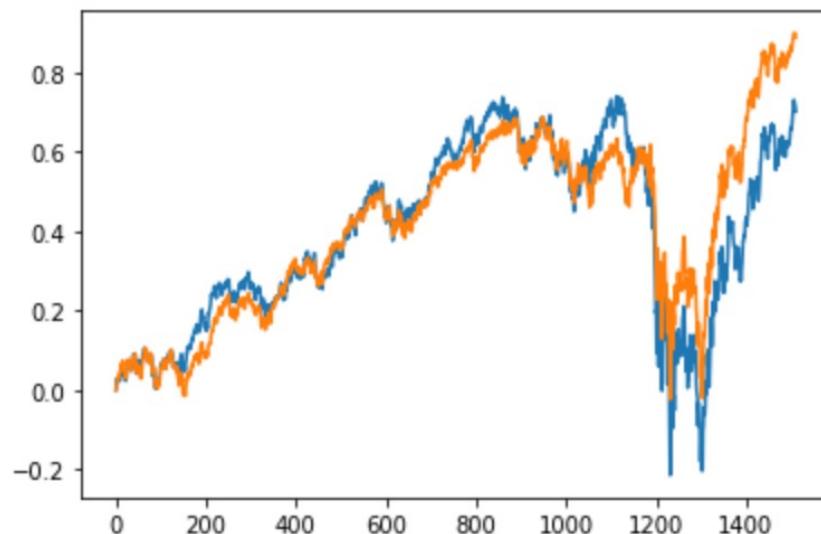
RMSE

[<matplotlib.lines.Line2D at 0x18d628fb588>]



[0.012294070825620255,
0.013808204514422844,
0.011102221284784917,
0.0125540078021477,
0.009915842205140876,
0.010503238031608209,
0.007659314102361465,
0.00889324902359399,
0.007989999425878925,
0.006900411993275364]

The RMSE results are better than those calculated in part C. The result is a lot better than the results using the randomized portfolios.



I chose $n=90$.
The RMSE is 0.0079
As we can see,
the orange and the
blue curve overlap
with a great degree.

Problem 2

2 (a)

I picked the portfolio randomly.

(i). See the attached code for the covariance matrix in details.

	27	73	114	116	120	123	127	131	167	184	...	1704	1
27	2.685492e-07	5.079331e-07	1.680050e-07	5.413246e-08	-2.800955e-07	-3.630514e-09	2.042172e-07	-1.425637e-07	1.369783e-07	6.004057e-08	...	3.217833e-07	1.50776
73	5.079331e-07	2.062655e-06	1.511189e-07	1.142487e-07	-4.978759e-07	1.809479e-07	5.998209e-07	-5.133512e-07	1.958215e-07	-4.417967e-08	...	5.015361e-07	2.37927
114	1.680050e-07	1.511189e-07	3.218177e-07	7.201542e-08	-3.773878e-07	-9.400559e-08	1.137366e-07	-7.282561e-08	1.653276e-07	1.399117e-07	...	4.040630e-07	2.45500
116	5.413246e-08	1.142487e-07	7.201542e-08	1.452485e-07	-1.679087e-07	-1.029774e-07	1.190849e-08	-1.132103e-08	5.979028e-08	4.731676e-08	...	1.135621e-07	1.4402C
120	-2.800955e-07	-4.978759e-07	-3.773878e-07	-1.679087e-07	8.881051e-07	3.530689e-07	-2.334050e-07	2.577304e-07	-3.183643e-07	-1.786217e-07	...	-7.660951e-07	-4.14348
123	-3.630514e-09	1.809479e-07	-9.400559e-08	-1.029774e-07	3.530689e-07	5.369387e-07	1.223457e-08	8.917249e-08	-1.452217e-07	-5.954692e-08	...	-3.347602e-07	-2.16598
127	2.042172e-07	5.998209e-07	1.137366e-07	1.190849e-08	-2.334050e-07	1.223457e-08	2.530210e-07	-1.784121e-07	1.096578e-07	1.677683e-08	...	2.657219e-07	4.52269
131	-1.425637e-07	-5.133512e-07	-7.282561e-08	-1.132103e-08	2.577304e-07	8.917249e-08	-1.784121e-07	2.353576e-07	-1.090656e-07	3.785115e-08	...	-2.404000e-07	-1.32372
167	1.369783e-07	1.958215e-07	1.653276e-07	5.979028e-08	-3.183643e-07	-1.452217e-07	1.096578e-07	-1.090656e-07	1.818124e-07	5.000719e-08	...	3.301909e-07	1.85509
184	6.004057e-08	-4.417967e-08	1.399117e-07	4.731676e-08	-1.786217e-07	-5.954692e-08	1.677683e-08	3.785115e-08	5.000719e-08	1.490619e-07	...	2.324737e-07	1.6043C
197	1.603344e-07	3.252570e-07	1.613124e-07	6.803790e-08	-3.071096e-07	-4.383807e-08	1.267980e-07	-8.774144e-08	1.032264e-07	9.700983e-08	...	3.106818e-07	1.6202C
204	6.123371e-07	1.668574e-06	4.997087e-07	2.153369e-07	-1.172187e-06	-2.724752e-07	6.106302e-07	-5.921301e-07	5.122958e-07	1.277141e-07	...	1.162056e-06	4.71216
205	1.476990e-07	-7.157486e-08	2.981312e-07	1.509596e-07	-4.213116e-07	-4.054732e-08	2.458104e-08	1.092888e-07	1.157284e-07	2.713478e-07	...	3.496934e-07	4.13464
221	4.349423e-07	1.111248e-06	3.691541e-07	2.094446e-07	-7.956261e-07	-6.889780e-08	3.718375e-07	-2.612546e-07	2.098245e-07	2.612944e-07	...	7.351716e-07	4.02311
...	1.375974e-08	3.803020e-08	8.083008e-08	2.779892e-08	-2.959927e-08	7.982972e-08	1.387962e-08	-1.335582e-08	1.055297e-08	2.247444e-08	...	2.352872e-08	8.8853C

This is just one example of 100x100 covariance matrix.

(ii). $\hat{\Sigma}_p$ for each rolling window can be found in the attached code.

(iii) \hat{r}_p of each portfolio can be found in the attached code.

(iv) $\tilde{\Sigma}_p$ can be found in the attached code.

Problem 2
2(b).

rw

bias statistics

504
252
126
63

1.33
1.13
1.06
1.05

Rolling window = 63 days provides the smallest bias statistics.

Intuitively, this is true because when you increase the resolution of the data, you get more accurate results.

Problem 3

- 3 (a) * Our functions are nested for problem 3, meaning that intermediate results are hidden and the final result shows the bias statistics directly. (No need to display an array whose length is 1000+)
- (i). Check **compute Beta And Idiosyncatic** function for the implementation of solving OLS.
 - (ii) Check **compute Mkt Var** function for the implementation of solving for the market variance.
 - (iii) Check **portfolioVar** function implementation of solving for the portfolio variance.
 - (iv). Also check **portfolioVar** for one-day ahead return \hat{r}_p .
 - (v). Check how we got the third return value from **portfolioVar**. The third return value calculates the $\tilde{\sigma}_p$.

3 (b).

```
96] def problemThree_3_4_5():
    WindowList = [504, 252, 126, 63]
    ans3List = []
    ans4List = []
    ans5List = []
    ans6List = []
    for windowSize in WindowList:
        (ans3, ans4, ans5) = portfolioVar(windowSize)
        ans3List.append(ans3)
        ans4List.append(ans4)
        ans5List.append(ans5)
        ans6List.append(np.sqrt(np.var(ans5)))
    return ans3List, ans4List, ans5List, ans6List

97] ans3List, ans4List, ans5List, ans6List = problemThree_3_4_5()

98] print(ans6List)
[1.3274856981776428, 1.133968910244764, 1.064211870389402, 1.0466144075363761]
```

rw	bias statistic
504	1.32748
252	1.13397
126	1.06421
63	1.04661

Once the function **problem Three-3-4-5** is called, all the functions above are executed and the bias statistics are outputted. The rolling window of 63 days gives the best volatility forecast. The closer the bias statistic to zero is, the more unbiased the estimator of variance is. The bias statistics are on average smaller than those calculated using the MPT approach.

Problem 4

4(a) (i) & (ii) The implementations for solving for Betas and covariance matrix of the Fama - French factors and idiosyncratic variance can be found in function `Compute Beta And Idiosyncratic And Cov` and `get All ParameterMatrix`.

(iii) The implementation for solving for $\hat{\sigma}_p^2$ can be found in function `profolioVar`.

(iv) & (v). One-day ahead return and \tilde{z}_p are implemented also in `profolioVar`.

4(b) Now, plug in all the inputs, we get the bias statistics.

r_w	bias statistics
504	1.32744
252	1.13273
126	1.06088
63	1.04069

Rolling window of 63 days gives the best result. Comparing to MPT and market model approaches, this Fama-French model yields even smaller bias statistic. However, I do prefer the market model because the Fama-French model contains more for loops and its runtime is very long and the bias statistic is only slightly smaller.

Problem 5
5(a).

See answer in attached code
Look for printed Beta M and Beta F.

5(b).

```
[16] > RM, RSMB, RHML, RP = p5_2()
      RM, RSMB, RHML, RP = p5_2()

[17] > print(RM)
      print(RM)
      [ 8.36507937e-05 -8.86349206e-04  1.37936508e-03]

[18] > print(RSMB)
      print(RSMB)
      [-6.50793651e-05 -4.90476190e-04 -1.28571429e-04]

[19] > print(RHML)
      print(RHML)
      [-0.0003127 -0.00048095 -0.00031587]

[20] > print(RP)
      print(RP)
      [[ 3.76435079e-04 -1.14849254e-03  1.21796905e-03]
       [-9.08695238e-05 -1.06781968e-03  1.63166048e-03]
       [ 4.54103651e-04 -1.34159778e-03  1.54306143e-03]
       [ 4.30072540e-04 -1.00047921e-03  1.31551238e-03]
       [ 7.11447937e-04 -8.41170476e-04  1.09416778e-03]
       [ 2.85202698e-04 -6.81376349e-04  2.08171825e-03]
       [ 9.45119048e-05 -1.39065063e-03  1.70521746e-03]
       [ 4.53862063e-04 -1.38642571e-03  1.90813254e-03]
       [ 4.73625238e-04 -1.73042365e-03  9.42619841e-04]
       [ 4.18744603e-04 -1.13735635e-03  1.36752159e-03]
       [ 9.34119206e-04 -1.28440127e-03  1.43878524e-03]
       [ 2.63243492e-04 -1.18739746e-03  2.12556175e-03]
       [ 1.10342857e-04 -9.84169048e-04  1.56720222e-03]
       [ 7.23901746e-04 -1.20248968e-03  1.62846365e-03]
       [ 5.29922381e-04 -1.28622587e-03  1.25992905e-03]
       [ 3.35299048e-04 -1.51929063e-03  1.41008048e-03]
       [ 1.75448889e-04 -1.33731778e-03  1.26799810e-03]
       [ 2.62645397e-04 -9.59989683e-04  1.41364603e-03]
       [ 7.87543016e-04 -9.57070159e-04  1.35668429e-03]
       [ 2.08256984e-04 -1.16828984e-03  1.40354651e-03]
       [ 6.64561905e-04 -7.86701587e-04  1.45531619e-03]
       [ 3.73815397e-04 -1.13180857e-03  1.39889000e-03]
       [ 7.67489206e-04 -1.11083556e-03  1.28951841e-03]
       [ 5.89965079e-05 -1.23050095e-03  1.75973825e-03]]
```

Econ 139 Final Project Q1 2

December 18, 2020

0.0.1 Problem 1 (a)

```
[112]: import pandas as pd  
seadata = pd.read_csv("seadata.txt", delimiter = ' ', usecols=[0,1,2],  
                      names=['Ticker', 'Returns', 'Market Cap'], header=None)  
seadata.head()
```

```
[112]:   Ticker    Returns  Market Cap  
0        1 -0.015048  13713091.20  
1        1  0.026042  14070202.95  
2        1  0.031472  14513021.52  
3        1  0.012795  14698719.63  
4        1  0.045675  15370089.72
```

```
[113]: fffdata = pd.read_csv("ffdata.txt", usecols = [0,1,2,3],  
                           names=['Market Returns', 'SMB', 'HML', 'Risk Free Rate'],  
                           header = None, sep = '\s+')
```

```
[113]:   Market Returns      SMB      HML  Risk Free Rate  
0        -0.0008  0.0083  0.0041      0.00004  
1         0.0122  0.0035  0.0002      0.00004  
2         0.0019  0.0012  0.0018      0.00004  
3         0.0027  0.0050 -0.0007      0.00004  
4         0.0048  0.0033  0.0062      0.00004
```

```
[114]: retdate = pd.read_csv("retdate.txt", delimiter = ' ', usecols=[0],  
                           names = ['Date'], header = None)
```

```
[115]: retdate.head()
```

```
[115]:      Date  
0  20040102  
1  20040105  
2  20040106  
3  20040107  
4  20040108
```

```
[116]: import numpy as np  
np.shape(secdata)
```

```
[116]: (2836147, 3)
```

```
[117]: (nobs, k) = np.shape(secdata)  
nsec = nobs / 1511  
nsec
```

```
[117]: 1877.0
```

```
[132]: def benchmark(secdata, begidx = None, endix = None, equalw = 1):  
    # inputs:  
    # secdata -- matrix of security data (ndate*nsec x 3)  
        #column 1: integer security id  
        #column 2: security return  
        #column 3: security market capitalization  
    #begidx -- beginning index (corresponding to a date)  
        #of security data to process, if empty all dates  
        #are processed  
    #endidx -- ending index (corresponding to a date)  
        #of security data to process, if empty all dates  
        #are processed  
    #equalw -- 1 = equally weighted returns  
        #0 = capitalization weighted returns  
  
    #outputs:  
    #mktlev -- imputed market level (ndate x 1)  
    #mktret -- imputed market return (ndate x 1)  
    #secret -- security returns (ndate x nsec)  
    #seccap -- security capitalizations (ndate x nsec)  
    ndate = 1511  
    (nobs, k) = np.shape(secdata)  
    nsec = nobs / ndate  
    secret = np.array(secdata.iloc[:, 1]).reshape(int(nsec), ndate)  
    seccap = np.array(secdata.iloc[:, 2]).reshape(int(nsec), ndate)  
  
    if begidx != None and endix != None:  
        secret = secret[begidx:endix, :]  
        seccap = seccap[begidx:endix, :]  
    if equalw == 1:  
        y = np.mean(secret[:,1:], axis = 0)  
        r = np.log(y + 1)  
        mktlev = np.exp(np.cumsum(r))*100  
        mktlev = np.concatenate((np.array([100]),mktlev))  
    else:  
        sumcap = np.sum(seccap, axis = 0)
```

```
mktlev = np.multiply(sumcap, 100) / sumcap[0]
return np.concatenate(([np.array([0])],np.subtract(np.divide(mktlev[1:], mktlev[0:-1]), 1)))
```

```
[119]: a = benchmark(secdata)
```

```
[337]: a
```

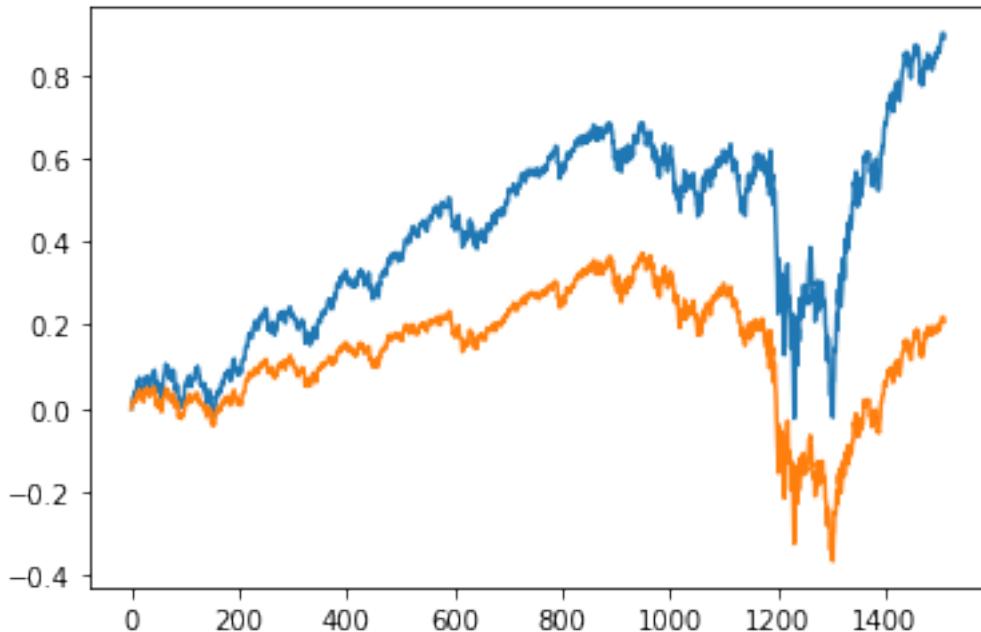
```
[337]: array([ 0.00000000e+00,  1.27829444e-02,  3.44514692e-03, ...,
   -9.74321641e-05,  5.97360688e-04, -1.04884904e-02])
```

```
[120]: len(a)
```

```
[120]: 1511
```

```
[351]: import matplotlib.pyplot as plt
plt.plot(list(np.cumsum(a)))
plt.plot(list(np.cumsum(ffdata['Market Returns'])))
```

```
[351]: [
```



```
[55]: np.cumsum(a)
```

```
[55]: array([0.00639946, 0.00812695, 0.01110043, ..., 0.46005679, 0.46044078,
 0.45350256])
```

```
[56]: a
```

```
[56]: array([ 6.39945927e-03,  1.72748654e-03,  2.97348619e-03, ...,
   -6.34373070e-05,  3.83992085e-04, -6.93821527e-03])
```

0.0.2 Problem 1 (b)

```
[57]: random_num_arr = np.random.randint(1877, size = 50)
```

```
[58]: seadata_50 = seadata.loc[seadata['Ticker'].isin(random_num_arr)]
seadata_50.head()
```

```
[58]:      Ticker  Returns  Market Cap
71017      48  0.026078  340597.62
71018      48  0.016618  346257.60
71019      48  0.028846  356245.80
71020      48  0.000935  356578.74
71021      48  0.048553  373891.62
```

```
[59]: max(seadata_50['Ticker'])
```

```
[59]: 1846
```

```
[60]: (nobs, k) = np.shape(seadata)
```

```
[61]: len(np.array(seadata.iloc[:, 1]).reshape(int(nobs/1511), 1511))
```

```
[61]: 1877
```

```
[126]: def benchmark_50(seadata, begidx = 0, endix = 1511, equalw = 1):
    # inputs:
    # seadata -- matrix of security data (ndate*nsec x 3)
    #           #column 1: integer security id
    #           #column 2: security return
    #           #column 3: security market capitalization
    #begidx -- beginning index (corresponding to a date)
    #          #of security data to process, if empty all dates
    #          #are processed
    #endidx -- ending index (corresponding to a date)
    #          #of security data to process, if empty all dates
    #          #are processed
    #equalw -- 1 = equally weighted returns
    #          #0 = capitalization weighted returns

    #outputs:
    #mktlev -- imputed market level (ndate x 1)
    #mktret -- imputed market return (ndate x 1)
```

```

#secret -- security returns (ndate x nsec)
#seccap -- security capitalizations (ndate x nsec)
ndate = 1511
(nobs, k) = np.shape(secdata)
nsec = nobs / ndate
secret = np.array(secdata.iloc[:, 1]).reshape(int(nsec), ndate)
seccap = np.array(secdata.iloc[:, 2]).reshape(int(nsec), ndate)

if equalw == 1:
    y = np.mean(secret[:,1:], axis = 0)
    r = np.log(y + 1)
    mktlev = np.exp(np.cumsum(r))*100
    mktlev = np.concatenate((np.array([100]),mktlev))
else:
    sumcap = np.sum(seccap, axis = 0)
    mktlev = np.multiply(sumcap, 100) / sumcap[0]
return np.concatenate((np.array([0]),np.subtract(np.divide(mktlev[1:], mktlev[0:-1]), 1)))

```

[63]: b = benchmark_50(secdata_50, equalw = 0)

[64]: b

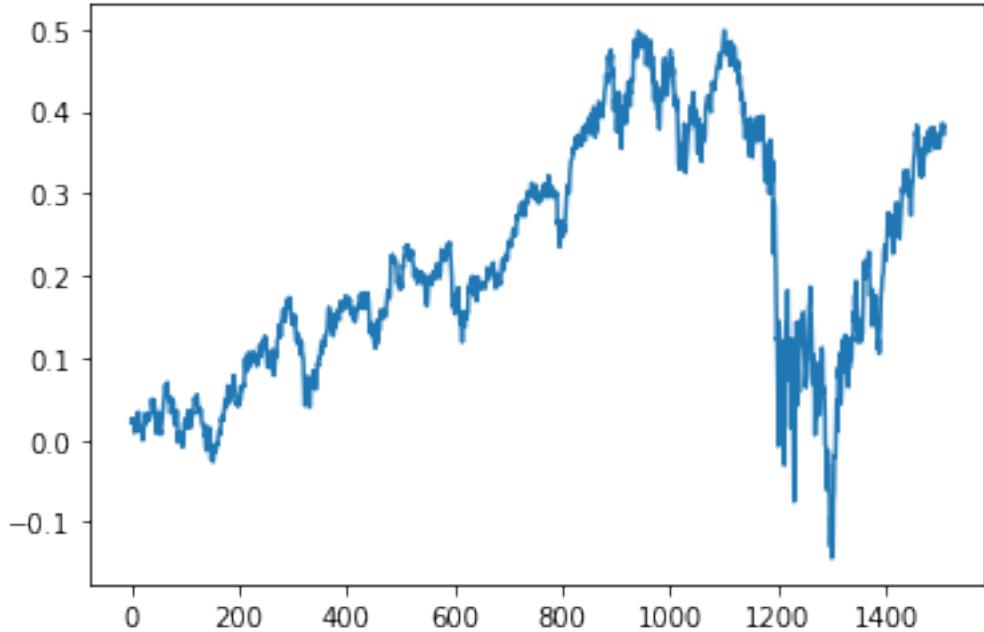
[64]: array([0.02222938, 0.0037195 , -0.00457966, ..., -0.00533613, 0.00311093, -0.01006329])

[65]: len(b)

[65]: 1510

[66]: plt.plot(list(np.cumsum(b)))

[66]: [`<matplotlib.lines.Line2D at 0x18d3fc87be0>`]



```
[67]: def RMSE (estimates, actuals):
        return np.sqrt(np.sum((actuals - estimates)**2) / len(estimates))
```

```
[68]: rnd_port_rmse = RMSE(b, a)
rnd_port_rmse
```

```
[68]: 0.009412637907763784
```

```
[69]: big_cap_ticker_arr = seadata.groupby("Ticker").mean().sort_values(by = "MarketCap", axis = 0, ascending = False).reset_index(drop=False)[['Ticker']][0:50]
```

```
[70]: seadata_50_big_cap = seadata.loc[seadata[['Ticker']].isin(big_cap_ticker_arr)]
seadata_50_big_cap.head()
```

```
[70]:   Ticker Returns Market Cap
7555      6 -0.004212  7847234.08
7556      6  0.041823  8175431.37
7557      6 -0.003608  8145930.49
7558      6  0.022635  8330310.99
7559      6  0.034086  8614256.96
```

```
[71]: c = benchmark_50(seadata_50_big_cap, equalw = 0)
c
```

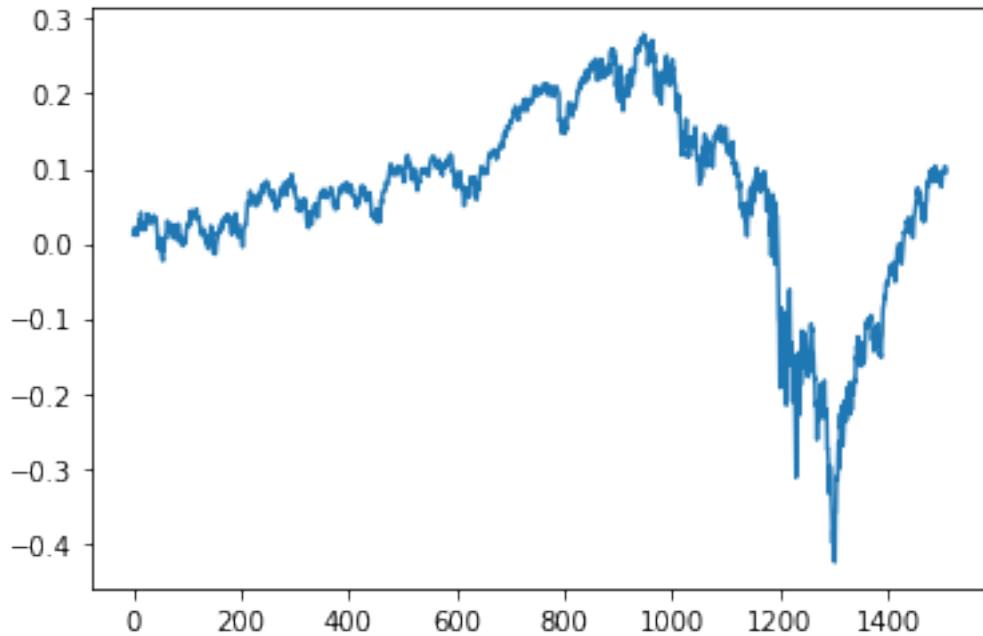
```
[71]: array([ 0.0129005 ,  0.00088549,  0.00315509, ..., -0.00100068,
       0.00027895, -0.0066524 ])
```

```
[122]: len(c)
```

```
[122]: 1510
```

```
[72]: plt.plot(list(np.cumsum(c)))
```

```
[72]: [
```



```
[73]: big_cap_port_rmse = RMSE(c, a)
big_cap_port_rmse
```

```
[73]: 0.006178845689182304
```

0.0.3 Problem 1 (C)

```
[74]: N = [10, 20, 30, 40, 50, 60, 70, 80, 90, 100]
```

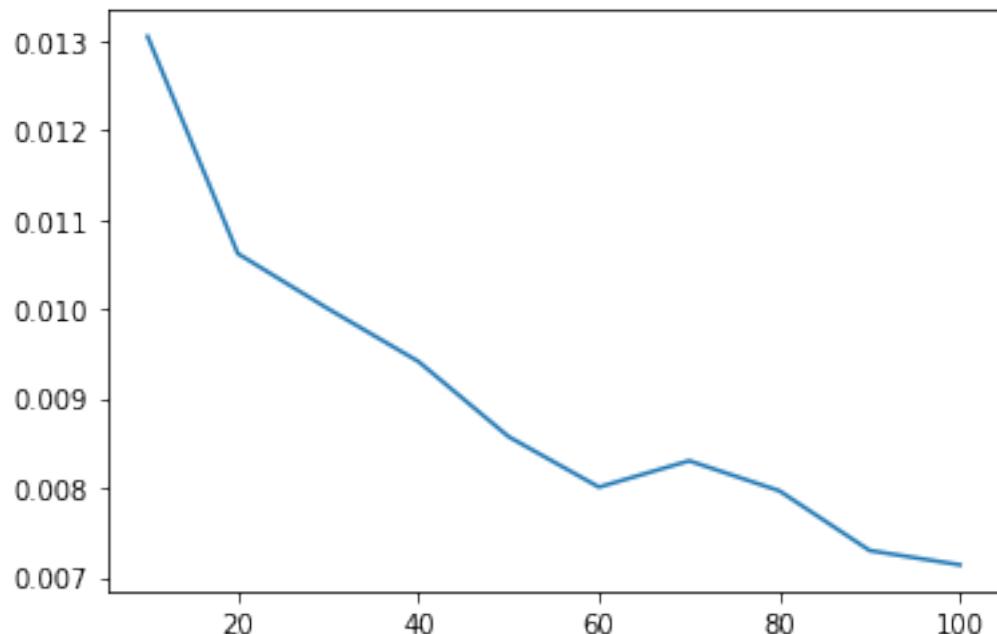
```
def mean_rmse_25(n):
    rmse = []
    for i in np.arange(25):
        random_num_arr = np.random.randint(1877, size = n)
        secdata_n = secdata.loc[secdata['Ticker'].isin(random_num_arr)]
        benchmark_n = benchmark_50(secdata_n, equalw = 0)
        rmse.append(RMSE(benchmark_n, a))
    return np.mean(rmse)
```

```
RMSE_result = []
for i in N:
    RMSE_result.append(mean_rmse_25(i))
RMSE_result
```

```
[74]: [0.013048874623342904,
0.010619402230173746,
0.010002261292308261,
0.009412900716445731,
0.008571121917512293,
0.008007531665750238,
0.008301732765943662,
0.007965239859548582,
0.007297700725015985,
0.007137555064368531]
```

```
[75]: plt.plot(N, RMSE_result)
```

```
[75]: [
```



The RMSE decreases as the number of securities increases. I choose $n = 90$ to do the additional testing.

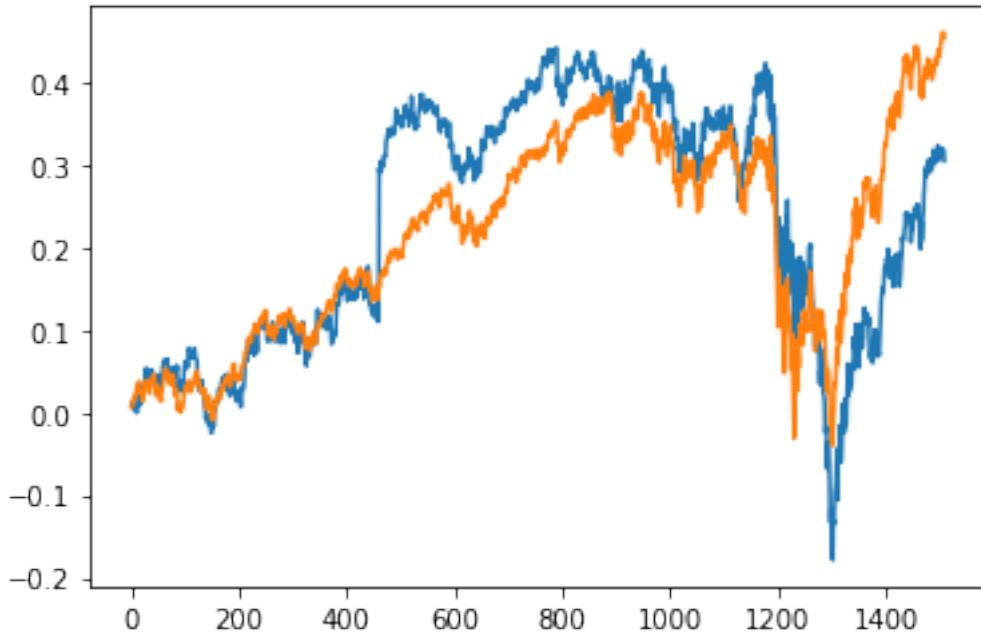
```
[76]: for i in np.arange(25):
    random_num_arr = np.random.randint(1877, size = 50)
```

```

secdata_n_50 = secdata.loc[secdata['Ticker'].isin(random_num_arr)]
benchmark_n_50 = benchmark_50(secdata_n_50, equalw = 0)
plt.plot(list(np.cumsum(benchmark_n_50)))
plt.plot(list(np.cumsum(a)))

```

[76]: [<matplotlib.lines.Line2D at 0x18d3fea8e10>]



0.0.4 Problem 1(d)

My heuristic approach is to find the stocks whose variance over the ndate window is similar to the overall variance of the market.

[77]: #Overall variance of the market
grouped_ticker_var = secdata.groupby("Ticker").var().reset_index(drop=False)
grouped_ticker_var.head()

	Ticker	Returns	Market Cap
0	1	0.000515	1.005023e+13
1	2	0.000994	6.440209e+13
2	3	0.001897	9.151436e+10
3	4	0.000888	3.753669e+09
4	5	0.000505	3.296720e+11

[78]: #The market variance of returns
market_ret_var = secdata.var().Returns

```
[79]: market_ret_var
```

```
[79]: 0.001111604368508923
```

```
[80]: grouped_ticker_var = grouped_ticker_var.loc[np.
    ↪abs(grouped_ticker_var['Returns'] - market_ret_var) < 0.000054]
grouped_ticker_var.head()
```

```
[80]:   Ticker  Returns  Market Cap
  34      35  0.001099  1.928441e+09
  47      48  0.001128  2.205419e+10
  96      97  0.001129  5.993275e+10
 104     105  0.001093  2.012605e+10
 118     119  0.001073  1.819244e+10
```

```
[81]: len(grouped_ticker_var)
```

```
[81]: 100
```

```
[82]: new_portfolio_ticker_100 = list(grouped_ticker_var['Ticker'])
new_portfolio_ticker_90 = np.random.choice(new_portfolio_ticker_100, 90)
new_portfolio_ticker_80 = np.random.choice(new_portfolio_ticker_100, 80)
new_portfolio_ticker_70 = np.random.choice(new_portfolio_ticker_100, 70)
new_portfolio_ticker_60 = np.random.choice(new_portfolio_ticker_100, 60)
new_portfolio_ticker_50 = np.random.choice(new_portfolio_ticker_100, 50)
new_portfolio_ticker_40 = np.random.choice(new_portfolio_ticker_100, 40)
new_portfolio_ticker_30 = np.random.choice(new_portfolio_ticker_100, 30)
new_portfolio_ticker_20 = np.random.choice(new_portfolio_ticker_100, 20)
new_portfolio_ticker_10 = np.random.choice(new_portfolio_ticker_100, 10)
```

```
[83]: secdata_100 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_100)].
    ↪reset_index(drop = True)
secdata_90 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_90)].
    ↪reset_index(drop = True)
secdata_80 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_80)].
    ↪reset_index(drop = True)
secdata_70 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_70)].
    ↪reset_index(drop = True)
secdata_60 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_60)].
    ↪reset_index(drop = True)
secdata_50 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_50)].
    ↪reset_index(drop = True)
secdata_40 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_40)].
    ↪reset_index(drop = True)
secdata_30 = secdata.loc[secdata['Ticker'].isin(new_portfolio_ticker_30)].
    ↪reset_index(drop = True)
```

```
secdatas_20 = secdatas.loc[secdatas['Ticker'].isin(new_portfolio_ticker_20)].  
    ↪reset_index(drop = True)  
secdatas_10 = secdatas.loc[secdatas['Ticker'].isin(new_portfolio_ticker_10)].  
    ↪reset_index(drop = True)
```

```
[123]: len(secdatas_10)
```

```
[123]: 15110
```

```
[356]: benchmark_100 = benchmark_50(secdatas_100, equalw = 0)
```

```
[357]: benchmark_90 = benchmark_50(secdatas_90, equalw = 0)
```

```
[358]: benchmark_80 = benchmark_50(secdatas_80, equalw = 0)
```

```
[359]: benchmark_70 = benchmark_50(secdatas_70, equalw = 0)
```

```
[360]: benchmark_60 = benchmark_50(secdatas_60, equalw = 0)
```

```
[361]: benchmark_50_ = benchmark_50(secdatas_50, equalw = 0)
```

```
[362]: benchmark_40 = benchmark_50(secdatas_40, equalw = 0)
```

```
[363]: benchmark_30 = benchmark_50(secdatas_30, equalw = 0)
```

```
[364]: benchmark_20 = benchmark_50(secdatas_20, equalw = 0)
```

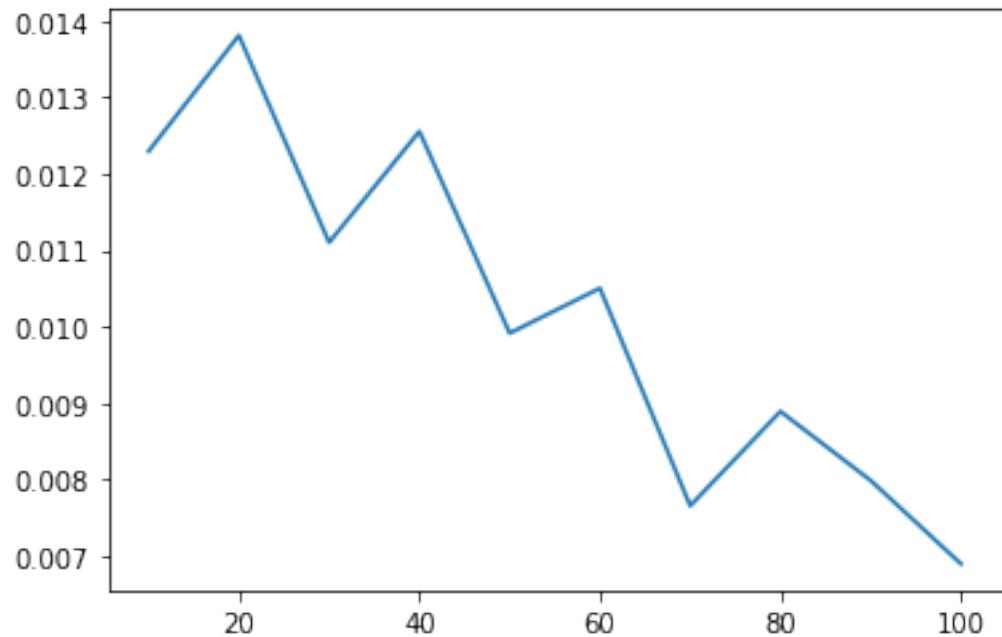
```
[365]: benchmark_10 = benchmark_50(secdatas_10, equalw = 0)
```

```
[366]: RMSE_result_1d = []  
benchmarks = [benchmark_10, benchmark_20, benchmark_30, benchmark_40,  
             benchmark_50_, benchmark_60, benchmark_70, benchmark_80,  
             benchmark_90, benchmark_100]  
for i in benchmarks:  
    RMSE_result_1d.append(RMSE(i, a))  
RMSE_result_1d
```

```
[366]: [0.012294070825620255,  
       0.013808204514422844,  
       0.011102221284784917,  
       0.0125540078021477,  
       0.009915842205140876,  
       0.010503238031608209,  
       0.007659314102361465,  
       0.00889324902359399,  
       0.007989999425878925,  
       0.006900411993275364]
```

```
[367]: plt.plot(N, RMSE_result_1d)
```

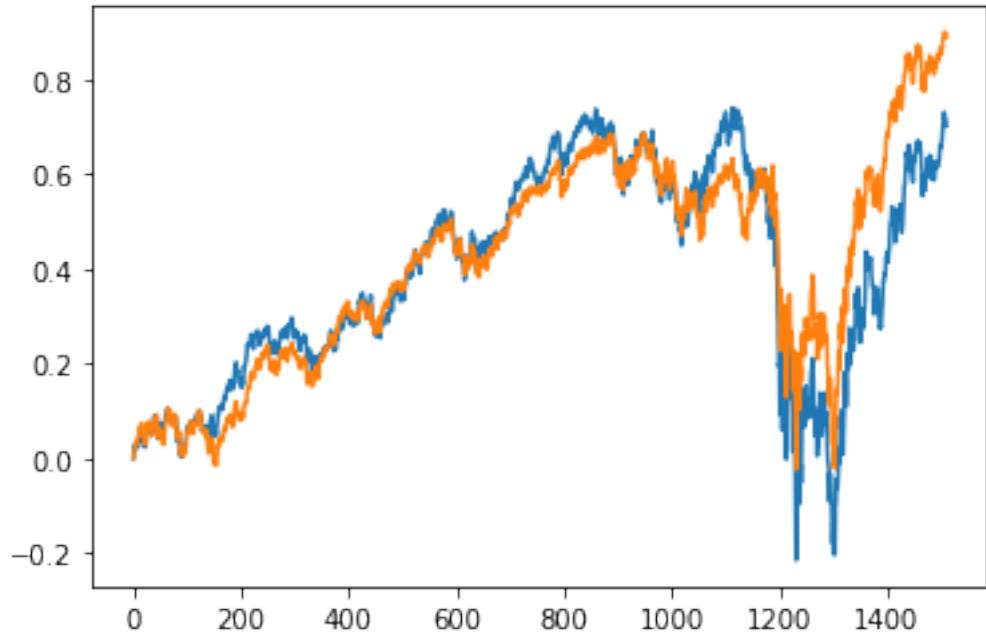
```
[367]: [
```



```
[369]: plt.plot(list(np.cumsum(benchmark_90)))
```

```
plt.plot(list(np.cumsum(a)))
```

```
[369]: [
```



0.0.5 Problem 2

Problem 2 (a)

```
[97]: rw = [504, 252, 126, 63]
```

```
[171]: # Pick 100 securities randomly
random_num_arr = np.random.choice(1877, size = 100, replace = False)
secdata_rnd_100 = secdata.loc[secdata['Ticker'].isin(random_num_arr)]
```

```
[172]: secdata_rnd_100.to_csv('secdata_rnd_100(1).csv')
```

```
[175]: secdata_rnd_100.head()
```

	Ticker	Returns	Market Cap
39286	27	0.077833	633097.80
39287	27	0.053931	667241.10
39288	27	-0.006938	662611.50
39289	27	-0.015284	652484.25
39290	27	-0.031486	631940.40

```
[370]: import numpy as np
from sklearn.linear_model import LinearRegression
import statsmodels.api as sm
from sklearn.metrics import mean_squared_error
```

```

stockSize = 1877
dateSize = 1511
ffMatrix = np.loadtxt('ffdata.txt', usecols=range(4))
secMatrix = np.loadtxt('secdta.txt', usecols=range(3))
secMatrix = secMatrix.reshape(stockSize, dateSize, 3)
stockList = np.genfromtxt('secdta_rnd_100(1).csv', delimiter=',', ↵
    skip_header=1)[:, 1]
stockListSet = {}
for Stockidx in stockList:
    stockListSet[int(Stockidx)] = 1
stockSize = 100

```

[371]:

```

def computeBetaAndidiosyncratic(startdate, enddate, stockNum):
    X = (ffMatrix[:, 0] - ffMatrix[:, 3])[startdate: enddate+1].reshape(-1, 1)
    y_true = (secMatrix[stockNum][:, 1] - ffMatrix[:, 3])[startdate: enddate+1].reshape(-1, 1)
    model = LinearRegression().fit(X, y_true)
    y_pred = model.predict(X)
    idiosyncratic = mean_squared_error(y_pred, y_true)
    beta = float(model.coef_)
    return beta, idiosyncratic

```

[372]:

```

def betaAndWeightAndidiosyncraticMatrix(windowSize):
    betaMatrixRes = np.zeros((dateSize - windowSize, stockSize))
    weightMatrix = np.zeros((dateSize - windowSize, stockSize))
    idiosyncraticMatrix = np.zeros((dateSize - windowSize, stockSize))
    for windowidx in range(dateSize - windowSize):
        idx = 0
        totalweight = 0
        for stockidx in stockListSet.keys():
            betaMatrixRes[windowidx][idx], idiosyncraticMatrix[windowidx][idx] = ↵
                computeBetaAndidiosyncratic(windowidx + 1, windowidx + windowSize, ↵
                stockidx)
            weightMatrix[windowidx][idx] = secMatrix[stockidx][windowidx + ↵
            windowSize][2]
            totalweight += weightMatrix[windowidx][idx]
            idx += 1
        for i in range(100):
            weightMatrix[windowidx][i] /= totalweight
    return betaMatrixRes, weightMatrix, idiosyncraticMatrix

```

[373]:

```

beta504, weight504, idiosyncratic504 = betaAndWeightAndidiosyncraticMatrix(504)
beta252, weight252, idiosyncratic252 = betaAndWeightAndidiosyncraticMatrix(252)
beta126, weight126, idiosyncratic126 = betaAndWeightAndidiosyncraticMatrix(126)
beta63, weight63, idiosyncratic63 = betaAndWeightAndidiosyncraticMatrix(63)

```

[374]:

```
weight504
```

```
[374]: array([[0.01081598, 0.00287169, 0.03510107, ..., 0.0070175 , 0.00151753,
   0.00102293],
 [0.01080765, 0.00281205, 0.03497511, ..., 0.00703494, 0.0015279 ,
  0.00101291],
 [0.01089566, 0.00282248, 0.03435014, ..., 0.00703282, 0.00153669,
  0.00101402],
 ...,
 [0.00920765, 0.00570466, 0.05880434, ..., 0.00983581, 0.0029951 ,
  0.00054646],
 [0.00924584, 0.00567889, 0.0586071 , ..., 0.00986037, 0.0029845 ,
  0.00054753],
 [0.00915414, 0.00561394, 0.05839392, ..., 0.00980836, 0.00296593,
  0.00055198]])
```

```
[375]: #rw = 504
rw_504 = {}
for i in seadata_rnd_100['Ticker'].unique():
    key = i
    value = list(seadata_rnd_100.loc[seadata_rnd_100['Ticker'] == i].Returns.
    →rolling(504).mean().dropna().reset_index(drop=True))[1:]
    rw_504[key] = value
```

```
[376]: rw504_df = pd.DataFrame.from_dict(rw_504, orient='index')
rw_504_cov = rw504_df.T.cov()
rw_504_cov
```

	27	73	114	116	120	\
27	2.685492e-07	5.079331e-07	1.680050e-07	5.413246e-08	-2.800955e-07	
73	5.079331e-07	2.062655e-06	1.511189e-07	1.142487e-07	-4.978759e-07	
114	1.680050e-07	1.511189e-07	3.218177e-07	7.201542e-08	-3.773878e-07	
116	5.413246e-08	1.142487e-07	7.201542e-08	1.452485e-07	-1.679087e-07	
120	-2.800955e-07	-4.978759e-07	-3.773878e-07	-1.679087e-07	8.881051e-07	
123	-3.630514e-09	1.809479e-07	-9.400559e-08	-1.029774e-07	3.530689e-07	
127	2.042172e-07	5.998209e-07	1.137366e-07	1.190849e-08	-2.334050e-07	
131	-1.425637e-07	-5.133512e-07	-7.282561e-08	-1.132103e-08	2.577304e-07	
167	1.369783e-07	1.958215e-07	1.653276e-07	5.979028e-08	-3.183643e-07	
184	6.004057e-08	-4.417967e-08	1.399117e-07	4.731676e-08	-1.786217e-07	
197	1.603344e-07	3.252570e-07	1.613124e-07	6.803790e-08	-3.071096e-07	
204	6.123371e-07	1.668574e-06	4.997087e-07	2.153369e-07	-1.172187e-06	
205	1.476990e-07	-7.157486e-08	2.981312e-07	1.509596e-07	-4.213116e-07	
221	4.349423e-07	1.111248e-06	3.691541e-07	2.094446e-07	-7.956261e-07	
227	1.375974e-07	3.803020e-07	8.083008e-08	2.779892e-08	-2.959927e-07	
243	-5.111976e-08	-3.098457e-07	1.346364e-08	2.830526e-08	6.379995e-08	
278	3.923822e-07	1.255216e-06	2.394191e-07	1.822965e-07	-6.952119e-07	
299	3.182821e-08	-7.265603e-08	3.975934e-08	6.729993e-08	-7.544609e-08	
300	-1.179394e-08	-1.364092e-07	5.221292e-08	-2.858025e-08	8.624222e-08	
327	1.660739e-07	-4.443237e-07	6.191814e-07	3.834658e-07	-9.094778e-07	

330	-9.171981e-08	-1.507109e-07	-1.831042e-07	-1.238986e-07	3.325170e-07	
359	1.756015e-07	5.028155e-07	1.604475e-07	9.922636e-08	-4.065111e-07	
367	6.970493e-08	3.375445e-07	-9.248148e-08	-7.673628e-08	1.850299e-07	
374	1.474891e-07	5.356364e-07	9.144652e-08	1.231856e-07	-3.533155e-07	
376	1.314410e-07	2.625378e-07	1.875391e-07	1.023895e-07	-3.856333e-07	
380	1.666385e-07	4.359016e-07	1.778782e-07	3.697980e-08	-3.076647e-07	
412	2.316642e-07	3.744022e-07	3.221226e-07	1.397060e-07	-5.802077e-07	
448	1.299711e-07	4.129501e-07	9.490782e-08	7.041504e-08	-2.626653e-07	
449	9.124082e-08	4.165773e-07	2.368465e-08	2.277777e-08	-1.357620e-07	
472	-7.609166e-08	-4.794735e-08	-1.392292e-07	-4.839517e-08	2.477758e-07	
...	
1484	1.262495e-08	5.152029e-07	-2.449210e-07	-2.121067e-07	4.046963e-07	
1487	2.857321e-07	5.960413e-07	3.387659e-07	1.696532e-07	-6.190492e-07	
1493	1.546938e-07	3.365761e-07	1.477661e-07	3.401393e-08	-2.702833e-07	
1505	5.522589e-07	1.384054e-06	4.302924e-07	1.708752e-07	-1.036154e-06	
1506	1.461704e-07	2.677167e-07	1.673580e-07	7.393295e-08	-3.306398e-07	
1512	1.288864e-07	4.141998e-07	7.199301e-08	2.145392e-08	-1.594435e-07	
1564	2.086183e-07	-2.929150e-07	5.851177e-07	2.749168e-07	-8.038614e-07	
1571	9.001158e-08	1.110658e-07	1.369834e-07	6.168532e-08	-2.573519e-07	
1588	2.599158e-07	4.996726e-07	4.445812e-07	2.298631e-07	-8.481617e-07	
1600	-8.309931e-08	-2.576354e-07	-7.343841e-08	4.304340e-09	2.963187e-07	
1620	1.213201e-07	4.968026e-08	2.368093e-07	1.064686e-07	-3.414840e-07	
1657	9.896319e-08	-2.563848e-07	2.324415e-07	1.542633e-07	-2.797921e-07	
1667	6.780741e-08	1.019117e-06	-4.106341e-07	-1.428347e-07	5.501539e-07	
1670	1.165586e-07	4.223224e-07	5.687341e-08	1.493424e-08	-1.605790e-07	
1672	2.940797e-07	6.877988e-07	3.123247e-07	1.325094e-07	-6.380523e-07	
1679	1.029398e-07	3.856253e-07	4.789700e-08	2.536115e-08	-1.841825e-07	
1681	2.232349e-07	3.987029e-07	2.988231e-07	1.928850e-07	-4.895081e-07	
1688	2.373057e-07	5.445698e-07	2.169684e-07	6.747797e-08	-3.437023e-07	
1690	1.243806e-07	-2.843752e-07	2.579622e-07	2.288411e-07	-3.349213e-07	
1694	5.962648e-07	1.151302e-06	6.727147e-07	2.014327e-07	-1.412284e-06	
1704	3.217833e-07	5.015361e-07	4.040630e-07	1.135621e-07	-7.660951e-07	
1721	1.507763e-07	2.379275e-08	2.455002e-07	1.440208e-07	-4.143489e-07	
1725	8.717274e-08	9.415990e-08	1.444113e-07	8.974527e-08	-3.071307e-07	
1744	-7.645601e-08	-3.991985e-07	3.089498e-08	2.412659e-08	1.800054e-07	
1775	8.230445e-08	8.564759e-11	6.950851e-08	9.266779e-08	-1.546060e-07	
1780	1.788931e-07	2.684501e-07	2.256122e-07	4.540349e-08	-3.709566e-07	
1782	3.181797e-07	6.853718e-07	3.331948e-07	9.686395e-08	-6.174481e-07	
1803	7.823660e-08	2.989466e-07	-5.469018e-08	2.564165e-08	1.890476e-08	
1814	3.263270e-07	5.900857e-07	3.839839e-07	1.960077e-07	-7.255856e-07	
1835	2.148100e-07	4.380064e-07	2.689338e-07	1.621223e-07	-6.197817e-07	
	123	127	131	167	184	\
27	-3.630514e-09	2.042172e-07	-1.425637e-07	1.369783e-07	6.004057e-08	
73	1.809479e-07	5.998209e-07	-5.133512e-07	1.958215e-07	-4.417967e-08	
114	-9.400559e-08	1.137366e-07	-7.282561e-08	1.653276e-07	1.399117e-07	
116	-1.029774e-07	1.190849e-08	-1.132103e-08	5.979028e-08	4.731676e-08	

120	3.530689e-07	-2.334050e-07	2.577304e-07	-3.183643e-07	-1.786217e-07	
123	5.369387e-07	1.223457e-08	8.917249e-08	-1.452217e-07	-5.954692e-08	
127	1.223457e-08	2.530210e-07	-1.784121e-07	1.096578e-07	1.677683e-08	
131	8.917249e-08	-1.784121e-07	2.353576e-07	-1.090656e-07	3.785115e-08	
167	-1.452217e-07	1.096578e-07	-1.090656e-07	1.818124e-07	5.000719e-08	
184	-5.954692e-08	1.677683e-08	3.785115e-08	5.000719e-08	1.490619e-07	
197	-4.383807e-08	1.267980e-07	-8.774144e-08	1.032264e-07	9.700983e-08	
204	-2.724752e-07	6.106302e-07	-5.921301e-07	5.122958e-07	1.277141e-07	
205	-4.054732e-08	2.458104e-08	1.092888e-07	1.157284e-07	2.713478e-07	
221	-6.889780e-08	3.718375e-07	-2.612546e-07	2.098245e-07	2.612944e-07	
227	7.982972e-09	1.387962e-07	-1.335582e-07	1.055297e-07	2.247444e-08	
243	-8.430325e-10	-9.982572e-08	1.347261e-07	-2.739922e-08	6.258337e-08	
278	-1.754904e-07	3.922934e-07	-4.048843e-07	2.718322e-07	5.501199e-08	
299	4.294122e-08	-2.607479e-08	8.610696e-08	-1.432525e-08	8.801089e-08	
300	1.271525e-07	-2.300105e-08	7.868713e-08	-1.509516e-08	2.602490e-08	
327	-4.840801e-07	-6.503649e-08	1.461338e-07	3.142827e-07	4.681571e-07	
330	2.296830e-07	-5.456723e-08	8.618169e-08	-1.222323e-07	-8.055362e-08	
359	-2.217180e-07	1.635861e-07	-2.459481e-07	2.073662e-07	7.771057e-09	
367	2.458202e-07	1.040475e-07	-5.282311e-08	-6.599261e-08	-8.759534e-08	
374	-8.293440e-08	1.478105e-07	-1.577792e-07	9.091798e-08	4.644244e-08	
376	-1.117226e-07	1.033641e-07	-1.081405e-07	1.054801e-07	1.084718e-07	
380	1.013620e-08	1.714499e-07	-1.372985e-07	9.482016e-08	7.948666e-08	
412	-2.570304e-07	1.835563e-07	-1.669051e-07	2.728208e-07	1.418347e-07	
448	-1.020422e-07	1.326821e-07	-1.466996e-07	1.197311e-07	2.099706e-08	
449	-1.811080e-08	1.320322e-07	-1.428644e-07	5.126388e-08	-3.062225e-08	
472	1.871026e-07	-5.502776e-08	9.076266e-08	-1.344301e-07	-2.266853e-08	
...
1484	5.017824e-07	1.410319e-07	-7.991353e-08	-1.812356e-07	-1.724623e-07	
1487	-2.279034e-07	2.360548e-07	-2.358594e-07	2.916035e-07	1.130241e-07	
1493	-5.572201e-08	1.478846e-07	-1.260411e-07	1.082332e-07	5.753910e-08	
1505	-2.285699e-07	5.122996e-07	-4.763048e-07	3.922518e-07	2.055336e-07	
1506	-9.499904e-08	1.163370e-07	-9.334448e-08	1.423066e-07	9.153677e-08	
1512	3.447686e-08	1.387470e-07	-1.092562e-07	4.368909e-08	2.435873e-08	
1564	-2.326862e-07	-3.191875e-08	1.227262e-07	2.800354e-07	4.406145e-07	
1571	-1.653598e-07	7.596969e-08	-8.053247e-08	1.062439e-07	6.731441e-08	
1588	-5.369287e-07	2.376257e-07	-3.185505e-07	4.001696e-07	1.428846e-07	
1600	2.616427e-07	-1.131929e-07	2.615988e-07	-1.934951e-07	1.017403e-07	
1620	-1.343879e-07	5.621716e-08	-1.624238e-08	1.514625e-07	1.460432e-07	
1657	8.415116e-08	-6.382503e-08	1.941566e-07	6.728760e-09	2.713924e-07	
1667	5.458085e-07	2.176714e-07	-1.581148e-07	-2.453906e-07	-2.832388e-07	
1670	4.665937e-08	1.435025e-07	-1.091823e-07	4.015153e-08	2.216614e-08	
1672	-2.433315e-07	2.743774e-07	-2.633108e-07	2.705944e-07	1.234372e-07	
1679	4.312116e-08	1.251196e-07	-9.772917e-08	1.176792e-08	3.498365e-08	
1681	-1.600938e-07	1.356748e-07	-6.853496e-08	2.153453e-07	1.838213e-07	
1688	9.539516e-08	2.104255e-07	-1.108145e-07	1.443260e-07	9.253439e-08	
1690	-2.335527e-08	-7.806033e-08	2.541828e-07	5.178599e-08	3.342792e-07	
1694	-4.413361e-07	5.253718e-07	-5.469470e-07	6.266520e-07	2.316620e-07	

1704	-3.347602e-07	2.657219e-07	-2.404000e-07	3.301909e-07	2.324737e-07
1721	-2.165988e-07	4.522690e-08	-1.323721e-08	1.855091e-07	1.604304e-07
1725	-1.312135e-07	4.408219e-08	-5.674632e-08	1.170162e-07	8.338133e-08
1744	1.000120e-07	-1.304259e-07	1.981098e-07	-1.018762e-07	9.403575e-08
1775	1.135905e-08	-2.945317e-09	9.709644e-08	1.825091e-08	1.557440e-07
1780	-5.549165e-08	1.443468e-07	-1.106474e-07	1.645039e-07	9.797738e-08
1782	-1.439938e-08	2.782784e-07	-1.885366e-07	2.286844e-07	1.855448e-07
1803	2.042636e-07	6.286460e-08	1.626829e-08	-3.206067e-08	-1.126067e-09
1814	-1.855981e-07	2.453185e-07	-1.527317e-07	2.593480e-07	2.557030e-07
1835	-1.622241e-07	1.706207e-07	-1.322219e-07	2.032507e-07	1.858340e-07

		1704	1721	1725	1744	\
27	...	3.217833e-07	1.507763e-07	8.717274e-08	-7.645601e-08	
73	...	5.015361e-07	2.379275e-08	9.415990e-08	-3.991985e-07	
114	...	4.040630e-07	2.455002e-07	1.444113e-07	3.089498e-08	
116	...	1.135621e-07	1.440208e-07	8.974527e-08	2.412659e-08	
120	...	-7.660951e-07	-4.143489e-07	-3.071307e-07	1.800054e-07	
123	...	-3.347602e-07	-2.165988e-07	-1.312135e-07	1.000120e-07	
127	...	2.657219e-07	4.522690e-08	4.408219e-08	-1.304259e-07	
131	...	-2.404000e-07	-1.323721e-08	-5.674632e-08	1.981098e-07	
167	...	3.301909e-07	1.855091e-07	1.170162e-07	-1.018762e-07	
184	...	2.324737e-07	1.604304e-07	8.338133e-08	9.403575e-08	
197	...	3.106818e-07	1.620201e-07	1.278219e-07	7.696033e-09	
204	...	1.162056e-06	4.712165e-07	3.740504e-07	-4.756498e-07	
205	...	3.496934e-07	4.134642e-07	2.180634e-07	2.265838e-07	
221	...	7.351716e-07	4.023111e-07	3.168191e-07	-1.944008e-08	
227	...	2.352872e-07	8.885304e-08	1.068925e-07	-1.354996e-07	
243	...	-4.918322e-08	6.289330e-08	5.076321e-09	1.352748e-07	
278	...	6.716824e-07	2.519831e-07	2.408151e-07	-2.975955e-07	
299	...	1.825050e-08	9.435294e-08	5.961444e-08	1.324887e-07	
300	...	-6.118130e-08	2.765505e-08	7.330054e-09	1.511577e-07	
327	...	8.133261e-07	8.379526e-07	4.635426e-07	3.684885e-07	
330	...	-2.938193e-07	-2.253617e-07	-1.158631e-07	3.013006e-08	
359	...	4.359551e-07	1.433594e-07	1.482022e-07	-2.193138e-07	
367	...	-1.391177e-07	-1.704999e-07	-8.076166e-08	-1.994776e-08	
374	...	2.946077e-07	1.198968e-07	1.361606e-07	-7.945367e-08	
376	...	3.511550e-07	1.618900e-07	1.710001e-07	2.592537e-08	
380	...	2.993205e-07	1.057035e-07	1.056636e-07	-2.409425e-08	
412	...	6.139735e-07	3.599772e-07	2.222360e-07	-9.059599e-08	
448	...	2.761463e-07	1.090844e-07	9.281493e-08	-1.228885e-07	
449	...	1.195211e-07	-1.303228e-08	2.877728e-08	-1.237245e-07	
472	...	-2.468595e-07	-1.626196e-07	-7.711623e-08	7.123008e-08	
...	
1484	...	-3.540644e-07	-4.224206e-07	-1.913601e-07	-6.613279e-08	
1487	...	6.571132e-07	3.481302e-07	2.368350e-07	-1.133310e-07	
1493	...	2.941282e-07	1.162656e-07	9.115294e-08	-5.409963e-08	
1505	...	1.081838e-06	4.554438e-07	3.791977e-07	-2.773749e-07	

1506	...	3.482805e-07	1.864385e-07	1.342874e-07	-3.945297e-08		
1512	...	1.458740e-07	3.712618e-08	5.111043e-08	-4.029532e-08		
1564	...	7.709700e-07	7.195059e-07	4.649649e-07	4.127136e-07		
1571	...	3.023233e-07	1.329550e-07	1.052170e-07	3.012082e-09		
1588	...	9.109882e-07	4.562925e-07	3.199982e-07	-1.716671e-07		
1600	...	-3.529997e-07	-3.464860e-08	-6.041689e-08	3.258233e-07		
1620	...	3.534825e-07	2.752116e-07	1.505482e-07	5.641817e-08		
1657	...	1.197419e-07	3.430432e-07	2.005350e-07	3.693039e-07		
1667	...	-5.832497e-07	-5.256931e-07	-2.836850e-07	-1.825537e-07		
1670	...	1.554852e-07	2.589134e-08	5.164734e-08	-6.837948e-08		
1672	...	6.616867e-07	3.117981e-07	2.204917e-07	-1.673121e-07		
1679	...	1.188432e-07	1.368916e-08	5.181477e-08	-3.749439e-08		
1681	...	5.122283e-07	4.234380e-07	2.267905e-07	2.848121e-08		
1688	...	2.787273e-07	1.681595e-07	1.143803e-07	-7.986523e-08		
1690	...	2.871436e-07	4.770794e-07	2.232504e-07	3.833503e-07		
1694	...	1.369464e-06	6.347937e-07	4.962036e-07	-4.487331e-07		
1704	...	9.876029e-07	4.311901e-07	2.824976e-07	-1.046576e-07		
1721	...	4.311901e-07	4.022798e-07	1.964534e-07	5.825680e-08		
1725	...	2.824976e-07	1.964534e-07	1.600639e-07	1.972488e-09		
1744	...	-1.046576e-07	5.825680e-08	1.972488e-09	3.653629e-07		
1775	...	1.878044e-07	2.015754e-07	1.233444e-07	1.647591e-07		
1780	...	4.055151e-07	2.063932e-07	1.458645e-07	-1.867845e-08		
1782	...	6.173225e-07	3.104917e-07	2.368767e-07	-5.836181e-08		
1803	...	-9.750434e-08	-4.129196e-09	6.033824e-10	-1.633077e-08		
1814	...	7.021382e-07	4.453440e-07	2.901579e-07	-1.239598e-08		
1835	...	5.289873e-07	3.062166e-07	2.554062e-07	-6.403621e-08		
		1775	1780	1782	1803	1814	\
27	8.230445e-08	1.788931e-07	3.181797e-07	7.823660e-08	3.263270e-07		
73	8.564759e-11	2.684501e-07	6.853718e-07	2.989466e-07	5.900857e-07		
114	6.950851e-08	2.256122e-07	3.331948e-07	-5.469018e-08	3.839839e-07		
116	9.266779e-08	4.540349e-08	9.686395e-08	2.564165e-08	1.960077e-07		
120	-1.546060e-07	-3.709566e-07	-6.174481e-07	1.890476e-08	-7.255856e-07		
123	1.135905e-08	-5.549165e-08	-1.439938e-08	2.042636e-07	-1.855981e-07		
127	-2.945317e-09	1.443468e-07	2.782784e-07	6.286460e-08	2.453185e-07		
131	9.709644e-08	-1.106474e-07	-1.885366e-07	1.626829e-08	-1.527317e-07		
167	1.825091e-08	1.645039e-07	2.286844e-07	-3.206067e-08	2.593480e-07		
184	1.557440e-07	9.797738e-08	1.855448e-07	-1.126067e-09	2.557030e-07		
197	1.687277e-07	1.952081e-07	3.389895e-07	7.687899e-08	3.794883e-07		
204	1.561911e-07	6.083599e-07	1.080511e-06	1.760141e-07	1.118560e-06		
205	4.848441e-07	2.812618e-07	5.409824e-07	2.149497e-07	7.150457e-07		
221	4.868376e-07	4.276885e-07	9.402930e-07	3.139804e-07	1.080997e-06		
227	1.115622e-07	1.681830e-07	3.285218e-07	1.415637e-07	2.992479e-07		
243	9.290272e-08	-2.951494e-08	-6.588397e-08	-1.375119e-08	-9.241893e-09		
278	1.273061e-07	3.218166e-07	6.436909e-07	1.472488e-07	6.953629e-07		
299	2.154951e-07	4.698709e-08	1.126549e-07	1.098035e-07	1.819492e-07		
300	5.447565e-08	5.056096e-08	4.629486e-08	2.846883e-08	2.014837e-08		

327	5.880417e-07	4.410305e-07	6.788087e-07	-3.596270e-08	1.082830e-06
330	-2.950201e-08	-1.078864e-07	-1.775955e-07	6.460624e-08	-2.929954e-07
359	-1.030451e-07	1.327834e-07	1.940197e-07	-1.258454e-07	2.133576e-07
367	-3.398741e-08	-1.178323e-08	-9.185991e-09	1.178977e-07	-1.228727e-07
374	1.189816e-07	1.427952e-07	2.988749e-07	8.548705e-08	3.404756e-07
376	1.311215e-07	1.819788e-07	3.097443e-07	-8.151532e-09	3.669862e-07
380	9.775315e-08	2.038595e-07	3.718613e-07	7.101879e-08	3.656981e-07
412	1.187474e-07	2.967053e-07	4.574025e-07	-3.646209e-08	5.540106e-07
448	1.481515e-08	1.089790e-07	2.078142e-07	5.902423e-09	2.307466e-07
449	-4.892836e-08	5.633958e-08	1.191213e-07	1.949167e-08	8.779492e-08
472	4.815283e-08	-1.134847e-07	-1.181869e-07	8.400813e-08	-1.596672e-07
...
1484	-1.054287e-07	-7.324776e-08	-4.658764e-08	2.067655e-07	-3.044039e-07
1487	5.594744e-08	3.069017e-07	4.537128e-07	-6.687668e-08	5.209131e-07
1493	5.597284e-08	1.635640e-07	2.732108e-07	2.151994e-08	2.781295e-07
1505	3.162603e-07	5.505906e-07	1.036491e-06	1.896211e-07	1.087507e-06
1506	1.204642e-07	1.813257e-07	2.992032e-07	1.995414e-08	3.408602e-07
1512	6.758519e-08	1.080395e-07	2.288416e-07	8.825837e-08	2.195112e-07
1564	6.392268e-07	4.878678e-07	7.928196e-07	4.329973e-08	1.037135e-06
1571	3.705942e-08	1.255485e-07	1.446017e-07	-8.754958e-08	2.031189e-07
1588	-2.270549e-08	3.746773e-07	4.801529e-07	-2.627896e-07	6.323669e-07
1600	3.055221e-07	-8.015170e-08	2.322599e-08	2.356794e-07	8.291734e-08
1620	1.421906e-07	1.828867e-07	2.848802e-07	-1.832606e-08	3.787889e-07
1657	5.246963e-07	2.078735e-07	4.423996e-07	2.677174e-07	6.057583e-07
1667	-1.531927e-07	-2.072590e-07	-1.526878e-07	3.579066e-07	-3.631767e-07
1670	7.390873e-08	1.038166e-07	2.477702e-07	1.131661e-07	2.199337e-07
1672	1.018411e-07	3.153779e-07	5.332208e-07	2.812643e-09	6.112586e-07
1679	1.137267e-07	1.091934e-07	2.543554e-07	1.446944e-07	2.610500e-07
1681	2.612769e-07	2.578930e-07	4.824444e-07	7.681947e-08	6.130508e-07
1688	1.400870e-07	2.186851e-07	4.660786e-07	2.000001e-07	4.614320e-07
1690	6.484476e-07	2.150248e-07	4.530790e-07	2.830257e-07	7.254030e-07
1694	1.996708e-07	7.346640e-07	1.186657e-06	4.534911e-08	1.244277e-06
1704	1.878044e-07	4.055151e-07	6.173225e-07	-9.750434e-08	7.021382e-07
1721	2.015754e-07	2.063932e-07	3.104917e-07	-4.129196e-09	4.453440e-07
1725	1.233444e-07	1.458645e-07	2.368767e-07	6.033824e-10	2.901579e-07
1744	1.647591e-07	-1.867845e-08	-5.836181e-08	-1.633077e-08	-1.239598e-08
1775	4.366875e-07	1.344541e-07	2.999937e-07	1.887138e-07	3.810762e-07
1780	1.344541e-07	2.704242e-07	3.890898e-07	3.459080e-08	3.931093e-07
1782	2.999937e-07	3.890898e-07	7.473319e-07	1.841676e-07	7.476646e-07
1803	1.887138e-07	3.459080e-08	1.841676e-07	3.016667e-07	1.671244e-07
1814	3.810762e-07	3.931093e-07	7.476646e-07	1.671244e-07	9.295048e-07
1835	2.792747e-07	2.810839e-07	5.679459e-07	1.215521e-07	6.700856e-07

1835

27	2.148100e-07
73	4.380064e-07
114	2.689338e-07

116	1.621223e-07
120	-6.197817e-07
123	-1.622241e-07
127	1.706207e-07
131	-1.322219e-07
167	2.032507e-07
184	1.858340e-07
197	2.775892e-07
204	8.533898e-07
205	4.937685e-07
221	8.090251e-07
227	2.609788e-07
243	-1.082818e-08
278	5.618240e-07
299	1.572912e-07
300	-3.025635e-08
327	8.063394e-07
330	-2.037219e-07
359	2.468625e-07
367	-1.192168e-07
374	3.042032e-07
376	3.352496e-07
380	2.609689e-07
412	4.103750e-07
448	1.888296e-07
449	8.675943e-08
472	-8.767544e-08
...	...
1484	-2.569385e-07
1487	4.124941e-07
1493	1.962458e-07
1505	8.456459e-07
1506	2.673264e-07
1512	1.570106e-07
1564	7.949418e-07
1571	1.598244e-07
1588	5.034298e-07
1600	-3.486858e-09
1620	2.752575e-07
1657	4.444623e-07
1667	-3.273407e-07
1670	1.734006e-07
1672	4.614710e-07
1679	2.074201e-07
1681	4.275731e-07
1688	3.499035e-07
1690	4.933126e-07

```
1694  9.971678e-07
1704  5.289873e-07
1721  3.062166e-07
1725  2.554062e-07
1744  -6.403621e-08
1775  2.792747e-07
1780  2.810839e-07
1782  5.679459e-07
1803  1.215521e-07
1814  6.700856e-07
1835  6.083722e-07
```

[100 rows x 100 columns]

```
[377]: np.shape(rw_504_cov)
```

```
[377]: (100, 100)
```

```
[378]: port_std_504 = []
for i in np.arange(len(weight504)):
    port_std_504.append(np.sqrt(weight504[i] @ rw_504_cov.to_numpy() @
                                weight504[i].T))
port_std_504
```

```
[378]: [0.0004844218888482598,
0.00048525596450900074,
0.00048704420225640125,
0.00048391579969528744,
0.00048198462191479936,
0.00048119317317854435,
0.00048163521633497685,
0.00048160220261562743,
0.00047941016992677056,
0.00047942635649621224,
0.00047950585530276896,
0.00047960212850662324,
0.000478533824858922,
0.00047759694479352873,
0.0004791763478934534,
0.0004802084384122258,
0.00047999548077584854,
0.0004804773035762073,
0.00048197811254850235,
0.0004827764619308019,
0.0004883245552306301,
0.0004900433938042697,
0.000492826338734277,
```

0.0004926308362497684,
0.0004934872984041935,
0.0004943926521866412,
0.0004924892433878827,
0.0004927420766396197,
0.0004926698880048495,
0.0004915830290773454,
0.0004900569137924639,
0.0004891492343802224,
0.0004865175454089452,
0.00048535571947055575,
0.00048412650804484245,
0.00048313241782032765,
0.00048174593547371846,
0.00048292916911613315,
0.0004792098453786307,
0.00047853436781088616,
0.00047853261900630763,
0.00047950106542992663,
0.00047974914111469476,
0.00048048640741208944,
0.00048114611757426353,
0.0004811555549066849,
0.00048091937815958807,
0.00047944969346126455,
0.0004781049305388196,
0.00047661615911668453,
0.00047436762951172146,
0.0004742313464244733,
0.00047548222692659405,
0.0004754901923586132,
0.00047532394414555936,
0.00047487367036506213,
0.00047318051652782503,
0.00047209565223773107,
0.0004709032764056962,
0.0004700529186188509,
0.0004715153082362738,
0.00047207566082429396,
0.0004717692829208178,
0.0004711297584493296,
0.0004696761274953951,
0.00046706848154936983,
0.00046768586105090773,
0.00046925029729702277,
0.0004697013813496044,
0.0004696045921867622,

0.0004707939841653123,
0.00046967831205980065,
0.0004693265209698596,
0.00046825363546512336,
0.0004676981154185181,
0.0004650451123454835,
0.0004659217963427005,
0.0004673120988536928,
0.0004674096332143892,
0.000471070347453676,
0.0004705547487393862,
0.0004705532072023362,
0.0004699259751747132,
0.00046836393495760403,
0.00046739183928813324,
0.0004655374239505184,
0.00046446119852944017,
0.0004644526713084116,
0.00046602177977480576,
0.00046828473152362094,
0.00047166564642758157,
0.00047235337700102194,
0.00047360760576407927,
0.0004764558984225017,
0.0004762421440232124,
0.00047637803013123655,
0.0004775892714398949,
0.0004774761793936023,
0.00047782086809318637,
0.0004767752639786493,
0.0004758987562132272,
0.0004761729868535885,
0.0004676441013104382,
0.00046784445060990684,
0.00046851515927394757,
0.0004706553421197629,
0.00047266685438766625,
0.00047559653605414086,
0.00047325337028526646,
0.00047364846828979254,
0.0004738663115198813,
0.0004729882616517084,
0.00047197982271086723,
0.00047025001544119343,
0.0004698111772361182,
0.0004729130963249601,
0.0004729328451948543,

0.0004723396642290309,
0.00047181612975946116,
0.00046985109157342985,
0.00047065754304254873,
0.0004706484511008874,
0.0004704878808362527,
0.00046836564546703496,
0.0004683752576662914,
0.0004677130154071231,
0.00046725152518716645,
0.00046581747511513857,
0.0004693778951819923,
0.0004686758260216652,
0.0004671172544992482,
0.00046716373198779523,
0.0004658671677812575,
0.00046509798863097145,
0.00046517206939960664,
0.000466387849106604,
0.00046665804375033273,
0.0004670189562716094,
0.00046793223830432235,
0.0004672298660019981,
0.0004690064750832787,
0.00046692040193095294,
0.00046694240668377447,
0.0004671070871131855,
0.0004682889558664545,
0.00046622474570873494,
0.0004693589992143753,
0.00046888993318602265,
0.0004681157304525755,
0.00046693241104770936,
0.00046598871345103965,
0.0004637775945508945,
0.000464523797753575,
0.0004650988473189708,
0.00046598398610040196,
0.0004644823738431701,
0.0004646601960961298,
0.00046592612287239707,
0.00046572515786784895,
0.00046638667426563335,
0.0004669860366049895,
0.00046827316737856447,
0.0004668044807442993,
0.0004665796598020532,

0.00046678631280963384,
0.000466825673758488,
0.00046756764642546454,
0.00046175012029498185,
0.0004621154562233281,
0.000461734256995123,
0.00046272290679791263,
0.0004635963574047535,
0.00046413925102707827,
0.00046547505875091594,
0.0004645910181724659,
0.0004631792328856184,
0.0004630821463393346,
0.0004635642803607048,
0.0004637849604549375,
0.00046696446359716006,
0.000468705123322058,
0.000467939671201078,
0.0004695245544872644,
0.0004712936986176048,
0.00047280286402362075,
0.00047269401848360333,
0.0004702592865039705,
0.00047033730461443516,
0.0004704906410588899,
0.00047262667311382143,
0.00047223414740320263,
0.0004713244107417693,
0.0004726827563357034,
0.0004734331294232009,
0.0004741599364940889,
0.00047538025438239185,
0.00047471626787416835,
0.0004734148170548171,
0.00047367993239226264,
0.0004752705887902418,
0.0004767987546698867,
0.00047579654524561646,
0.0004755363526472766,
0.0004738782738042219,
0.00047366390949780767,
0.0004734504417973716,
0.00047452829044394623,
0.000474682178746085,
0.0004755856270901801,
0.0004879143379147236,
0.00048698592193589275,

0.00048800440144240167,
0.00048687454696686366,
0.0004859139285092109,
0.00048564507437725006,
0.0004844969122337747,
0.0004854003054863769,
0.00048459069829700417,
0.00048540355975437184,
0.0004837371389426386,
0.0004836138176004829,
0.0004862979947870805,
0.0004860184483417558,
0.00048706997238507136,
0.0004862517360205183,
0.00048659032355617335,
0.00048574690880388074,
0.00048578865735667324,
0.0004842044398130559,
0.0004834849822780797,
0.0004817406062821089,
0.00048274389547211334,
0.0004834952446826702,
0.00048370158907113807,
0.00048324500676814343,
0.00048509064411671887,
0.0004875791055161285,
0.0004891916803203223,
0.0004896822311698867,
0.0004897914681075999,
0.0004898409559878715,
0.0004908169451415428,
0.0004930176821384153,
0.0004937712524981364,
0.000494322866489957,
0.0004950320691480029,
0.0004965211491676496,
0.0004973209309928996,
0.0004956566550468999,
0.0004952599194640759,
0.0004942607708371796,
0.000497094716843137,
0.0004996620197284457,
0.0004987517710203993,
0.0004993493314206459,
0.0004988463452303169,
0.0004999198178422729,
0.0005014791161304168,

0.0005006177649293974,
0.0005013392685025784,
0.0005010061794902266,
0.0005020604016598647,
0.0004983859538814544,
0.0004992042908606839,
0.0004981910534317213,
0.000496893796153784,
0.0004955728488315932,
0.0004943689292039844,
0.0004935853931674339,
0.0004961273243364094,
0.0004948080013427946,
0.0004924531047424145,
0.0004931292145095495,
0.0004923969241186487,
0.0004931673632945115,
0.0004940670463728875,
0.000491639233073228,
0.0004916720636744865,
0.0004918807330787553,
0.0004920721455767016,
0.0004917204063662077,
0.0004931689751323986,
0.0004926368006464952,
0.0004932086539273557,
0.0004931657873376455,
0.0004925386580951951,
0.0004916590060358101,
0.0004894011469736766,
0.000488362216770385,
0.0004840177181352367,
0.000483481198185411,
0.00048308923260980693,
0.00048265073452348934,
0.000482307636248791,
0.0004809336542907553,
0.0004798949579394699,
0.0004801654841361867,
0.00047928233932496096,
0.0004782933349855412,
0.000477509737062698,
0.00047717840621205697,
0.0004785724653856042,
0.0004777128792646297,
0.0004797198559023352,
0.0004782096405818474,

0.00047522772824073556,
0.0004743138016812676,
0.00047610744345827393,
0.00047616218538582326,
0.00047563764883613104,
0.00047545787722414915,
0.000475381742814833,
0.0004767850298052277,
0.0004780750019881612,
0.00047868199152975555,
0.0004811600496295571,
0.0004809992428704828,
0.00048039361108480203,
0.0004800423663750923,
0.00048010752437632976,
0.0004814969537908453,
0.00048030612248211636,
0.0004788374740981216,
0.0004787604225339139,
0.0004786035299236086,
0.00047699120918993454,
0.0004781996818093143,
0.0004790244330152897,
0.00047863542236274497,
0.0004764219442442228,
0.0004736918567352,
0.0004745959431800633,
0.00047393813029414556,
0.0004745363659366452,
0.00047482243950947565,
0.0004758919545615652,
0.00047744070665331446,
0.0004782815793375511,
0.0004763024556760116,
0.00047628455945249973,
0.0004750403607024942,
0.00047474088242028015,
0.00047379490270701833,
0.00047514627261814683,
0.0004739520165152375,
0.00047302978066283757,
0.0004737465165323656,
0.00047267611907913886,
0.0004731682791622439,
0.00047350262658107353,
0.0004735118022813594,
0.0004728750364563169,

0.00047205556333686867,
0.00046964933864547217,
0.0004686715167786442,
0.00046760962243773977,
0.0004678225627913562,
0.00046742649221127484,
0.00046797810582600207,
0.00046834834776202474,
0.0004678664434185393,
0.00046727798531133897,
0.00046699261646429547,
0.00046726617332230506,
0.00046676530740134625,
0.00046697829037426885,
0.0004689688254885992,
0.0004736342570521234,
0.00047050742812721597,
0.0004715604057527686,
0.0004715714822576307,
0.0004712919266561507,
0.0004703294351154937,
0.00047034756754590874,
0.000469520634644238,
0.0004708678181478813,
0.00046966044027290716,
0.00046821945139368466,
0.00046673888159888717,
0.00046578142789041404,
0.00046470755781496937,
0.0004643910386396414,
0.00046210709494167075,
0.000462525644668103,
0.00046348005414002797,
0.0004650556975744313,
0.0004638629782338671,
0.0004624717901220386,
0.00046199192966227113,
0.00046241442392307017,
0.0004640796082615192,
0.0004637787733879247,
0.0004625235351986113,
0.0004631268473909237,
0.0004623958152557684,
0.0004622799793230073,
0.0004588632609991824,
0.00046053445671975725,
0.0004614858945211763,

0.00046038840830747984,
0.0004601769186292206,
0.0004612420459657906,
0.00046163926702822767,
0.00046070774898905744,
0.00046136791652400607,
0.0004590343612096315,
0.0004617947142841713,
0.00046192569871231855,
0.0004595637452472287,
0.00045972821718734766,
0.00046122673416843516,
0.0004609947731785804,
0.0004614965550604333,
0.00045975806180724666,
0.0004607517966839708,
0.0004598446284397546,
0.00046000443239920875,
0.000458823775186609,
0.0004580263259560359,
0.0004584379082373258,
0.0004580759348342836,
0.0004568754187487703,
0.0004562284838955718,
0.0004562818531149265,
0.0004563337287609784,
0.0004567197675064213,
0.0004590408419647113,
0.00045649158997744055,
0.00045444703188639817,
0.0004543879568812637,
0.0004529498193814075,
0.0004526129832003997,
0.0004505329194164231,
0.0004508979063129928,
0.00045202529846780494,
0.0004510656630193874,
0.0004512625883285653,
0.0004521260396127658,
0.00045286251926273134,
0.0004529007388597736,
0.00045400860541600346,
0.00045482328467777395,
0.00045419464242207154,
0.00045520836499311274,
0.00045523021498367506,
0.00045485187223224627,

0.0004550868101665986,
0.0004551985457330465,
0.0004537194849487563,
0.000453186216176235,
0.00045364706216469044,
0.00045203869265246613,
0.0004552876802088965,
0.00045643120034941575,
0.00045653156731606103,
0.0004571834093730643,
0.0004536614664164731,
0.0004560931468421984,
0.00045428779831148674,
0.0004546655022351459,
0.00045677649384235204,
0.00045714516150862153,
0.0004556981045592513,
0.0004550973867374627,
0.0004567559821493549,
0.0004565012146029493,
0.00045546487899396116,
0.0004570984655737381,
0.000458327259851934,
0.00045938392093565673,
0.00045697440369031123,
0.00045806133931594357,
0.00045770080906424525,
0.0004556422521270493,
0.0004549104565932925,
0.00045496175172390815,
0.0004547945452876828,
0.00045438614552568204,
0.0004557832105843449,
0.00045735595969423375,
0.00045717837024762524,
0.0004541734225674039,
0.00045443051205953824,
0.0004546512215710047,
0.00045156899508317104,
0.0004529739263730829,
0.0004525497718374813,
0.0004518944100826797,
0.00045191258283160433,
0.0004502359992113992,
0.0004494997980088882,
0.00045105619378858693,
0.0004499162684570303,

0.0004496302298754155,
0.00044869218757120325,
0.00044847346451617066,
0.0004486644430827621,
0.00045025212174050195,
0.00045018982183366946,
0.0004498651068577738,
0.00044957367986713035,
0.00044952037214592087,
0.00044925880429428104,
0.00045102059813827367,
0.0004493033363163793,
0.00044966023609910137,
0.00045008309840945034,
0.000450193204883916,
0.00045185288493932455,
0.000453534540444433,
0.0004532146608579475,
0.0004525143847639301,
0.00045553959463470696,
0.0004573133417956394,
0.00045630999376577156,
0.00045549186491987816,
0.0004548423423803533,
0.0004552414109711408,
0.000453614817766012,
0.00045261149380304653,
0.00045247151134612394,
0.00045323450253025743,
0.0004531555486925327,
0.00045411284893700235,
0.0004533324343719949,
0.00045296369940207203,
0.00045544174279404557,
0.00045401604944335686,
0.00045383565040654967,
0.0004522524263034864,
0.0004560430716017881,
0.00045598903671265555,
0.0004552032852501867,
0.0004565244385181442,
0.0004543812615752238,
0.00045280597444505457,
0.0004539773943287534,
0.0004528435772412376,
0.00045155113979431215,
0.00045024957716232,

0.00045055442039081616,
0.00044780991569184605,
0.0004472378703916897,
0.00044617755140836696,
0.00044693086820673145,
0.0004459608802314507,
0.0004442512408701242,
0.000445835787708448,
0.0004443211953687682,
0.00044375457186337716,
0.0004435477288004082,
0.0004412665056559792,
0.00043992295035321657,
0.00044030164730463734,
0.0004402885191258911,
0.0004445204604214775,
0.00044414654939887955,
0.00044680072127113995,
0.0004479548385648792,
0.00044427992303278265,
0.0004422437989647464,
0.00043972779541021594,
0.00043978687796677443,
0.00044246841671916737,
0.00044166748023085267,
0.0004420501735649907,
0.0004413444752263348,
0.0004416855135829844,
0.00044193069017346806,
0.00044056946760925587,
0.00044054420535131404,
0.0004395530908732165,
0.00043788505871781376,
0.00043762831575824563,
0.00043610232579386086,
0.0004376334345178836,
0.000436794044410474,
0.00043754444310325265,
0.000436162882141405,
0.00043681620583813205,
0.000440833143931744,
0.0004403486112556112,
0.0004400711151674362,
0.0004407691844587028,
0.00043776678661995865,
0.0004429206359940486,
0.0004430198624070578,

0.0004451708049470098,
0.00044490855875352315,
0.0004437271604985428,
0.00044385006334908333,
0.00044288618086825015,
0.00044336000214623107,
0.0004432679726859269,
0.00044338275619519054,
0.00044489852939622564,
0.0004431875115129106,
0.0004417783619117617,
0.0004399816387844132,
0.0004417634087883795,
0.0004438305155753881,
0.0004425799305828554,
0.00044519180145099384,
0.00044276770284020324,
0.0004442795872517456,
0.00044286824211091255,
0.00044203725285113683,
0.00044355547006592904,
0.00044324782897973335,
0.0004432415714331444,
0.000440714352976684,
0.00043845612070633706,
0.0004385872796038744,
0.0004380099537322073,
0.0004380241933922891,
0.0004401274194373036,
0.00043905936484596366,
0.00043829287030700714,
0.0004385121694910407,
0.00044109118265227005,
0.00043899341411998184,
0.00043824970471638495,
0.00043837346409978376,
0.00044011434432637093,
0.00043979030405332035,
0.000438045749379378,
0.00043967650236566356,
0.00043978258016374376,
0.0004389035310013951,
0.0004396676573407247,
0.0004394698356104614,
0.0004392678744072348,
0.0004388558816367541,
0.00043827532040125323,

0.0004399623670117646,
0.0004395740536124271,
0.000442164609293139,
0.0004491162065229845,
0.00045312673838023395,
0.0004545682722135438,
0.00045099019809751183,
0.0004531010064854155,
0.0004554315809183212,
0.0004547467259633693,
0.00045562179748550485,
0.0004530529685508759,
0.0004557404882183536,
0.00045191574011139616,
0.0004521396381318531,
0.0004526441961910068,
0.00045603597261974395,
0.0004580459287256524,
0.00045634213881356924,
0.00045541731241576953,
0.0004606803203149302,
0.00046256754074619803,
0.0004612489822104787,
0.0004581279152840246,
0.00045923392056562804,
0.00046155110002604375,
0.0004613543274706387,
0.00045934822565947715,
0.0004575762955213303,
0.00045656946598388314,
0.000458926375026224,
0.0004586123980542465,
0.0004593549943672885,
0.00045932856958441604,
0.0004601769928692276,
0.00046178558167352866,
0.00046603707777458206,
0.00046428964632695604,
0.00046095417692901486,
0.00046110932976912826,
0.0004635907324356818,
0.0004642028028114109,
0.00046172002072459635,
0.00045862030155477916,
0.00045607029448714695,
0.00045783460173403956,
0.00045595705368399426,

0.00045323670262704144,
0.0004529724601338807,
0.00045102121058651135,
0.00044756514419288,
0.000449502137028023,
0.0004530288822546288,
0.0004521917912849523,
0.00045490223941472847,
0.0004545424034004499,
0.0004517189044017183,
0.00044999897310081966,
0.00044909197221483017,
0.00044848632544890464,
0.00044534287992435126,
0.00044610471079947186,
0.000449331804975528,
0.0004521690467663939,
0.0004508802274198987,
0.00044815888124426114,
0.0004471151439995045,
0.00044708613089840867,
0.00044356975981118684,
0.0004460689877677964,
0.0004456817924744879,
0.00044214366196801175,
0.0004407285912884363,
0.0004346940804625965,
0.00043551631023879445,
0.0004337105902870021,
0.0004383171694360065,
0.0004340961939133793,
0.00043379758290807417,
0.00043261211925764605,
0.0004333258726505276,
0.00043581609538740837,
0.0004320956949795786,
0.00043148515687056483,
0.00043191159528333726,
0.00042816580458006917,
0.0004290278578243141,
0.0004264914653101767,
0.00042426687974824633,
0.00042602311151057815,
0.00042375921684642244,
0.00041939078249369127,
0.00042069560968280035,
0.00041910437751249745,

0.0004243343569713457,
0.0004160316099829707,
0.0004200438453714614,
0.0004193373815300104,
0.00042365794638525003,
0.0004250915770260303,
0.00042973539842608107,
0.0004315974341405952,
0.00043857230860784265,
0.0004387599090924494,
0.00043959156810915605,
0.00044038585104402584,
0.0004405185884185137,
0.00043944893652064147,
0.00043932235841879336,
0.00043831681964156773,
0.00044272288388470544,
0.0004429514678972707,
0.00044492567794829693,
0.0004457929272180221,
0.00044273556906094245,
0.00044168184575543165,
0.00044198548667468226,
0.0004428368916876284,
0.0004407080573970111,
0.0004421759196176735,
0.00044266426755122353,
0.0004436550448988309,
0.00044160783169219016,
0.00044317855953284114,
0.0004400798765927994,
0.0004407384461083311,
0.00043945581835853166,
0.0004400826258228203,
0.000439563662054415,
0.0004383018591068843,
0.00043702265387134695,
0.00043671190647225723,
0.0004331881636021182,
0.00043807430536562444,
0.000437841395783322,
0.0004376600679328281,
0.00043762999815485763,
0.0004401359721584819,
0.00044085490885270915,
0.0004394741746478361,
0.0004377623062942899,

0.00044270694350456854,
0.0004420770781688787,
0.0004401503968450492,
0.00044013678600144773,
0.0004396801430394251,
0.0004360029490684409,
0.00043390820197824456,
0.00043516729243639994,
0.00043676703333276565,
0.000434682957938727,
0.0004330558359397238,
0.0004341816462235441,
0.0004300835374849135,
0.0004291464742865738,
0.0004333310242201659,
0.0004355843824302725,
0.00043619435551997104,
0.00043118199031026824,
0.00043314921704852105,
0.00043500922809996327,
0.0004326859361145201,
0.0004324261900229165,
0.000430258413016703,
0.00043447918719894356,
0.0004304041888817976,
0.0004363206513967126,
0.000435666948693036,
0.0004385043174061619,
0.0004375280006341426,
0.00043564055154579655,
0.00043553840026337574,
0.00043818947352128345,
0.0004295366841317794,
0.00043378891852162877,
0.0004383608946572489,
0.00043717232272886034,
0.0004377797034832554,
0.00043715091614061734,
0.00043291224025255985,
0.0004150293208876223,
0.00041933674010343353,
0.00042269464749648746,
0.00042210598384882086,
0.00042353708458681914,
0.00042245051081931837,
0.00042206208575039817,
0.00042297449427127544,

0.00042437520082137814,
0.00042508753388337186,
0.0004244456440203837,
0.0004262217145143785,
0.0004282548499784614,
0.0004257646463890513,
0.0004228102410538536,
0.0004243462726159491,
0.00042424092549791094,
0.0004236319548331259,
0.0004225106387939893,
0.00042101734895389994,
0.0004202578970679531,
0.0004203007141135482,
0.0004215571720816061,
0.00042409242912770634,
0.00042831758141022855,
0.00042835043244705465,
0.0004275729732836998,
0.00042619497881161343,
0.0004269717907695099,
0.000425302840105168,
0.00042376606321993385,
0.00042812016690003566,
0.00042740690496376925,
0.00042682669223240627,
0.0004288858847768107,
0.00042513887567864297,
0.0004239798862328588,
0.0004258344337536774,
0.000426780622893694,
0.0004274032884282072,
0.0004268873557985629,
0.0004280812539817186,
0.0004282686007684287,
0.0004262642329951525,
0.000427749176006072,
0.0004276795605773428,
0.0004280292965699977,
0.00042896076585505785,
0.0004312359547288971,
0.0004348556844445592,
0.0004339979270623937,
0.0004325566743497158,
0.0004305090954089081,
0.00043005384336476107,
0.00043091870619617876,

0.00043211503717834385,
0.0004331483353104289,
0.00043416957226700883,
0.00043420068903678177,
0.0004352090091411896,
0.0004365347965517427,
0.00043643112579159327,
0.00043580961529859344,
0.0004353442985589874,
0.0004138839471115489,
0.00041364780336549187,
0.00041283153392219677,
0.00041331384982868616,
0.0004135764284436153,
0.00041352389382742473,
0.0004141838086401736,
0.0004141704177337117,
0.0004149652487503884,
0.0004152366104897268,
0.00041631462951178947,
0.00041717289894537967,
0.00041561593970908034,
0.0004180916454550878,
0.0004160086035648842,
0.000415475414490062,
0.00041503324398855726,
0.00041323320568104055,
0.00041275334558405326,
0.00041181632856083605,
0.000413083815687098,
0.00041209393764088625,
0.00040921330324620816,
0.00040865151712440965,
0.0004109434780649433,
0.0004103823989689439,
0.000410491877281731,
0.0004129492140703774,
0.0004143896949734678,
0.00041381500944230067,
0.0004139171442882386,
0.0004121722230681462,
0.00041260207892836306,
0.00041237946855021663,
0.0004121713077125476,
0.00041196331201690363,
0.0004120217157534937,
0.00041192347436790517,

0.000413099373034533,
0.00041315628004161514,
0.00041399689417165086,
0.0004130413408787924,
0.0004122902359778036,
0.0004129912880203813,
0.00041290300856112365,
0.0004138444435643195,
0.0004136514587476627,
0.00041368129777434343,
0.0004116928967019042,
0.000412461000869645,
0.00041341439761025995,
0.0004127773538732736,
0.00041185362924389907,
0.00041140136515412605,
0.0004111809531487344,
0.0004102880842112332,
0.0004111793439397155,
0.00041230097374841447,
0.0004120916210788329,
0.00041202891635800753,
0.00041160701332005435,
0.0004113486786565439,
0.00041265779106534016,
0.0004125145567383785,
0.00041179715208141125,
0.0004164789882592145,
0.0004160828963461659,
0.00041591706259481434,
0.00041517197151343116,
0.00041496111780563725,
0.0004145958330342317,
0.0004134338341628968,
0.0004128658469699013,
0.0004130131101617225,
0.0004113974378047082,
0.000409870693505946,
0.00040933618671970025,
0.0004112048896700224,
0.0004120993591385862,
0.00041114733579854587,
0.00041114792429850546,
0.0004095828076966872,
0.00041056536586397686,
0.00040971908327710945,
0.0004103455954800749,

```
0.0004110899997215895,  
0.0004113886269755215,  
0.00041089671900834397,  
0.00041019852154150493,  
0.00041092908619481293,  
0.00041177352827541597,  
0.00041167684033373275,  
0.00041189457012620005,  
0.0004113729355480804,  
0.00041221638423809796,  
0.0004123707303950247,  
0.00041292982015535317,  
0.00041308881559148984,  
0.00041324380561149243,  
0.0004142185538402414,  
0.0004134263269034383,  
0.0004119013915200295,  
0.0004121550634693263,  
0.0004103160554654226,  
0.00040932176334380394,  
0.00040904600471522066,  
0.00040755261343552323,  
0.0004074294951207634,  
0.00040731020401606644,  
0.0004085398681288942,  
0.00040846596317325415,  
0.0004084089135531139,  
0.00040854403546685645,  
0.00040904894435046135,  
0.00040626449129836434,  
0.0004058307840853063,  
0.0004049212694619944,  
0.00040469142608684484,  
0.00040496210594754813,  
0.00040491310978581414,  
0.00040435516664692376,  
0.0004057443452525924,  
...]
```

```
[379]: np.sqrt(weight504[0] @ rw_504_cov.to_numpy() @ weight504[0].T)
```

```
[379]: 0.0004844218888482598
```

```
[380]: #rw = 252  
rw_252 = []  
for i in secdata_rnd_100['Ticker'].unique():  
    key = i
```

```

    value = list(secdata_rnd_100.loc[secdata_rnd_100['Ticker'] == i].Returns.
    ↪rolling(252).mean().dropna().reset_index(drop=True))
    rw_252[key] = value

```

[381]: rw252_df = pd.DataFrame.from_dict(rw_252, orient='index')
rw_252_cov = rw252_df.T.cov()
rw_252_cov

	27	73	114	116	120	\
27	9.539598e-07	2.073255e-06	4.900310e-07	6.053027e-07	-3.587238e-07	
73	2.073255e-06	8.532339e-06	2.775868e-07	1.681303e-06	-4.805784e-07	
114	4.900310e-07	2.775868e-07	8.562077e-07	3.845881e-07	-5.078682e-07	
116	6.053027e-07	1.681303e-06	3.845881e-07	1.172786e-06	-1.016809e-07	
120	-3.587238e-07	-4.805784e-07	-5.078682e-07	-1.016809e-07	1.591806e-06	
123	4.105023e-07	7.627082e-07	2.436757e-07	5.732676e-08	3.431259e-07	
127	6.983988e-07	2.064316e-06	3.527991e-07	4.252102e-07	-3.025186e-07	
131	-3.010678e-07	-1.314675e-06	-1.565637e-08	-2.040450e-07	2.954477e-07	
167	2.834021e-07	2.392421e-07	3.207614e-07	2.022392e-07	-3.636034e-07	
184	3.867868e-08	-1.716075e-07	1.935643e-07	-6.104841e-08	-2.578162e-07	
197	5.054129e-07	1.164947e-06	4.301458e-07	3.937990e-07	-3.693622e-07	
204	1.792201e-06	5.200948e-06	1.079010e-06	1.346564e-06	-1.308722e-06	
205	5.361049e-07	7.744819e-07	6.601821e-07	4.173210e-07	-2.090104e-07	
221	2.043239e-06	6.352417e-06	1.110932e-06	2.220077e-06	-7.711739e-07	
227	4.295840e-07	9.670846e-07	3.100881e-07	2.419756e-07	-4.573257e-07	
243	-2.005653e-07	-8.768595e-07	4.953151e-09	-9.665572e-08	3.839695e-08	
278	1.681972e-06	5.727509e-06	6.105431e-07	1.995887e-06	-5.530855e-07	
299	4.612190e-08	-1.807340e-07	-8.009416e-08	-1.279301e-07	-1.842232e-07	
300	3.783995e-08	-3.291057e-07	2.516207e-07	6.857874e-08	6.493098e-07	
327	5.043859e-07	-3.801201e-07	1.344009e-06	1.272741e-06	-5.056135e-07	
330	-3.448639e-07	-1.047384e-06	-3.184191e-07	-5.130654e-07	4.523292e-07	
359	1.065652e-07	1.133744e-06	-2.068945e-07	5.228920e-07	-2.288712e-07	
367	7.393741e-07	1.611306e-06	4.306471e-07	6.384225e-07	3.489253e-07	
374	6.308984e-07	2.322282e-06	2.096513e-07	8.867699e-07	-4.713986e-07	
376	3.277049e-07	7.662460e-07	3.422700e-07	5.925346e-07	-4.052291e-07	
380	2.818614e-07	9.518705e-07	2.362446e-07	-6.553292e-08	-3.805205e-07	
412	3.853899e-07	8.281574e-07	4.769475e-07	3.598099e-07	-4.946299e-07	
448	4.172881e-07	1.660380e-06	1.079544e-07	5.356789e-07	-2.194959e-07	
449	2.869816e-07	1.456520e-06	-4.006287e-08	3.159835e-07	-1.056072e-07	
472	9.708101e-08	4.817405e-07	-8.689159e-08	1.687307e-07	8.495389e-08	
...	
1484	2.139179e-07	1.311331e-06	-2.053609e-07	-1.913887e-07	8.061499e-07	
1487	6.426870e-07	1.643163e-06	4.521378e-07	6.947022e-07	-5.663448e-07	
1493	1.502058e-07	5.331475e-07	9.726574e-08	-1.363191e-07	-3.060932e-07	
1505	1.545843e-06	4.812234e-06	7.860074e-07	1.296583e-06	-1.100466e-06	
1506	3.205141e-07	6.524388e-07	2.860581e-07	2.037779e-07	-4.271924e-07	
1512	4.016473e-07	1.607858e-06	5.465290e-08	1.858806e-07	-1.784694e-07	
1564	6.561071e-07	-9.502374e-07	1.410158e-06	5.581296e-07	-1.573583e-06	

1571	9.260754e-08	-1.751723e-07	1.948409e-07	6.670835e-08	-3.718982e-07	
1588	3.940146e-07	9.234604e-07	5.870281e-07	8.438321e-07	-6.268057e-07	
1600	4.135265e-07	1.373727e-06	2.524080e-07	5.530063e-07	5.460301e-07	
1620	2.817641e-07	1.208417e-07	4.994114e-07	2.857759e-07	-4.301172e-07	
1657	5.615320e-07	5.445688e-07	6.259697e-07	6.087892e-07	-3.677285e-07	
1667	9.997014e-07	5.243042e-06	-5.947422e-07	7.131610e-07	9.804298e-07	
1670	5.842489e-07	1.916853e-06	2.834841e-07	5.662523e-07	-5.961302e-08	
1672	7.202344e-07	2.234999e-06	4.576852e-07	5.833045e-07	-6.121624e-07	
1679	4.748966e-07	1.754835e-06	1.016877e-07	3.518711e-07	-3.153162e-08	
1681	4.032515e-07	1.963677e-06	1.632828e-07	5.342141e-07	-2.284867e-07	
1688	1.185477e-06	2.421272e-06	9.539445e-07	8.562624e-07	-7.051623e-07	
1690	6.020696e-07	7.770570e-07	7.078919e-07	7.862284e-07	-8.676689e-08	
1694	1.513678e-06	2.277010e-06	1.636152e-06	1.043381e-06	-1.842028e-06	
1704	9.400176e-08	-1.345460e-07	3.393895e-07	-3.518088e-07	-9.480307e-07	
1721	1.821175e-07	1.455584e-07	3.133104e-07	1.797195e-07	-4.285002e-07	
1725	-1.678588e-08	-1.036150e-07	3.713133e-08	7.225900e-08	-3.725177e-07	
1744	-2.387107e-07	-8.783969e-07	4.273234e-08	-1.500449e-08	5.598934e-07	
1775	4.806664e-07	1.029242e-06	3.104553e-07	4.882385e-07	-7.931360e-08	
1780	4.279105e-07	3.968248e-07	5.572479e-07	1.958499e-07	-2.492005e-07	
1782	1.098223e-06	2.432279e-06	1.008242e-06	8.408149e-07	-6.817877e-07	
1803	9.312964e-07	2.419131e-06	4.449015e-07	8.450094e-07	1.501405e-08	
1814	1.055598e-06	2.775472e-06	8.187046e-07	9.460596e-07	-7.668709e-07	
1835	4.672121e-07	1.259534e-06	2.660176e-07	2.567133e-07	-1.140828e-06	

	123	127	131	167	184	\
27	4.105023e-07	6.983988e-07	-3.010678e-07	2.834021e-07	3.867868e-08	
73	7.627082e-07	2.064316e-06	-1.314675e-06	2.392421e-07	-1.716075e-07	
114	2.436757e-07	3.527991e-07	-1.565637e-08	3.207614e-07	1.935643e-07	
116	5.732676e-08	4.252102e-07	-2.040450e-07	2.022392e-07	-6.104841e-08	
120	3.431259e-07	-3.025186e-07	2.954477e-07	-3.636034e-07	-2.578162e-07	
123	1.733460e-06	3.415067e-07	8.470348e-08	-2.452930e-08	-2.755142e-07	
127	3.415067e-07	7.982051e-07	-3.496634e-07	1.747044e-07	-1.375567e-08	
131	8.470348e-08	-3.496634e-07	5.044270e-07	-9.249210e-08	1.662267e-07	
167	-2.452930e-08	1.747044e-07	-9.249210e-08	3.372073e-07	3.901959e-08	
184	-2.755142e-07	-1.375567e-08	1.662267e-07	3.901959e-08	4.320548e-07	
197	1.355245e-07	4.118580e-07	-1.322893e-07	1.758572e-07	2.121981e-07	
204	2.799893e-07	1.598064e-06	-9.841755e-07	7.722962e-07	2.434711e-07	
205	-1.958006e-07	1.740417e-07	4.146963e-07	3.002894e-07	9.570760e-07	
221	2.875017e-07	1.657148e-06	-8.019812e-07	4.493539e-07	5.178842e-07	
227	4.147736e-07	3.660524e-07	-1.948905e-07	2.204781e-07	2.235644e-08	
243	-1.746876e-07	-2.530679e-07	3.025577e-07	-1.865924e-08	1.884429e-07	
278	2.588231e-08	1.419338e-06	-1.087812e-06	4.777258e-07	-7.269795e-08	
299	-1.391419e-08	-1.763140e-07	2.073219e-07	1.657042e-08	2.627221e-07	
300	2.061060e-07	-5.003466e-08	2.626857e-07	1.736204e-07	1.738708e-07	
327	-1.145356e-06	-8.808142e-08	5.085650e-07	6.430670e-07	1.192312e-06	
330	2.167006e-07	-2.344943e-07	1.973352e-07	-1.335375e-07	-6.464631e-08	
359	-1.058535e-06	6.102315e-09	-6.139415e-07	1.909112e-07	-8.412255e-08	

367	1.048635e-06	6.636109e-07	-2.479291e-07	9.639061e-08	-3.256383e-07
374	2.328647e-09	5.828755e-07	-4.663593e-07	1.537588e-07	-6.586565e-08
376	-3.319529e-07	2.134338e-07	-2.576927e-07	2.012736e-07	1.273739e-07
380	2.959116e-08	3.155266e-07	-1.083749e-07	1.062693e-07	2.990938e-07
412	-5.328935e-07	2.690045e-07	-1.161925e-07	3.929479e-07	3.868009e-07
448	-1.669512e-07	3.723043e-07	-3.487649e-07	1.595447e-07	-9.632364e-09
449	-5.208697e-08	3.457785e-07	-3.363054e-07	5.673401e-08	-9.721613e-08
472	4.380580e-07	1.176273e-07	7.999264e-09	-1.594567e-07	-1.192609e-07
...
1484	9.201786e-07	4.131640e-07	-2.135866e-07	-1.519741e-07	-2.280044e-07
1487	-1.735702e-07	4.570969e-07	-4.167174e-07	4.713727e-07	2.259436e-08
1493	-1.741113e-07	1.689396e-07	-9.944407e-08	1.056110e-07	2.287602e-07
1505	-1.373690e-07	1.319809e-06	-9.580396e-07	5.496141e-07	3.990989e-07
1506	-1.406798e-08	2.252106e-07	-9.556280e-08	2.270820e-07	1.766812e-07
1512	9.652030e-08	3.749796e-07	-2.220828e-07	5.052068e-08	1.068404e-07
1564	5.443182e-07	1.005304e-07	4.951357e-07	6.372212e-07	6.351347e-07
1571	-1.899915e-07	7.110042e-08	-9.199229e-08	1.355908e-07	4.955657e-08
1588	-1.080024e-06	2.858287e-07	-4.670905e-07	5.568081e-07	1.824343e-07
1600	3.624459e-07	2.904562e-07	3.939382e-07	-1.426373e-07	5.157513e-07
1620	-5.403225e-08	1.435170e-07	7.883835e-08	2.535331e-07	2.837784e-07
1657	2.682448e-07	8.877955e-08	3.652034e-07	2.045548e-07	7.008154e-07
1667	1.243102e-06	1.088422e-06	-7.526436e-07	-2.979214e-07	-5.491258e-07
1670	2.282100e-07	5.504599e-07	-2.897091e-07	1.034884e-07	6.487986e-08
1672	-3.740480e-07	6.191840e-07	-4.153258e-07	3.591455e-07	3.015555e-07
1679	1.083530e-08	3.951755e-07	-2.326979e-07	4.686034e-08	1.884471e-07
1681	-7.726144e-07	2.120656e-07	-2.409106e-08	2.695689e-07	6.643387e-07
1688	1.111252e-06	9.748404e-07	-1.988120e-07	3.768271e-07	7.565504e-08
1690	-4.617534e-07	1.143231e-07	5.821920e-07	2.505499e-07	1.108183e-06
1694	4.139038e-07	1.196633e-06	-6.905161e-07	1.106426e-06	2.664842e-07
1704	-9.279736e-07	1.236586e-07	-1.138077e-07	3.006930e-07	6.220956e-07
1721	-4.322092e-07	-1.240828e-08	1.270557e-07	2.633628e-07	4.131625e-07
1725	-2.988914e-07	-1.042912e-07	-6.939356e-08	1.577749e-07	1.215132e-07
1744	-1.847906e-07	-3.038052e-07	3.780401e-07	-9.088324e-08	3.029781e-07
1775	8.017956e-08	2.312153e-07	1.762612e-07	1.356465e-07	4.469163e-07
1780	2.072648e-07	2.800867e-07	-3.766987e-08	3.643916e-07	2.109754e-07
1782	5.538512e-07	9.105520e-07	-2.661267e-07	4.614125e-07	3.919891e-07
1803	9.953016e-07	7.094731e-07	-9.733835e-08	1.362501e-07	1.553672e-08
1814	-1.687683e-07	7.962292e-07	-2.074684e-07	4.123532e-07	6.711443e-07
1835	-1.198483e-07	2.963786e-07	-1.820445e-07	2.414678e-07	3.671011e-07

...	1704	1721	1725	1744	\
27	...	9.400176e-08	1.821175e-07	-1.678588e-08	-2.387107e-07
73	...	-1.345460e-07	1.455584e-07	-1.036150e-07	-8.783969e-07
114	...	3.393895e-07	3.133104e-07	3.713133e-08	4.273234e-08
116	...	-3.518088e-07	1.797195e-07	7.225900e-08	-1.500449e-08
120	...	-9.480307e-07	-4.285002e-07	-3.725177e-07	5.598934e-07
123	...	-9.279736e-07	-4.322092e-07	-2.988914e-07	-1.847906e-07

127	...	1.236586e-07	-1.240828e-08	-1.042912e-07	-3.038052e-07
131	...	-1.138077e-07	1.270557e-07	-6.939356e-08	3.780401e-07
167	...	3.006930e-07	2.633628e-07	1.577749e-07	-9.088324e-08
184	...	6.220956e-07	4.131625e-07	1.215132e-07	3.029781e-07
197	...	3.533781e-07	3.442518e-07	1.598580e-07	2.106096e-07
204	...	9.586389e-07	8.316806e-07	3.804983e-07	-4.354721e-07
205	...	6.118267e-07	1.872990e-06	7.262781e-07	1.827138e-06
221	...	2.188566e-07	1.208503e-06	4.174059e-07	5.046664e-07
227	...	1.198964e-07	1.715988e-07	1.643593e-07	-1.364338e-07
243	...	1.378252e-07	2.244832e-07	2.659935e-08	2.956758e-07
278	...	3.541083e-08	4.665256e-07	2.977458e-07	-2.545175e-07
299	...	9.413072e-08	3.871818e-07	3.169060e-07	4.164373e-07
300	...	-1.081982e-07	6.646599e-07	2.524225e-07	1.243717e-06
327	...	1.120806e-06	2.453569e-06	1.040025e-06	2.328937e-06
330	...	-8.358067e-08	-3.223802e-07	-7.653666e-08	2.458186e-07
359	...	5.559513e-07	1.218698e-07	3.884717e-07	-1.272922e-07
367	...	-6.354775e-07	-5.350875e-07	-4.248368e-07	-2.927049e-07
374	...	3.462587e-08	4.012267e-08	1.682184e-07	-2.694131e-07
376	...	3.877544e-07	1.902555e-07	2.494976e-07	1.856930e-07
380	...	5.423055e-07	3.992222e-07	2.039163e-07	2.936702e-07
412	...	9.146983e-07	9.052070e-07	3.780053e-07	4.497444e-07
448	...	1.692884e-07	1.651356e-07	1.375620e-07	-1.544026e-07
449	...	1.999944e-08	-5.350606e-08	6.281129e-08	-1.785655e-07
472	...	-4.156218e-07	-4.826934e-07	-2.269879e-07	-3.747264e-07
...
1484	...	-4.754523e-07	-5.167406e-07	-2.817453e-07	2.433663e-07
1487	...	5.061855e-07	5.295841e-07	3.836160e-07	-4.750995e-09
1493	...	5.679465e-07	3.476601e-07	1.956648e-07	1.742565e-07
1505	...	1.096797e-06	9.925701e-07	5.419822e-07	1.836949e-08
1506	...	4.381565e-07	3.365111e-07	2.003316e-07	5.274728e-08
1512	...	9.627093e-08	2.411888e-07	1.342794e-07	8.810902e-08
1564	...	7.287804e-07	1.030851e-06	6.136412e-07	4.046208e-07
1571	...	4.389678e-07	-5.723069e-08	7.671728e-08	-1.542624e-07
1588	...	1.134977e-06	6.576045e-07	4.821977e-07	2.546370e-07
1600	...	-4.890111e-07	7.366047e-07	6.245506e-08	1.224164e-06
1620	...	4.268469e-07	5.711856e-07	2.054437e-07	2.615024e-07
1657	...	-6.940806e-08	1.312467e-06	6.421459e-07	1.308937e-06
1667	...	-1.438055e-06	-5.668378e-07	-3.951473e-07	-3.735016e-07
1670	...	-3.756842e-09	1.571366e-07	5.132542e-08	5.297395e-08
1672	...	7.907176e-07	7.369524e-07	3.438179e-07	1.622093e-07
1679	...	7.794853e-08	3.816870e-07	2.264092e-07	4.628960e-07
1681	...	8.712813e-07	1.517972e-06	6.435995e-07	9.903902e-07
1688	...	-2.588648e-07	1.693974e-07	-1.029884e-07	-4.850545e-07
1690	...	7.111235e-07	1.937832e-06	6.079059e-07	1.983454e-06
1694	...	1.168070e-06	7.596983e-07	5.384079e-07	-5.664257e-07
1704	...	2.133262e-06	6.666233e-07	3.009364e-07	1.107726e-07
1721	...	6.666233e-07	1.111514e-06	3.934275e-07	5.449775e-07

1725	...	3.009364e-07	3.934275e-07	4.901439e-07	2.012661e-07		
1744	...	1.107726e-07	5.449775e-07	2.012661e-07	1.323883e-06		
1775	...	2.685364e-07	7.639075e-07	3.195440e-07	7.391914e-07		
1780	...	4.436881e-07	5.493577e-07	2.735363e-07	4.982480e-07		
1782	...	5.060659e-07	7.560736e-07	2.536710e-07	2.902134e-07		
1803	...	-6.232338e-07	1.903555e-07	-9.426124e-08	-2.531878e-08		
1814	...	7.826192e-07	1.311788e-06	5.160510e-07	6.860374e-07		
1835	...	6.223980e-07	5.329050e-07	5.401315e-07	-2.033320e-07		
		1775	1780	1782	1803	1814	\
27	4.806664e-07	4.279105e-07	1.098223e-06	9.312964e-07	1.055598e-06		
73	1.029242e-06	3.968248e-07	2.432279e-06	2.419131e-06	2.775472e-06		
114	3.104553e-07	5.572479e-07	1.008242e-06	4.449015e-07	8.187046e-07		
116	4.882385e-07	1.958499e-07	8.408149e-07	8.450094e-07	9.460596e-07		
120	-7.931360e-08	-2.492005e-07	-6.817877e-07	1.501405e-08	-7.668709e-07		
123	8.017956e-08	2.072648e-07	5.538512e-07	9.953016e-07	-1.687683e-07		
127	2.312153e-07	2.800867e-07	9.105520e-07	7.094731e-07	7.962292e-07		
131	1.762612e-07	-3.766987e-08	-2.661267e-07	-9.733835e-08	-2.074684e-07		
167	1.356465e-07	3.643916e-07	4.614125e-07	1.362501e-07	4.123532e-07		
184	4.469163e-07	2.109754e-07	3.919891e-07	1.553672e-08	6.711443e-07		
197	6.937321e-07	5.758159e-07	1.131918e-06	6.865681e-07	1.231332e-06		
204	1.414120e-06	1.395520e-06	3.184868e-06	2.029986e-06	3.392418e-06		
205	2.637622e-06	1.761535e-06	2.654384e-06	1.549715e-06	3.885446e-06		
221	2.659169e-06	1.566315e-06	4.148263e-06	3.128046e-06	4.918405e-06		
227	4.762802e-07	4.929383e-07	1.019329e-06	6.997156e-07	8.717665e-07		
243	1.461785e-07	-3.190427e-08	-2.117324e-07	-2.171571e-07	-2.871097e-08		
278	1.280829e-06	8.550189e-07	2.556409e-06	2.034872e-06	2.897834e-06		
299	6.750312e-07	2.718125e-07	1.820415e-07	1.978543e-07	6.638979e-07		
300	8.933532e-07	1.036416e-06	9.500006e-07	4.481573e-07	1.112947e-06		
327	2.796394e-06	2.090239e-06	2.940219e-06	1.169340e-06	4.365246e-06		
330	-1.439744e-07	-2.752937e-08	-4.530260e-07	-3.226033e-07	-6.683668e-07		
359	-1.944442e-07	-9.390339e-08	-1.545195e-07	-5.461458e-07	2.355809e-07		
367	5.102326e-08	2.732235e-07	8.316511e-07	1.055920e-06	7.192275e-08		
374	3.666775e-07	1.623419e-07	8.428063e-07	6.893392e-07	9.046539e-07		
376	3.474151e-07	3.743532e-07	7.178131e-07	1.723128e-07	7.472329e-07		
380	6.099049e-07	5.614783e-07	9.338324e-07	3.692537e-07	1.194396e-06		
412	8.017237e-07	7.815364e-07	1.151013e-06	2.783667e-07	1.640323e-06		
448	2.674925e-07	1.522287e-07	5.709416e-07	3.856523e-07	7.549497e-07		
449	4.414642e-08	4.061277e-08	2.852734e-07	2.122738e-07	3.483478e-07		
472	-1.396741e-07	-3.947399e-07	-1.928038e-07	2.586927e-07	-4.617290e-07		
...	
1484	2.150952e-07	4.445200e-07	6.552300e-07	6.628911e-07	1.746392e-07		
1487	3.145278e-07	5.585987e-07	8.368257e-07	2.927857e-07	9.673458e-07		
1493	3.380689e-07	3.492275e-07	4.930782e-07	4.644372e-08	7.344268e-07		
1505	1.626273e-06	1.255082e-06	3.041074e-06	1.773491e-06	3.473653e-06		
1506	4.514056e-07	3.956492e-07	6.721796e-07	3.043431e-07	8.038002e-07		
1512	5.209695e-07	3.280083e-07	7.366475e-07	5.544598e-07	9.939861e-07		

1564	1.317739e-06	1.094305e-06	1.777408e-06	8.578078e-07	1.645466e-06
1571	-2.026112e-07	1.825196e-08	-8.496974e-08	-2.928995e-07	-2.079936e-07
1588	2.602370e-07	6.969048e-07	8.481081e-07	-2.423508e-07	1.171749e-06
1600	1.846725e-06	7.782714e-07	1.720895e-06	1.578414e-06	2.459608e-06
1620	5.168083e-07	4.595469e-07	7.957698e-07	3.097845e-07	9.693662e-07
1657	2.112495e-06	1.280294e-06	2.152961e-06	1.566342e-06	2.929932e-06
1667	4.472272e-07	-5.517773e-08	8.811558e-07	1.812333e-06	9.159524e-07
1670	6.393808e-07	4.586510e-07	1.198087e-06	9.298488e-07	1.215380e-06
1672	8.230936e-07	7.295237e-07	1.421843e-06	6.510119e-07	1.878489e-06
1679	9.428690e-07	6.635798e-07	1.177620e-06	8.611005e-07	1.584118e-06
1681	1.579157e-06	8.851614e-07	1.586546e-06	7.143868e-07	2.750503e-06
1688	7.279257e-07	6.294106e-07	1.907779e-06	1.735708e-06	1.564130e-06
1690	2.899656e-06	1.585381e-06	2.563923e-06	1.661432e-06	3.993180e-06
1694	1.019781e-06	1.676609e-06	3.091634e-06	1.476690e-06	2.634748e-06
1704	2.685364e-07	4.436881e-07	5.060659e-07	-6.232338e-07	7.826192e-07
1721	7.639075e-07	5.493577e-07	7.560736e-07	1.903555e-07	1.311788e-06
1725	3.195440e-07	2.735363e-07	2.536710e-07	-9.426124e-08	5.160510e-07
1744	7.391914e-07	4.982480e-07	2.902134e-07	-2.531878e-08	6.860374e-07
1775	1.683130e-06	8.037874e-07	1.476297e-06	1.078946e-06	1.982013e-06
1780	8.037874e-07	1.065473e-06	1.289106e-06	5.807984e-07	1.296437e-06
1782	1.476297e-06	1.289106e-06	2.742392e-06	1.672931e-06	2.674117e-06
1803	1.078946e-06	5.807984e-07	1.672931e-06	1.874298e-06	1.616747e-06
1814	1.982013e-06	1.296437e-06	2.674117e-06	1.616747e-06	3.618294e-06
1835	7.708918e-07	3.308720e-07	9.199524e-07	5.260906e-07	1.435195e-06

1835	
27	4.672121e-07
73	1.259534e-06
114	2.660176e-07
116	2.567133e-07
120	-1.140828e-06
123	-1.198483e-07
127	2.963786e-07
131	-1.820445e-07
167	2.414678e-07
184	3.671011e-07
197	5.158412e-07
204	1.499554e-06
205	1.234036e-06
221	1.740641e-06
227	5.243372e-07
243	-1.037982e-09
278	1.017871e-06
299	7.215381e-07
300	-3.091464e-07
327	1.108878e-06
330	-3.820993e-07

```
359  2.241112e-07
367 -4.415292e-07
374  5.813932e-07
376  3.560481e-07
380  5.951296e-07
412  5.656373e-07
448  3.552267e-07
449  1.904815e-07
472  3.051094e-08
...
...
1484 -5.735013e-07
1487 5.200514e-07
1493 4.194269e-07
1505 1.503975e-06
1506 5.031449e-07
1512 4.995350e-07
1564 1.537764e-06
1571 1.463964e-07
1588 3.088637e-07
1600 4.573833e-07
1620 4.212026e-07
1657 1.294322e-06
1667 -2.039526e-08
1670 3.216362e-07
1672 7.951304e-07
1679 5.219136e-07
1681 9.711554e-07
1688 8.347263e-07
1690 1.188735e-06
1694 1.386724e-06
1704 6.223980e-07
1721 5.329050e-07
1725 5.401315e-07
1744 -2.033320e-07
1775 7.708918e-07
1780 3.308720e-07
1782 9.199524e-07
1803 5.260906e-07
1814 1.435195e-06
1835 1.682160e-06
```

[100 rows x 100 columns]

```
[382]: port_std_252 = []
for i in np.arange(len(weight252)):
    port_std_252.append(np.sqrt(weight252[i] @ rw_252_cov.to_numpy() @
                                weight252[i].T))
```

port_std_252

[382] : [0.0007567663620790721,
0.000755963163409917,
0.0007548843467688334,
0.0007539786307041914,
0.0007535840589166914,
0.0007524874104496,
0.0007481607478823567,
0.0007476780947567991,
0.0007481571437778202,
0.0007483210737579717,
0.0007479717899060654,
0.0007466511939496373,
0.0007477224739674722,
0.0007493213160447835,
0.0007468690955042748,
0.0007436302692595085,
0.0007408410361450065,
0.0007393572052806658,
0.0007388418847026883,
0.0007376149031028665,
0.0007370596073607003,
0.0007376269015046035,
0.0007371274024480294,
0.0007336333799530637,
0.0007344617522730917,
0.0007342918695990247,
0.0007356073479028532,
0.0007343990016507947,
0.0007338917373274982,
0.0007314828211614422,
0.0007323260629856522,
0.0007296759415637043,
0.0007314837371777999,
0.0007292566093868419,
0.0007297849477039671,
0.0007298058102343318,
0.0007253446395210976,
0.0007211808627910556,
0.0007226597914581557,
0.0007271884218985389,
0.0007281213229357134,
0.0007276636903427913,
0.0007262219582527855,
0.0007274602679535608,
0.0007257788746800774,

0.000726895410023017,
0.0007297402351997337,
0.0007286790379683008,
0.0007285587642363013,
0.0007340601563584008,
0.0007336856954166366,
0.0007382708058614238,
0.000738376105100678,
0.0007363604558758613,
0.0007341159941413923,
0.0007329736348353713,
0.0007312609996528361,
0.0007308234130691253,
0.0007276314133812993,
0.0007276531978341653,
0.000733629116844287,
0.000733125279071323,
0.0007353398961055418,
0.0007390083848542919,
0.0007352974937761442,
0.0007375426462761541,
0.0007406681154187573,
0.000738667204192927,
0.0007399109058041484,
0.0007408270250467778,
0.0007420680619422901,
0.0007424140149363765,
0.000744617199601143,
0.0007425829570899229,
0.0007436133554092828,
0.0007464472218436966,
0.0007453696397188112,
0.0007446107187347185,
0.0007453168556095502,
0.0007456032550983693,
0.000743723376045006,
0.0007407257373171906,
0.000738727303092187,
0.0007382004102034216,
0.0007430680638855737,
0.0007410148116769779,
0.0007419277915315976,
0.0007423199969467744,
0.000740470031940917,
0.000739226578847971,
0.000743552776039154,
0.000744316389830214,

0.0007433484637173588,
0.0007418492376678428,
0.000743617048884164,
0.0007466407569790629,
0.0007461088831172936,
0.0007439405055805576,
0.0007449258241857233,
0.000743919004986274,
0.0007433984296543501,
0.0007428214371208475,
0.0007460334359681192,
0.0007445073966759472,
0.0007410820517853537,
0.0007419573906743297,
0.0007390041291727793,
0.0007383824409481045,
0.0007371724223765261,
0.000734820309351227,
0.0007342887847959357,
0.0007348473566702517,
0.0007317770518628635,
0.0007308326065119432,
0.0007295526459403363,
0.0007283401635819957,
0.0007316716936198968,
0.0007355947496546763,
0.0007358417421547325,
0.0007344559999770612,
0.0007355125777351789,
0.0007319326515634441,
0.0007315130669021905,
0.0007307095955376292,
0.0007348724102175185,
0.0007315895056105621,
0.0007270871562896165,
0.0007282559263123879,
0.0007249861891236122,
0.0007253717207986809,
0.0007231001889365741,
0.0007244873214567132,
0.0007243732051796645,
0.0007277904728399348,
0.0007284503797186,
0.0007282445569448076,
0.000727774872088092,
0.000729303353672422,
0.0007307226615381889,

0.0007289517704214127,
0.0007282682265960254,
0.000730886405473815,
0.0007315363816222222,
0.00073299682188881,
0.0007322366812040667,
0.0007317321790230344,
0.0007342717115335784,
0.0007326973466085507,
0.0007363843935018935,
0.0007433867464365072,
0.000742790836340409,
0.0007481435054984786,
0.0007443492613582836,
0.0007452296927836316,
0.0007440761583592185,
0.0007462506851081748,
0.0007476788537456204,
0.0007482483199413281,
0.0007475987883151026,
0.0007466429068516437,
0.0007453398284425482,
0.0007447365189722545,
0.0007426713803663083,
0.0007431606818040652,
0.0007436248766014037,
0.0007424271387397124,
0.0007453272324746289,
0.0007437723568483812,
0.000743250187638287,
0.0007429910343231916,
0.0007426151968981664,
0.0007435289017145982,
0.0007433775496385429,
0.000742037132847761,
0.0007402388359051302,
0.0007412582601335441,
0.0007409596103946671,
0.000747046135182547,
0.0007492727630010921,
0.0007471072460012615,
0.000746855714674111,
0.000744093335738346,
0.000744095347785563,
0.0007426770654480021,
0.0007395933021876126,
0.0007385493717768124,

0.0007392916582388998,
0.0007409666234866728,
0.0007413322943451882,
0.0007419512198413852,
0.0007452102569008731,
0.0007459920101070058,
0.0007469304288160386,
0.0007459206130353636,
0.0007478382533027431,
0.0007449461026386101,
0.0007441274926033657,
0.0007464934925160952,
0.0007484489038203863,
0.0007475197825494488,
0.0007448607460347392,
0.0007426957039872075,
0.0007408723306469327,
0.0007384829917745096,
0.0007394720972507301,
0.0007380133675431779,
0.0007401922252309372,
0.000743089920033895,
0.0007418505450228197,
0.0007429468923463723,
0.0007399724190360138,
0.0007404114290658288,
0.0007367098570464834,
0.0007372058959657143,
0.0007370391873948815,
0.0007373056447526935,
0.0007385756684450388,
0.0007369770022859349,
0.0007374977444245123,
0.0007374979896179844,
0.0007367647770284555,
0.0007364501746520743,
0.000737391163987761,
0.0007379977553603506,
0.0007361219865069264,
0.0007368554862155728,
0.0007388173495429556,
0.0007383028972613194,
0.000738768277945781,
0.0007366566575756427,
0.000733583954301022,
0.0007323998129219187,
0.0007328051303023255,

0.0007328198164129705,
0.0007334420508350053,
0.000733546602381526,
0.0007294319164091325,
0.000728345483006567,
0.000729314858934162,
0.0007333230564174167,
0.0007330398890816021,
0.0007327758028320119,
0.000735570415822089,
0.0007365435011088962,
0.0007340002253801237,
0.0007312201662795705,
0.0007316817200757247,
0.000731023971409706,
0.0007323079501593458,
0.0007301112632304917,
0.0007306304913615179,
0.0007300286051026595,
0.0007279408950503104,
0.0007288878413538034,
0.000731270236419171,
0.0007273433932052103,
0.0007255102424947336,
0.0007243648233906485,
0.0007249393707531696,
0.0007248628646399779,
0.0007230087734728006,
0.0007229793498624737,
0.0007226561578015232,
0.0007234642808224514,
0.0007227271005251565,
0.0007221594153683002,
0.0007244506810410114,
0.0007256362760108946,
0.0007263747875759824,
0.0007270204357027737,
0.0007292171135302328,
0.0007291813252071474,
0.0007358536963510023,
0.0007377890958073792,
0.0007411222346867431,
0.0007416636970109053,
0.0007422791541790167,
0.0007431347195036127,
0.0007396544421040859,
0.0007397741732848859,

0.0007396588261535462,
0.0007384791660373049,
0.0007369705594975709,
0.0007361603185320515,
0.0007330034816714395,
0.0007313782447128099,
0.0007294456266449832,
0.0007276691792017314,
0.0007261042350903965,
0.0007274505820879332,
0.0007230487939147552,
0.0007230781403310862,
0.0007232445302571741,
0.0007242867009036222,
0.0007242140735272482,
0.0007244040649969023,
0.0007241840598577085,
0.0007244570207665868,
0.0007242722123626725,
0.0007221550049353506,
0.0007207794994086196,
0.0007187714555521429,
0.0007158443103533166,
0.0007152374619575261,
0.0007166430328033167,
0.0007167301298932834,
0.0007166156721168812,
0.0007160295151268807,
0.0007145917875270943,
0.0007133125625588134,
0.0007117623358121732,
0.0007109867616066631,
0.0007131360508850295,
0.0007140135520522876,
0.0007136788246403429,
0.0007125651387566069,
0.0007110467404617719,
0.0007077104036678968,
0.0007084817128933913,
0.000710737861530434,
0.0007110270287579931,
0.000710551474617659,
0.0007118672734351648,
0.0007115439273836301,
0.0007125078250425744,
0.000712320369505553,
0.000710349806732077,

0.0007067412196653451,
0.0007073098735962686,
0.0007093106927114708,
0.0007096510450721866,
0.0007142007793935344,
0.0007126900725548646,
0.0007123562277366436,
0.0007126323138347538,
0.0007109920170081377,
0.0007099987883814427,
0.0007084415227328422,
0.0007068163860835851,
0.0007069315360310496,
0.0007083866802664897,
0.000711205779462259,
0.0007146795458774761,
0.0007146885844386883,
0.0007160737388012315,
0.0007191164184819472,
0.0007186746475976505,
0.0007188605148060906,
0.0007199230237197575,
0.0007203712734831642,
0.0007208530629827304,
0.0007199205824292706,
0.0007187442821820814,
0.000718235367908996,
0.0007079495908757287,
0.0007082490834245175,
0.0007089137498387365,
0.0007110380537520441,
0.0007131124709187217,
0.0007164297853481916,
0.0007127691163039794,
0.0007130484425802936,
0.0007126556881534647,
0.0007106538013451194,
0.0007104426445296541,
0.0007095878100790118,
0.0007089875243568054,
0.0007122302066879744,
0.0007118284903547384,
0.0007115582231807842,
0.0007106976243616399,
0.0007090059445596559,
0.00070966822914976,
0.0007095200139284082,

0.000709482951495532,
0.0007075156163978208,
0.0007080066005155589,
0.0007073836518307883,
0.0007062076548405346,
0.0007041631943672975,
0.0007090982854731215,
0.0007079298312061762,
0.0007060895367332864,
0.000706127925692871,
0.0007038454653069507,
0.0007025679629362513,
0.0007025483631244908,
0.0007040634895698493,
0.0007048152147829951,
0.0007053046576086868,
0.0007060610220347075,
0.0007056860795093392,
0.0007087517290712855,
0.0007064997082421802,
0.0007066163315024736,
0.0007073858751475688,
0.000709245450988834,
0.0007072944848131464,
0.0007107989921237232,
0.000710223554843873,
0.0007086877291133845,
0.0007073494363046952,
0.0007057608464182126,
0.0007032199770670434,
0.0007043701823216406,
0.0007048989259942287,
0.0007065265175022206,
0.0007053859548168942,
0.0007060226943010556,
0.0007075206662277361,
0.0007070827527241892,
0.0007078840656037909,
0.0007087619549541001,
0.0007103569456849734,
0.0007079716030585105,
0.0007080623449360734,
0.0007083707039141206,
0.000708726831144798,
0.0007095163560607141,
0.0007022355295342117,
0.000703120808388952,

0.0007032956123566714,
0.0007042206998714152,
0.0007052630839343742,
0.0007056290460939417,
0.0007065503703853775,
0.0007053885846848632,
0.0007041356273009055,
0.0007037011729130109,
0.0007038684152313826,
0.0007042521190518476,
0.000708002332472029,
0.0007103132870292736,
0.0007094541393398748,
0.0007112165285014569,
0.0007138237034632298,
0.0007160441397171949,
0.0007158136827393513,
0.0007127601342644547,
0.0007127240486164021,
0.0007127333557673537,
0.0007148557504037919,
0.0007143655282533832,
0.000713159959794842,
0.0007148670941303341,
0.0007160394608302765,
0.0007176022333385205,
0.0007184580868119861,
0.0007183025745252317,
0.0007167254610186001,
0.0007179635194688995,
0.0007200218753808072,
0.0007220824598058799,
0.0007202816756854636,
0.0007196587259345243,
0.0007179245846721522,
0.000717743840301114,
0.0007182354488488096,
0.0007193166296992659,
0.0007192756591589642,
0.0007207544459815944,
0.0007597012307788134,
0.000758307427207289,
0.0007590471623732582,
0.00075779934676653,
0.0007559427375439837,
0.0007555913771425066,
0.000754741347135562,

0.000757077660118418,
0.0007558937230184722,
0.0007568262752370174,
0.0007546024990948846,
0.0007546309238640866,
0.0007579904801792056,
0.0007576478825769851,
0.0007592234149264793,
0.0007582683385205695,
0.000759022478757907,
0.00075803721551436,
0.0007570135507489607,
0.0007543280887411533,
0.000753608839327752,
0.0007511052417025333,
0.000752555071825312,
0.0007538658574098667,
0.0007545339403071919,
0.000754200010035069,
0.0007565288566670878,
0.0007596140899591218,
0.0007608138317667353,
0.000761638904826262,
0.0007621227013747174,
0.0007620931346568001,
0.0007636837781028074,
0.0007656780124792541,
0.0007663756579677062,
0.0007670197770503243,
0.0007680901438130856,
0.0007700822471370073,
0.0007711946735420937,
0.0007695547867740502,
0.0007692976281316443,
0.0007678753462220519,
0.0007732089014225762,
0.0007767549770696348,
0.0007757824676913103,
0.0007771239951309758,
0.000777405168122192,
0.0007795578571381219,
0.0007815739905485017,
0.0007813903289981391,
0.0007815585037179451,
0.0007811735885302583,
0.0007821141736050589,
0.0007782453996365394,

0.000779367904534628,
0.0007796595216757869,
0.0007778517575317897,
0.000775736763187521,
0.00077468978535161,
0.0007734522292616123,
0.000777111598300881,
0.0007757029723040657,
0.000773299261048586,
0.0007739606796361157,
0.0007739876191010295,
0.0007752590951530207,
0.0007766361165860434,
0.0007741169488634038,
0.0007741693423169348,
0.0007737401642313175,
0.0007733734139046708,
0.0007733829160854527,
0.0007750653490667483,
0.0007738910983902474,
0.0007749414925794193,
0.0007750513820670555,
0.0007746057315362513,
0.0007740899700151089,
0.0007702214932177368,
0.0007684237123289977,
0.0007632535399434725,
0.0007632599928686432,
0.0007620083477194316,
0.0007612404572041342,
0.0007614484711011332,
0.0007601508134373015,
0.000759453633524392,
0.0007599397982576754,
0.0007592139791669174,
0.0007569873080276343,
0.000755655421923507,
0.000755540712014119,
0.000757334818588653,
0.0007569577238636842,
0.0007586947841959821,
0.0007573229252552374,
0.0007535090829302175,
0.0007525444725993522,
0.0007549319852621289,
0.0007552227161498648,
0.0007546176264103983,

0.0007547852706497471,
0.0007552030006540906,
0.0007568240127291956,
0.0007581161260007532,
0.0007590415658467887,
0.0007620769277261143,
0.0007620555175758405,
0.0007625434095321926,
0.0007624453131846094,
0.0007625107980322843,
0.0007643152499347973,
0.00076283826545976,
0.0007603029364159791,
0.0007595586648218687,
0.000759071385748491,
0.0007566404234385165,
0.0007577399171222704,
0.0007585951773794843,
0.0007590712193774699,
0.0007555724020932155,
0.0007525213051890519,
0.0007531551603177711,
0.0007520129379452279,
0.0007523395640032669,
0.000752842978481241,
0.0007539385554843086,
0.0007552664120856676,
0.0007561173076855724,
0.0007534897167830934,
0.0007533808402525708,
0.0007519156495039954,
0.0007513459103066822,
0.0007496698066548985,
0.0007507827594888754,
0.0007505552218279723,
0.000749384819498545,
0.0007500761588858782,
0.0007484005818294982,
0.0007493409182662399,
0.0007493050665091557,
0.0007492321006859468,
0.0007487505419785832,
0.0007478552628495409,
0.0007472184695254119,
0.0007460895023365557,
0.0007448275586629527,
0.0007454041465454275,

0.0007445828904757519,
0.000744949076849656,
0.0007458122380013304,
0.0007456918030488886,
0.000745267552707941,
0.0007453110559947023,
0.0007458764362725112,
0.0007452818767839984,
0.0007460181316622966,
0.0007486587434383061,
0.0007541375732895983,
0.0007503789504420672,
0.0007516534360793955,
0.0007507925928918901,
0.0007506696751726135,
0.000749722243109119,
0.0007496943967884099,
0.0007489746480136098,
0.0007516507625961919,
0.000750548871694037,
0.0007483268477219368,
0.0007464025999028224,
0.0007456252055831528,
0.0007444766876358582,
0.000743913682100915,
0.0007400508212953269,
0.0007413172177569122,
0.0007418695528149295,
0.0007432514017107208,
0.0007435201200677696,
0.000743080408145672,
0.0007423381820704829,
0.00074258995218176,
0.0007434939827355398,
0.0007431987624395944,
0.000740945215886661,
0.000741258567467244,
0.0007415730922905713,
0.000741561438283627,
0.0007372116572516792,
0.0007393608164951549,
0.000739622082881875,
0.0007381653695718823,
0.0007383994822076725,
0.0007412451031756981,
0.000740856392789959,
0.0007401561012697405,

0.0007403586319712887,
0.000736034997118984,
0.0007373470272316705,
0.0007385661979634952,
0.0007380241435987323,
0.0007371624574678994,
0.0007388014196062425,
0.0007394245776864492,
0.0007395558643807892,
0.0007372446303045486,
0.0007380102351432991,
0.0007358682274793901,
0.0007371693910405359,
0.000735378186553992,
0.0007346312825171486,
0.0007358553553224565,
0.0007359114206180041,
0.0007342757878899327,
0.0007326171836684853,
0.0007324752081685259,
0.0007335235498027382,
0.0007332115735229445,
0.000736721584389478,
0.0007334794805210705,
0.000730637654991003,
0.000732415423042922,
0.0007314165148454257,
0.0007305103613149014,
0.0007292384405936934,
0.0007285248387248625,
0.0007311402505879377,
0.0007308674696646411,
0.000731276994814443,
0.0007324329151565338,
0.0007335661891362491,
0.0007339980667645127,
0.0007354459429599666,
0.0007363044684072465,
0.0007359647136713097,
0.0007373385383517446,
0.0007384992546844265,
0.0007381944657518665,
0.0007384721088720751,
0.0007389311097744445,
0.0007368175753883783,
0.0007372622374165148,
0.0007396110701909291,

0.0007371602088859583,
0.0007419963179820831,
0.0007441663115367639,
0.0007443262364012731,
0.0007447521602905493,
0.0007423051496171301,
0.0007456634779656365,
0.0007429073036920094,
0.0007446376898979086,
0.0007495493465512724,
0.0007507070930781424,
0.0007498830365284832,
0.0007481946177155728,
0.0007500845995427218,
0.000749745695371664,
0.0007477894987472654,
0.0007498014660185028,
0.0007500521173294618,
0.000751275284756421,
0.0007494416182477778,
0.0007513592890738528,
0.0007493706244013939,
0.0007450067152197892,
0.000744322248599669,
0.0007449543364449561,
0.000744422332195819,
0.000744443677308037,
0.0007463791337626619,
0.0007495353865078192,
0.0007489894859156243,
0.0007465534479743858,
0.000748108968943501,
0.0007487737453522882,
0.0007439871981568164,
0.0007467644559827736,
0.0007463912862160363,
0.0007461282200935556,
0.0007461782280411039,
0.0007426723870974766,
0.0007420364155939903,
0.0007442004038784429,
0.0007419032132403115,
0.000741723280616596,
0.000741645637106648,
0.0007418695572296957,
0.0007434466897932839,
0.0007457729890063649,

0.0007465051376682378,
0.0007453480988511774,
0.0007451281074489686,
0.000744569256160447,
0.00074463328779758,
0.0007482490101871155,
0.0007438943708801661,
0.0007433817247429073,
0.0007431640582961779,
0.000742071721966178,
0.0007453201908745085,
0.0007467084682948084,
0.000747586493067842,
0.0007457309086137217,
0.0007484204934416285,
0.00075161512773016,
0.0007501870249630909,
0.0007501762933013684,
0.000750073890886197,
0.0007522054128742391,
0.0007504935210267792,
0.0007481115879185718,
0.0007498394037530033,
0.0007502941868681819,
0.0007518165559118104,
0.0007534786793495479,
0.0007528326210858282,
0.0007512790456718825,
0.0007528372262021334,
0.000751021604096789,
0.0007516433385137869,
0.0007505275214126776,
0.0007551752023526021,
0.0007552427985448636,
0.0007538387909294721,
0.0007541062666952642,
0.0007498940572494025,
0.0007486012614122977,
0.0007499699460403623,
0.0007478457334166423,
0.0007487146755769189,
0.0007472190405161709,
0.0007483939376931029,
0.0007449253414047483,
0.0007446331688649165,
0.0007439514807351833,
0.0007458838223161893,

0.0007451066937770132,
0.0007400119401550607,
0.0007412293922868737,
0.000738350154718738,
0.0007412675058173834,
0.00074049899407359,
0.0007384442427839419,
0.0007362649316109368,
0.0007363841514574886,
0.0007380339558236545,
0.0007429151438781137,
0.0007461122908720969,
0.0007531074165387769,
0.0007554298261878797,
0.0007511090750211753,
0.0007449793508747376,
0.0007414361096398936,
0.0007425056435311123,
0.000747374558612281,
0.0007467454185437502,
0.0007481935572952265,
0.0007469700696523604,
0.000747169841692145,
0.0007478168471956989,
0.00074490985333793,
0.0007457571267792547,
0.0007427906650081193,
0.0007408318548123141,
0.0007407931422427357,
0.0007394948616618773,
0.0007395599121527232,
0.0007383642333796932,
0.0007397660543020331,
0.0007375269100933234,
0.0007385023038795787,
0.0007449719785713705,
0.0007472456826198931,
0.0007452414897778959,
0.0007451123544692823,
0.0007436528650658203,
0.0007507959306257862,
0.0007511034526628001,
0.0007539438298535991,
0.0007544991590551766,
0.0007529220113656001,
0.0007533943195659893,
0.0007522100185450079,

0.0007528540479627782,
0.0007527537712092153,
0.0007527382578113959,
0.0007560613401142097,
0.0007530228643162579,
0.0007493311579778056,
0.0007470996494709381,
0.000747706480788954,
0.0007501174520083707,
0.0007501386301409415,
0.0007542045073387029,
0.0007524784597638059,
0.0007545362293914194,
0.0007543602621935975,
0.000751753014072031,
0.0007531180148713203,
0.0007534481094965692,
0.0007545518650237774,
0.0007509945787295986,
0.0007484575912286767,
0.0007482763010271018,
0.0007461139222791694,
0.0007464360802987204,
0.0007502019637404394,
0.0007486239227982849,
0.00074792633710361,
0.0007493163939287918,
0.000753965114467125,
0.0007500822565072973,
0.000750340188343442,
0.0007490390983565207,
0.0007500300421794632,
0.0007476110315054311,
0.0007451828643368641,
0.0007466813831821574,
0.0007469424077000265,
0.0007447472948940249,
0.0007463566799018184,
0.0007452488442638515,
0.000746884901982371,
0.0007466943894473732,
0.0007477742700012541,
0.0007510349915792226,
0.0007490071116019082,
0.0007529261142081102,
0.0007640939116052762,
0.000774329564755782,

0.0007776220793913132,
0.0007729494531667411,
0.0007736388240721679,
0.0007750316965364179,
0.000772832002420672,
0.0007756381066617115,
0.000771449635019554,
0.0007753148821789144,
0.0007702182103797439,
0.0007703359712116896,
0.0007709051359916172,
0.0007730495919978799,
0.000777342511897649,
0.0007739758796503905,
0.0007721722516151141,
0.0007773270512442612,
0.0007806673179555935,
0.0007790191670204551,
0.0007745389504709553,
0.0007743316920803404,
0.0007772740438298495,
0.0007765214192003584,
0.0007748224595760415,
0.0007739670936375702,
0.0007718133463496592,
0.0007741777344996911,
0.0007739518019903616,
0.000775328388626691,
0.0007760335792575807,
0.0007773330615212513,
0.0007786399960502102,
0.0007843623515304014,
0.0007818471964223044,
0.0007767422649742538,
0.0007775781542167375,
0.0007795283850944312,
0.0007779793749928501,
0.0007768820394726991,
0.0007742513397515844,
0.0007678495504685743,
0.0007704850299165225,
0.0007700302398656794,
0.000760334763692596,
0.000760450016440237,
0.000757256893963938,
0.0007507125799125362,
0.0007541194145998094,

0.0007616131499518664,
0.0007588187744600901,
0.0007637637312304986,
0.000766858590459869,
0.0007603118222510942,
0.0007541999724063805,
0.0007496659546094868,
0.0007520518644198919,
0.0007487409149422399,
0.0007534775473879071,
0.0007594458043030089,
0.0007653126921831841,
0.0007661859994588911,
0.0007637603688685516,
0.0007589836758489152,
0.0007504926407652322,
0.0007472345134544451,
0.0007523625177578938,
0.0007491006992399011,
0.0007396457526126061,
0.0007354030556498513,
0.0007259518083747675,
0.0007291180612126973,
0.0007249555825559775,
0.0007335771572166696,
0.0007331029401327384,
0.0007326348563080858,
0.0007301761714650918,
0.0007324971980485098,
0.0007373751920238814,
0.0007322070604150285,
0.000727956654519421,
0.0007280755508111593,
0.0007214395852041081,
0.0007225057548411979,
0.0007185693533028192,
0.0007175675396036278,
0.000716156546188375,
0.0007152741875173324,
0.0007098555695747332,
0.0007106165429555352,
0.0007088212820387287,
0.0007172520730761252,
0.0007089191552447461,
0.0007108833939457911,
0.0007136724100432852,
0.0007178430331211487,

```

0.0007154207510829946,
0.0007231355992895862,
0.0007282550871850522,
0.0007324098958885595,
0.0007359453961861857,
0.0007412528201826965,
0.0007439329036628718,
0.0007426974907672998,
0.0007350761208320094,
0.0007354780753517792,
0.0007327338062550557,
0.0007395798989976818,
0.0007401565253920882,
0.0007417002342947638,
0.0007474276586373283,
...
]
```

[383]: `np.shape(port_std_252)`

[383]: (1259,)

```

[384]: #rw = 126
rw_126 = {}
for i in secdata_rnd_100['Ticker'].unique():
    key = i
    value = list(secdata_rnd_100.loc[secdata_rnd_100['Ticker'] == i].Returns.
    ↪rolling(126).mean().dropna().reset_index(drop=True))
    rw_126[key] = value

```

```

[385]: rw126_df = pd.DataFrame.from_dict(rw_126, orient='index')
rw_126_cov = rw126_df.T.cov()
rw_126_cov

```

	27	73	114	116	120	\
27	3.980169e-06	6.562136e-06	2.386244e-06	1.709411e-06	-6.794196e-07	
73	6.562136e-06	2.731853e-05	3.781738e-06	5.992908e-06	-3.492124e-06	
114	2.386244e-06	3.781738e-06	3.373018e-06	1.142645e-06	-6.839585e-07	
116	1.709411e-06	5.992908e-06	1.142645e-06	3.060137e-06	-9.160074e-07	
120	-6.794196e-07	-3.492124e-06	-6.839585e-07	-9.160074e-07	3.486598e-06	
123	3.032259e-06	8.360375e-06	2.790313e-06	1.057860e-06	-9.396433e-07	
127	2.622891e-06	6.045843e-06	1.951906e-06	1.420230e-06	-5.254044e-07	
131	-5.495537e-08	-1.376990e-06	1.160754e-07	-2.827623e-07	4.018107e-07	
167	7.328272e-07	2.653637e-07	4.753286e-07	2.301500e-07	-1.256166e-07	
184	1.258178e-06	1.634241e-06	1.222508e-06	2.591396e-07	-4.017575e-07	
197	2.097158e-06	4.014905e-06	1.551545e-06	1.452063e-06	-8.625300e-07	
204	4.304275e-06	1.620413e-05	2.686343e-06	4.519117e-06	-3.182033e-06	
205	2.925717e-06	7.013996e-06	2.385886e-06	2.060537e-06	-9.711124e-07	

221	7.486855e-06	1.912672e-05	5.228828e-06	6.414265e-06	-2.661532e-06	
227	8.655748e-07	2.940312e-06	2.190296e-07	1.014267e-06	-1.273993e-06	
243	1.934512e-07	-2.369259e-07	3.346405e-07	-6.906759e-09	-1.136797e-07	
278	4.589448e-06	1.420525e-05	2.307084e-06	4.980715e-06	-1.589967e-06	
299	1.000830e-06	4.270577e-06	4.154279e-07	8.605966e-07	-1.699266e-06	
300	5.379120e-07	-1.943393e-07	1.377354e-06	-9.384028e-08	1.606418e-06	
327	2.278292e-06	6.574628e-06	3.440709e-06	3.562570e-06	-1.639421e-06	
330	-6.482319e-07	-3.513286e-06	-7.061308e-07	-1.245557e-06	1.021398e-06	
359	6.756263e-07	9.691225e-07	1.412050e-07	2.030443e-07	1.613767e-07	
367	2.946703e-06	4.455616e-06	2.207346e-06	1.865744e-06	2.864349e-07	
374	1.422486e-06	7.789130e-06	6.395592e-07	2.988712e-06	-2.144673e-06	
376	1.703120e-06	3.300963e-06	1.717421e-06	1.606683e-06	-1.141589e-06	
380	1.204180e-06	3.457886e-06	1.261193e-06	3.935409e-07	-8.355987e-07	
412	1.230450e-06	3.072685e-06	1.186980e-06	8.077308e-07	-3.616157e-07	
448	1.027991e-06	4.175283e-06	5.698604e-07	1.419004e-06	-5.114351e-07	
449	5.157307e-07	2.567611e-06	9.751475e-08	7.892306e-07	-2.598186e-07	
472	1.172876e-06	2.603859e-06	8.742830e-07	8.488523e-07	-4.956448e-07	
...
1484	1.156221e-06	2.498228e-06	6.693672e-07	-1.005141e-08	9.863805e-07	
1487	2.491625e-06	7.448285e-06	2.237759e-06	2.032068e-06	-1.218935e-06	
1493	8.427171e-07	1.169966e-06	5.879679e-07	-1.211263e-07	-2.717058e-07	
1505	5.416510e-06	1.293611e-05	3.529900e-06	3.740322e-06	-2.115635e-06	
1506	1.198454e-06	2.405051e-06	7.802559e-07	6.510120e-07	-7.213338e-07	
1512	1.598345e-06	3.864569e-06	8.630741e-07	6.856805e-07	-4.893212e-07	
1564	5.371771e-06	6.635605e-06	5.760598e-06	2.260993e-06	-3.140853e-06	
1571	4.308840e-07	-1.097996e-06	3.893522e-07	4.475738e-08	-2.609596e-07	
1588	8.412038e-08	-4.738789e-07	5.271006e-07	7.834986e-07	3.655425e-07	
1600	2.665618e-06	5.954364e-06	2.078172e-06	1.929446e-06	1.811311e-07	
1620	1.579250e-06	3.368381e-06	1.730872e-06	9.641860e-07	-8.081303e-07	
1657	4.516659e-06	8.750935e-06	3.976902e-06	2.837943e-06	-2.119597e-06	
1667	2.320963e-06	1.183044e-05	-2.915804e-07	2.558805e-06	-7.554375e-08	
1670	2.000924e-06	5.411434e-06	1.474221e-06	1.666449e-06	-3.843279e-07	
1672	1.835287e-06	5.400638e-06	1.179689e-06	1.503327e-06	-7.943080e-07	
1679	1.118343e-06	6.607812e-06	8.074456e-07	1.947765e-06	-1.124038e-06	
1681	2.650121e-06	8.239023e-06	1.521474e-06	1.482388e-06	-5.952221e-07	
1688	4.609686e-06	1.239114e-05	4.140365e-06	3.351299e-06	-2.259076e-06	
1690	4.448591e-06	1.271335e-05	3.265334e-06	4.195151e-06	-2.293385e-06	
1694	3.072733e-06	6.087887e-06	2.658778e-06	2.713813e-06	-2.623784e-06	
1704	1.630429e-06	1.550053e-06	1.283752e-06	-4.258252e-07	-7.792624e-07	
1721	1.531820e-06	2.069066e-06	1.026497e-06	5.063631e-07	-4.855818e-07	
1725	2.665091e-07	3.761651e-07	2.404602e-07	2.385332e-07	-6.400495e-07	
1744	1.226509e-06	1.461841e-07	1.651366e-06	-1.280600e-07	1.096972e-06	
1775	2.594889e-06	5.716461e-06	1.310156e-06	2.194529e-06	-8.533676e-07	
1780	1.612636e-06	1.556519e-06	1.507917e-06	4.679634e-07	-3.111645e-08	
1782	4.149812e-06	1.136449e-05	3.989165e-06	3.298453e-06	-1.919215e-06	
1803	3.076943e-06	9.734543e-06	1.478364e-06	3.165515e-06	-1.444111e-06	
1814	3.894036e-06	9.856949e-06	2.622650e-06	3.060504e-06	-1.865962e-06	

1835	1.921329e-06	7.119483e-06	1.253787e-06	1.829339e-06	-3.012064e-06	
	123	127	131	167	184	\
27	3.032259e-06	2.622891e-06	-5.495537e-08	7.328272e-07	1.258178e-06	
73	8.360375e-06	6.045843e-06	-1.376990e-06	2.653637e-07	1.634241e-06	
114	2.790313e-06	1.951906e-06	1.160754e-07	4.753286e-07	1.222508e-06	
116	1.057860e-06	1.420230e-06	-2.827623e-07	2.301500e-07	2.591396e-07	
120	-9.396433e-07	-5.254044e-07	4.018107e-07	-1.256166e-07	-4.017575e-07	
123	9.031634e-06	2.329753e-06	4.331148e-07	3.575014e-07	6.508059e-07	
127	2.329753e-06	2.600530e-06	-1.278916e-07	4.157621e-07	1.036449e-06	
131	4.331148e-07	-1.278916e-07	8.919074e-07	4.992557e-08	6.453317e-07	
167	3.575014e-07	4.157621e-07	4.992557e-08	7.600187e-07	8.841389e-08	
184	6.508059e-07	1.036449e-06	6.453317e-07	8.841389e-08	2.162254e-06	
197	1.249130e-06	1.667168e-06	1.881291e-07	2.568890e-07	1.591147e-06	
204	3.725177e-06	3.913859e-06	-1.082049e-06	9.929256e-07	1.097392e-06	
205	2.406123e-06	2.180885e-06	8.022181e-07	5.145014e-07	2.818160e-06	
221	5.020784e-06	5.938681e-06	-3.555172e-07	4.418182e-07	4.425527e-06	
227	1.722849e-06	5.770062e-07	-1.111606e-07	3.444654e-07	3.491489e-08	
243	2.172893e-07	3.024041e-08	4.947998e-07	7.579327e-08	6.765826e-07	
278	2.710955e-06	3.686598e-06	-1.029499e-06	6.345356e-07	1.347670e-06	
299	1.774198e-06	4.149367e-07	1.191759e-07	-9.373774e-08	6.506703e-07	
300	1.231008e-06	2.591290e-07	2.119577e-07	4.402796e-07	6.120446e-08	
327	1.444314e-06	1.482035e-06	4.885871e-07	4.033294e-07	2.285872e-06	
330	1.063994e-07	-6.370506e-07	4.136288e-07	1.157108e-07	-5.709236e-08	
359	2.026582e-07	2.777480e-07	-3.465041e-07	4.681520e-07	6.125168e-07	
367	2.878574e-06	2.376123e-06	6.941487e-08	4.906128e-07	9.697750e-07	
374	1.251747e-06	1.361139e-06	-6.745943e-07	-1.645384e-07	2.242502e-07	
376	1.473647e-06	1.319056e-06	-4.751973e-08	8.498786e-08	1.493265e-06	
380	1.364869e-06	1.108786e-06	2.284080e-08	9.865869e-09	1.185792e-06	
412	4.133225e-07	9.588209e-07	5.331683e-08	5.777583e-07	8.338960e-07	
448	6.442395e-08	9.826704e-07	-4.216831e-07	1.838329e-07	3.153681e-07	
449	1.465513e-07	6.247408e-07	-3.163343e-07	1.003226e-07	1.064928e-07	
472	1.776186e-06	9.246937e-07	2.288965e-07	-1.909762e-07	9.405626e-07	
...	
1484	2.771915e-06	1.059233e-06	8.928632e-08	8.159538e-08	5.031086e-07	
1487	2.606863e-06	2.179549e-06	-3.885515e-07	7.892893e-07	9.055649e-07	
1493	1.327028e-07	6.649768e-07	8.511690e-08	1.828572e-07	9.299670e-07	
1505	2.911282e-06	4.116938e-06	-6.294715e-07	6.826139e-07	3.159555e-06	
1506	1.043407e-06	8.050190e-07	1.486229e-07	3.704293e-07	8.760391e-07	
1512	1.196778e-06	1.244589e-06	-6.976086e-08	1.071747e-07	1.006076e-06	
1564	6.680971e-06	3.485088e-06	1.246291e-06	7.671525e-07	4.083932e-06	
1571	-6.223655e-07	3.116862e-07	9.348312e-08	5.674025e-08	5.858374e-07	
1588	-1.663249e-06	1.006187e-07	-3.644400e-07	5.751715e-07	1.062864e-07	
1600	2.207332e-06	1.769800e-06	6.480879e-07	-1.881329e-07	2.059207e-06	
1620	1.709943e-06	1.155713e-06	2.447725e-07	4.352606e-07	1.060708e-06	
1657	4.567163e-06	3.182115e-06	5.825935e-07	3.542720e-07	3.354241e-06	
1667	2.980593e-06	2.120053e-06	-1.066789e-06	-2.799389e-07	-5.968734e-07	

1670	1.996870e-06	1.648867e-06	-1.781172e-07	1.417476e-07	8.144917e-07
1672	4.885673e-07	1.627775e-06	-2.438359e-07	4.335206e-07	1.120577e-06
1679	6.902096e-07	1.247730e-06	-5.600747e-07	-2.201063e-07	6.106582e-07
1681	2.586867e-06	1.865499e-06	5.364159e-07	5.884613e-07	2.160509e-06
1688	6.501894e-06	3.839220e-06	-1.215993e-07	7.241688e-07	1.252474e-06
1690	3.333730e-06	3.442747e-06	1.048856e-06	3.566205e-07	3.950877e-06
1694	2.594401e-06	2.306775e-06	-5.504707e-07	1.641992e-06	6.297746e-07
1704	-4.232060e-08	1.364714e-06	6.401282e-07	3.811290e-07	2.846060e-06
1721	4.737082e-07	9.198862e-07	5.055944e-07	5.652726e-07	1.353837e-06
1725	-2.093253e-08	3.911698e-08	-4.016864e-08	1.417443e-07	4.366293e-07
1744	1.371834e-06	6.404782e-07	6.259443e-07	-1.092570e-07	1.554165e-06
1775	1.070666e-06	1.756250e-06	5.826117e-07	2.242523e-07	2.276781e-06
1780	1.754995e-06	9.993661e-07	2.238754e-07	6.987695e-07	8.526874e-07
1782	4.601482e-06	3.492808e-06	-1.085466e-07	6.625585e-07	2.223118e-06
1803	4.120691e-06	2.313914e-06	2.380147e-08	3.872861e-07	6.292456e-07
1814	2.409024e-06	2.991121e-06	2.014578e-07	4.994494e-07	2.777147e-06
1835	2.268347e-06	1.616607e-06	4.276709e-08	1.738287e-07	1.837240e-06

	1704	1721	1725	1744	\
27	...	1.630429e-06	1.531820e-06	2.665091e-07	1.226509e-06
73	...	1.550053e-06	2.069066e-06	3.761651e-07	1.461841e-07
114	...	1.283752e-06	1.026497e-06	2.404602e-07	1.651366e-06
116	...	-4.258252e-07	5.063631e-07	2.385332e-07	-1.280600e-07
120	...	-7.792624e-07	-4.855818e-07	-6.400495e-07	1.096972e-06
123	...	-4.232060e-08	4.737082e-07	-2.093253e-08	1.371834e-06
127	...	1.364714e-06	9.198862e-07	3.911698e-08	6.404782e-07
131	...	6.401282e-07	5.055944e-07	-4.016864e-08	6.259443e-07
167	...	3.811290e-07	5.652726e-07	1.417443e-07	-1.092570e-07
184	...	2.846060e-06	1.353837e-06	4.366293e-07	1.554165e-06
197	...	2.069745e-06	1.317101e-06	5.967284e-07	1.418785e-06
204	...	1.991019e-06	2.132092e-06	5.641288e-07	-7.776664e-07
205	...	2.895342e-06	4.097142e-06	1.607416e-06	3.692289e-06
221	...	3.916898e-06	4.392813e-06	1.873670e-06	4.102965e-06
227	...	9.384710e-08	5.202557e-07	5.054482e-07	-4.142279e-07
243	...	8.958005e-07	6.232127e-07	1.630834e-07	7.154599e-07
278	...	1.259709e-06	1.825431e-06	9.746939e-07	7.168242e-07
299	...	7.549734e-07	9.059251e-07	1.010218e-06	7.967822e-07
300	...	-7.738882e-08	1.091669e-06	6.351952e-07	2.987909e-06
327	...	2.273543e-06	3.857217e-06	1.801554e-06	4.374726e-06
330	...	4.670533e-07	-3.978329e-07	1.723313e-07	7.100612e-07
359	...	1.417982e-06	6.179158e-07	8.187160e-07	8.200014e-07
367	...	1.025832e-06	5.991240e-07	-1.797492e-07	1.093531e-06
374	...	8.502657e-08	2.206924e-07	6.603849e-07	-3.325495e-07
376	...	1.819748e-06	6.900714e-07	9.552200e-07	1.873033e-06
380	...	1.527965e-06	7.777435e-07	5.287369e-07	1.503198e-06
412	...	1.792013e-06	1.622863e-06	5.337091e-07	1.254718e-06
448	...	4.686469e-07	5.576239e-07	3.281683e-07	-1.921511e-07

449	...	6.123892e-08	1.662765e-08	2.131081e-07	-1.809835e-07		
472	...	5.338472e-07	-9.662878e-08	1.607805e-07	3.110247e-07		
...	
1484	...	8.509487e-07	3.010779e-08	1.103153e-07	1.865915e-06		
1487	...	1.674437e-06	1.565436e-06	8.465298e-07	8.267243e-07		
1493	...	1.642575e-06	8.686036e-07	4.587003e-07	1.016908e-06		
1505	...	4.450673e-06	3.516878e-06	1.762995e-06	2.744842e-06		
1506	...	1.317754e-06	8.148234e-07	4.365753e-07	6.759488e-07		
1512	...	9.535943e-07	9.219712e-07	5.078629e-07	1.078445e-06		
1564	...	4.142967e-06	3.244632e-06	1.879107e-06	4.609995e-06		
1571	...	1.306409e-06	-4.911789e-10	2.433550e-07	5.539382e-07		
1588	...	1.258511e-06	2.265398e-07	3.592776e-07	9.845518e-07		
1600	...	8.716179e-07	1.913975e-06	5.602106e-07	3.510307e-06		
1620	...	1.429202e-06	1.283577e-06	4.030273e-07	1.081250e-06		
1657	...	2.288343e-06	3.972395e-06	2.011924e-06	3.984717e-06		
1667	...	-1.845968e-06	2.015871e-08	-2.397769e-07	-6.527486e-07		
1670	...	7.579075e-07	8.963161e-07	4.779962e-07	1.067021e-06		
1672	...	1.857487e-06	1.545635e-06	5.997014e-07	8.641308e-07		
1679	...	5.323183e-07	8.666151e-07	8.700147e-07	7.108580e-07		
1681	...	2.903781e-06	3.517337e-06	1.147323e-06	2.554973e-06		
1688	...	4.439006e-07	1.483176e-06	2.604093e-07	3.919541e-07		
1690	...	5.026142e-06	5.134895e-06	1.821804e-06	4.196827e-06		
1694	...	1.329647e-06	1.353763e-06	8.363507e-07	-5.850946e-07		
1704	...	6.586336e-06	2.144892e-06	6.638327e-07	2.075507e-06		
1721	...	2.144892e-06	2.822296e-06	7.375165e-07	1.479570e-06		
1725	...	6.638327e-07	7.375165e-07	1.160131e-06	7.305082e-07		
1744	...	2.075507e-06	1.479570e-06	7.305082e-07	4.556470e-06		
1775	...	2.759734e-06	2.431905e-06	1.095688e-06	2.065282e-06		
1780	...	1.444944e-06	1.272253e-06	5.927087e-07	1.924051e-06		
1782	...	2.532428e-06	2.544850e-06	9.971069e-07	2.170436e-06		
1803	...	-6.504694e-08	1.403891e-06	2.732288e-07	-9.642848e-08		
1814	...	3.157828e-06	3.158965e-06	1.160710e-06	2.365426e-06		
1835	...	1.953009e-06	1.393261e-06	1.493558e-06	1.108761e-07		
		1775	1780	1782	1803	1814	\
27		2.594889e-06	1.612636e-06	4.149812e-06	3.076943e-06	3.894036e-06	
73		5.716461e-06	1.556519e-06	1.136449e-05	9.734543e-06	9.856949e-06	
114		1.310156e-06	1.507917e-06	3.989165e-06	1.478364e-06	2.622650e-06	
116		2.194529e-06	4.679634e-07	3.298453e-06	3.165515e-06	3.060504e-06	
120		-8.533676e-07	-3.111645e-08	-1.919215e-06	-1.444111e-06	-1.865962e-06	
123		1.070666e-06	1.754995e-06	4.601482e-06	4.120691e-06	2.409024e-06	
127		1.756250e-06	9.993661e-07	3.492808e-06	2.313914e-06	2.991121e-06	
131		5.826117e-07	2.238754e-07	-1.085466e-07	2.380147e-08	2.014578e-07	
167		2.242523e-07	6.987695e-07	6.625585e-07	3.872861e-07	4.994494e-07	
184		2.276781e-06	8.526874e-07	2.223118e-06	6.292456e-07	2.777147e-06	
197		3.189992e-06	1.557064e-06	3.720217e-06	2.280935e-06	3.868218e-06	
204		5.099164e-06	2.255355e-06	9.282372e-06	7.683371e-06	8.177819e-06	

205	6.735484e-06	3.487245e-06	7.940022e-06	5.184085e-06	8.879302e-06
221	1.074201e-05	4.056572e-06	1.434215e-05	9.807043e-06	1.463125e-05
227	1.680000e-06	9.579610e-07	2.412000e-06	2.651079e-06	2.106576e-06
243	7.324347e-07	2.141172e-07	3.742663e-07	-2.246688e-08	5.402687e-07
278	5.590920e-06	2.083484e-06	8.039094e-06	6.687811e-06	8.049744e-06
299	2.463640e-06	7.934265e-07	2.502085e-06	2.344825e-06	2.646384e-06
300	9.770369e-07	2.329767e-06	2.337852e-06	4.946582e-07	1.392728e-06
327	6.425028e-06	3.718641e-06	8.715376e-06	5.114610e-06	9.061270e-06
330	-4.692383e-07	4.469866e-07	-1.318743e-06	-1.138691e-06	-1.407911e-06
359	4.816409e-08	3.925532e-07	1.650366e-07	-7.911405e-07	7.277764e-07
367	2.234707e-06	1.609234e-06	3.841824e-06	2.904307e-06	2.512997e-06
374	2.582524e-06	3.422854e-07	3.749166e-06	3.505825e-06	3.382861e-06
376	2.580391e-06	1.472418e-06	3.496583e-06	1.481656e-06	3.238358e-06
380	1.778690e-06	1.212080e-06	2.614607e-06	1.044408e-06	2.864693e-06
412	1.786250e-06	1.380979e-06	2.688860e-06	1.289832e-06	2.973382e-06
448	1.412530e-06	2.172030e-07	2.266431e-06	1.544339e-06	2.015474e-06
449	4.416824e-07	1.240358e-07	7.330777e-07	5.818945e-07	8.623683e-07
472	1.275703e-06	-6.444308e-08	1.531897e-06	1.179427e-06	1.123694e-06
...
1484	1.378465e-06	1.849927e-06	2.321354e-06	1.391595e-06	1.422699e-06
1487	2.023124e-06	1.530116e-06	4.544153e-06	2.498927e-06	3.172283e-06
1493	1.121478e-06	8.119476e-07	1.151575e-06	1.556342e-07	1.643775e-06
1505	7.520027e-06	3.172610e-06	1.029817e-05	6.236830e-06	9.961239e-06
1506	1.649899e-06	9.387851e-07	1.795932e-06	1.207229e-06	2.162334e-06
1512	1.928649e-06	9.447588e-07	2.298746e-06	1.480735e-06	2.748239e-06
1564	6.118712e-06	3.551505e-06	8.682585e-06	4.053156e-06	7.429942e-06
1571	3.043680e-07	2.800913e-07	-4.023195e-07	-7.485376e-07	6.994267e-09
1588	-2.914348e-07	1.037142e-06	-2.184882e-07	-1.143463e-06	7.192013e-07
1600	4.748833e-06	1.976400e-06	5.237575e-06	3.669507e-06	6.486504e-06
1620	1.771025e-06	1.117853e-06	3.065300e-06	1.611659e-06	2.640749e-06
1657	7.454059e-06	3.356992e-06	9.913874e-06	5.884039e-06	8.951833e-06
1667	2.291431e-06	2.314543e-07	3.389075e-06	4.896476e-06	3.404248e-06
1670	2.497961e-06	1.325423e-06	4.036747e-06	2.990208e-06	3.491870e-06
1672	2.492536e-06	1.277227e-06	3.359000e-06	2.129647e-06	4.030154e-06
1679	3.298681e-06	1.212135e-06	4.764864e-06	3.398206e-06	4.002608e-06
1681	4.162615e-06	2.078359e-06	5.167960e-06	3.464359e-06	6.385030e-06
1688	3.353739e-06	1.774153e-06	8.146023e-06	6.355989e-06	5.771000e-06
1690	9.918753e-06	3.744767e-06	1.129041e-05	8.257244e-06	1.207497e-05
1694	2.980414e-06	2.717444e-06	6.116452e-06	4.475478e-06	4.977009e-06
1704	2.759734e-06	1.444494e-06	2.532428e-06	-6.504694e-08	3.157828e-06
1721	2.431905e-06	1.272253e-06	2.544850e-06	1.403891e-06	3.158965e-06
1725	1.095688e-06	5.927087e-07	9.971069e-07	2.732288e-07	1.160710e-06
1744	2.065282e-06	1.924051e-06	2.170436e-06	-9.642848e-08	2.365426e-06
1775	6.414154e-06	2.068686e-06	5.722784e-06	4.168082e-06	6.301418e-06
1780	2.068686e-06	2.566215e-06	3.021771e-06	1.526959e-06	2.674085e-06
1782	5.722784e-06	3.021771e-06	1.013198e-05	6.105847e-06	7.744201e-06
1803	4.168082e-06	1.526959e-06	6.105847e-06	6.655387e-06	5.388947e-06

1814	6.301418e-06	2.674085e-06	7.744201e-06	5.388947e-06	9.265278e-06
1835	3.687540e-06	7.288054e-07	4.523662e-06	3.333528e-06	4.851543e-06

	1835
27	1.921329e-06
73	7.119483e-06
114	1.253787e-06
116	1.829339e-06
120	-3.012064e-06
123	2.268347e-06
127	1.616607e-06
131	4.276709e-08
167	1.738287e-07
184	1.837240e-06
197	2.271380e-06
204	5.130541e-06
205	4.333266e-06
221	8.017695e-06
227	1.822918e-06
243	5.054742e-07
278	4.436018e-06
299	3.185759e-06
300	-1.078842e-06
327	3.553776e-06
330	-8.359218e-07
359	9.527320e-07
367	6.977231e-07
374	3.037823e-06
376	2.461841e-06
380	1.866214e-06
412	1.029106e-06
448	1.371779e-06
449	8.167787e-07
472	1.756931e-06
...	...
1484	-1.693877e-07
1487	2.608445e-06
1493	9.975705e-07
1505	5.655404e-06
1506	1.544826e-06
1512	1.767997e-06
1564	6.019442e-06
1571	2.313892e-07
1588	-8.255905e-07
1600	2.322318e-06
1620	1.582314e-06
1657	5.985775e-06

```
1667 1.666977e-06
1670 1.705093e-06
1672 2.044894e-06
1679 2.763915e-06
1681 2.985356e-06
1688 4.405115e-06
1690 6.553375e-06
1694 3.049654e-06
1704 1.953009e-06
1721 1.393261e-06
1725 1.493558e-06
1744 1.108761e-07
1775 3.687540e-06
1780 7.288054e-07
1782 4.523662e-06
1803 3.333528e-06
1814 4.851543e-06
1835 6.393718e-06
```

[100 rows x 100 columns]

```
[386]: port_std_126 = []
for i in np.arange(len(weight126)):
    port_std_126.append(np.sqrt(weight126[i] @ rw_126_cov.to_numpy() @
                               weight126[i].T))
port_std_126
```

```
[386]: [0.001200482403249036,
        0.0012016068244023231,
        0.001200163151995053,
        0.0011999906623133296,
        0.0011996865889845848,
        0.0011993168462325814,
        0.0011966273268963256,
        0.0011928115509270653,
        0.0011907932369448293,
        0.0011967299806786207,
        0.001198114090894283,
        0.001201579477221827,
        0.0012011631003264172,
        0.0012008748899597708,
        0.0011984239601304531,
        0.0012002963876204384,
        0.0011993492890065966,
        0.0011967718923943296,
        0.0011964261937425927,
        0.0011968875683527958,
```

0.0011977020522633164,
0.0011999051104306605,
0.0011990803204218975,
0.001198608370900137,
0.0011948257075217745,
0.0011975830957119196,
0.0011943244928712276,
0.0011926466367167294,
0.0011920200208047221,
0.0011967613978456965,
0.0011983047622491194,
0.001199515671689268,
0.0012002483651241673,
0.0011993921443988528,
0.0012000799906395415,
0.0011991114397240387,
0.0011999868485974008,
0.0011994337984786358,
0.0012001216349827107,
0.0011977706642870508,
0.0011944068416853298,
0.0011911925405998967,
0.0011892548894222902,
0.0011869618333279178,
0.0011882309773232126,
0.001187907644852207,
0.001187847649214648,
0.0011902394935152099,
0.0011881649465617533,
0.0011917217206339334,
0.0011921572452638376,
0.0011926217457148027,
0.0011927749955266307,
0.001192745450704044,
0.001187982053871545,
0.0011881022235939237,
0.0011914703334203955,
0.001189714557404893,
0.00118687831520633,
0.0011837686813679915,
0.001183993767758933,
0.0011843648788962939,
0.0011898740717873196,
0.0011919094097364953,
0.0011908628346308232,
0.0011879930240533824,
0.001188544623546859,

0.001185919307061889,
0.001187761690487281,
0.0011897603355588832,
0.0011906908077564155,
0.0011885168683958254,
0.0011871965252267464,
0.0011899048872017538,
0.0011921346788422787,
0.0011878956415934513,
0.0011873626548110584,
0.001188815123328492,
0.0011886398594496894,
0.0011865143965923604,
0.0011888717972379553,
0.0011908898019142942,
0.0011809233739367038,
0.001180541647298677,
0.0011818870298242867,
0.0011831772234364823,
0.0011820454367886992,
0.0011773770338826043,
0.001178971421358354,
0.001183111776686196,
0.0011841713236350484,
0.0011845645808729384,
0.001183143173297186,
0.001185258892028091,
0.0011859462935481535,
0.001184583105264249,
0.001186204984636494,
0.001186285299886854,
0.0011864452673569462,
0.0011909397444357793,
0.0011927555803733125,
0.0011914771827150796,
0.0011911786861234152,
0.0011902062039710222,
0.0011956967130686807,
0.001198510268067901,
0.001195891645755528,
0.001197211915640608,
0.0011996776437068538,
0.0011970361220458414,
0.0011969318159482135,
0.0011985597507122756,
0.001202162884303217,
0.001207200483130251,

0.0012069418614231201,
0.0012083189125317226,
0.0012069888687198146,
0.00120614619982053,
0.001204763494406826,
0.0012030808980350845,
0.001200879248345092,
0.0012047500747537016,
0.0012042997257499925,
0.001202406765786676,
0.0012028225215190318,
0.0012034969997320006,
0.0012054224729603142,
0.001204405734765153,
0.0012028815720798458,
0.0012019702190568032,
0.001201774082567394,
0.0012010129423091764,
0.0011971047969148736,
0.0011959569406308295,
0.0011965200381365143,
0.001197105610274709,
0.001197072549253452,
0.0011954632885188307,
0.001196027035177921,
0.0011969146717627234,
0.0011939063707365456,
0.0011905855583775246,
0.001188643630546706,
0.0011872363188061453,
0.0011870114298084833,
0.0011866353816710519,
0.001185883591624078,
0.0011863392594153915,
0.0011852030105485958,
0.0011819214639003162,
0.0011830473808811684,
0.001183173290692067,
0.0011842743732237227,
0.0011823976260389344,
0.0011819045150483535,
0.001179654881222468,
0.0011803218500628053,
0.0011774126323963032,
0.0011791546782898487,
0.0011764730432473928,
0.0011762902908884574,

0.0011761916852131107,
0.0011725704185300962,
0.0011692949447036874,
0.0011699393205527324,
0.001175184426571818,
0.0011757309744208964,
0.0011755586694561276,
0.0011747808863567795,
0.0011759309501351953,
0.0011742428226460585,
0.0011759032406548047,
0.0011784924139766123,
0.0011779166370454973,
0.0011774701050764169,
0.0011824643901274911,
0.0011812662792626463,
0.0011852306785026274,
0.0011845641494595363,
0.0011829851244497135,
0.0011812915237554237,
0.0011803059301060408,
0.0011792441362404587,
0.00117903764987748,
0.0011751531377989827,
0.0011756154099848255,
0.0011819763185609042,
0.0011807441163828813,
0.0011840818707518697,
0.0011880067792224868,
0.0011835601034935483,
0.0011851258731240247,
0.0011878675873467253,
0.0011857708996259027,
0.0011875579012922133,
0.0011884717967155626,
0.0011896152116344224,
0.0011898208781214868,
0.0011924156000999565,
0.0011910215454969183,
0.001191603607794955,
0.001194004618966735,
0.0011923561316404495,
0.0011921994873849966,
0.0011932429976794488,
0.0011940836378305211,
0.0011926549394920924,
0.0011895575372082789,

0.0011873541099689485,
0.0011870702123440865,
0.0011915103974468448,
0.0011899337263041895,
0.0011918207301391355,
0.0011921667131303795,
0.0011902643862464184,
0.0011892783538983082,
0.001193023079835169,
0.0011941044619596844,
0.0011944157641567749,
0.0011924417700107076,
0.0011947766766553863,
0.0011967638776257696,
0.00119669662626341,
0.001194115687463079,
0.001195108815474916,
0.0011935260894955792,
0.0011933580283000156,
0.0011927301211293116,
0.0011961539114396134,
0.0011948349133916612,
0.0011916093721017064,
0.001192250551828359,
0.001190138504807022,
0.0011894759787228664,
0.0011881235075999902,
0.0011861842532514106,
0.0011862187732348726,
0.0011874239737494734,
0.001185402309325962,
0.0011840127267922804,
0.0011823748994544492,
0.0011808227633125121,
0.0011834430531847628,
0.0011868073873379592,
0.0011873918069740784,
0.0011864509631468443,
0.0011876228393747695,
0.0011842761497330224,
0.0011851578656959917,
0.001184712998113339,
0.0011896887725344756,
0.001186629448495253,
0.0011822672827047206,
0.0011837471841088028,
0.0011809865866582187,

0.0011820493155692828,
0.0011807699986285728,
0.0011821883907439665,
0.0011818863204045142,
0.0011844316620321777,
0.0011849462097827666,
0.0011849019059343134,
0.0011848068277633022,
0.0011860172203820307,
0.0011864797449832184,
0.0011847775995200364,
0.0011837874728488221,
0.0011863068829511881,
0.0011869881994619076,
0.001188829573126252,
0.0011885002628779873,
0.0011878178218211117,
0.001189209154439177,
0.0011874810872083686,
0.001190074410756111,
0.0011956430622769118,
0.0011943169253174977,
0.0011990041858681722,
0.0011955084827265084,
0.0011963256933690339,
0.0011955094593986244,
0.0011978279358159797,
0.0011991428143069895,
0.0012000888944946476,
0.0011995673939368503,
0.0011987229560914978,
0.0011973304213479497,
0.001197009696395606,
0.001195764666695942,
0.0011964348597920818,
0.0011968623512661587,
0.001196206607634431,
0.0011978508831297242,
0.0011965918613199074,
0.0011956108648876924,
0.0011952532101162843,
0.0011955401391082524,
0.001196565159718006,
0.0011961191730270096,
0.001194273696638086,
0.0011930305863576893,
0.0011942626284501248,

0.001193903065754581,
0.0011994207146025675,
0.0012003792404141856,
0.001198482178316307,
0.00119792053957164,
0.0011948791102815454,
0.0011956983582238467,
0.0011949762205264826,
0.0011919119730238999,
0.0011909084981735324,
0.0011911816627099235,
0.0011930590871824323,
0.0011946997122825426,
0.001195909363397597,
0.0011985745788848975,
0.0011982302810783579,
0.0011997003515744468,
0.001198637038250089,
0.0012003912395203986,
0.0011971029298155761,
0.0011960323096614183,
0.001198388271163707,
0.0012006194349314888,
0.0011995624452473242,
0.0011974680712469464,
0.0011956565959198586,
0.0011944609321937563,
0.0011929315930931262,
0.001193929418304019,
0.0011923363570073488,
0.0011949729078353688,
0.0011976827042436623,
0.00119599900764923,
0.0011985658961685464,
0.0011952928775449598,
0.0011958202103238824,
0.0011925795212829925,
0.0011936403901357283,
0.001194112814662748,
0.0011938151742941494,
0.0011957606194517567,
0.001193968307769547,
0.0011942066321526208,
0.001194478836395465,
0.001193235369248921,
0.0011930509447642269,
0.001194586412857052,

0.0011946230105390296,
0.0011931609564321155,
0.001194208476554463,
0.0011962644447194007,
0.0011963984874125285,
0.001196694271790865,
0.0011947724506528286,
0.0011895921389452541,
0.0011887116537963249,
0.0011888360859001422,
0.001188586293992196,
0.0011889942524141422,
0.001189590690001964,
0.0011858804147453093,
0.001185224478916586,
0.001185962204165298,
0.0011900235880547626,
0.0011897983630127437,
0.0011892812268740876,
0.0011921009815589847,
0.001192936460279484,
0.0011906078199585648,
0.0011881731796880388,
0.001188946740472952,
0.0011884766509711634,
0.0011897618606790347,
0.0011879508198097586,
0.001188513045063359,
0.0011874572015801606,
0.0011853073461938297,
0.001185795756340944,
0.0011883520318861352,
0.0011846943202410147,
0.0011840886299389524,
0.0011830228999473865,
0.0011829876033910042,
0.001182726647413908,
0.0011812906323667132,
0.001180105955155008,
0.001180335192626697,
0.0011818620720400988,
0.0011819167232898485,
0.0011813683007134638,
0.0011840082284724116,
0.0011851356430099458,
0.0011880329106164,
0.0011885713935262433,

0.0011904905189502762,
0.0011912834537072398,
0.0011969304984942423,
0.0011983471683837189,
0.001201495262793048,
0.0012017872654297439,
0.0012021139051987288,
0.00120227258944055,
0.0011991822534217678,
0.0011995297582465684,
0.0011995714483051434,
0.0011998811528585395,
0.0011993082006007292,
0.001199146454582797,
0.0011956581545721082,
0.0011935365498244072,
0.0011921952313236031,
0.0011901392804552218,
0.001188560229182168,
0.001190345078451273,
0.001186686501738166,
0.0011867400200359644,
0.0011870863750601019,
0.0011877882983091694,
0.0011875303122334954,
0.001187214079760695,
0.0011862794868667593,
0.0011870068722147837,
0.0011876120612490933,
0.0011848326921649031,
0.0011837802163934615,
0.0011820423478971394,
0.0011789476853748134,
0.0011780174181674203,
0.0011791108457004928,
0.001178768355447439,
0.0011790739558740465,
0.0011784673719074871,
0.0011769224053222083,
0.0011754647937706132,
0.0011741169947201372,
0.0011738167672394485,
0.0011761744109111418,
0.001177767699596105,
0.0011773355563879323,
0.0011764508250457439,
0.0011753641359605244,

0.0011727783942833032,
0.0011736749369371442,
0.001175214179136234,
0.0011748337154058597,
0.0011746641156478916,
0.0011754859018841349,
0.0011752542137578785,
0.0011763772305600497,
0.0011775816224401277,
0.001175081312455925,
0.0011706268459666254,
0.0011706668298856768,
0.0011729511752542423,
0.001173728323832833,
0.001177006250684841,
0.0011739862326353373,
0.0011729437854167612,
0.00117279633209156,
0.0011720831762027828,
0.0011712577537181833,
0.0011711409124141247,
0.0011693268582093068,
0.0011687973803674082,
0.00116982662544164,
0.0011717123401775982,
0.0011743729155619111,
0.001174251876782978,
0.0011759859630313162,
0.001179024944066653,
0.001178643244690147,
0.0011786954386609546,
0.0011788822272287274,
0.0011793626566303898,
0.0011802714880938647,
0.0011792802133994875,
0.0011783925815759791,
0.001177703648076261,
0.0011688671399691,
0.001169389523481624,
0.0011694788690317602,
0.0011707408314971116,
0.0011724465289920964,
0.001175693386503727,
0.0011717643242305177,
0.0011716295601525582,
0.0011697024517317099,
0.001167961804588002,

0.0011676781323615645,
0.0011681058159048487,
0.001168018702527352,
0.0011706344653840124,
0.0011699311390960738,
0.0011700617972810973,
0.0011692128953149157,
0.0011687957786286902,
0.0011687518211972508,
0.0011675770379555245,
0.0011670319852030715,
0.0011663603259917741,
0.0011677478815443423,
0.0011671401727520497,
0.001164739163286732,
0.0011628620004642566,
0.0011669989041383387,
0.0011655656498159653,
0.001163339070534516,
0.001162810411093207,
0.0011594417298995989,
0.0011565997950381077,
0.0011573744681236172,
0.001158002472328861,
0.0011597289439700628,
0.0011600851855599458,
0.0011603856584187567,
0.0011604100477996709,
0.001163355326374996,
0.0011608664803018731,
0.0011606121567785698,
0.0011631045176494022,
0.0011647076280442393,
0.0011629911795368185,
0.001166328250176221,
0.0011662369663529685,
0.0011640014293385656,
0.0011622801772314631,
0.0011599353605912272,
0.0011569658686024914,
0.001158182585015037,
0.0011582181959990923,
0.00116094491858115,
0.0011615829161187865,
0.001164048925336018,
0.001165033486860844,
0.0011640534521673818,

0.0011647360839102006,
0.0011658077058797826,
0.0011674007438140228,
0.0011644334562038931,
0.001164554388425851,
0.001165575096150013,
0.0011666079154735534,
0.0011677110130123025,
0.0011622015277159914,
0.0011629208403779595,
0.0011627098582780028,
0.0011633906601200023,
0.0011637756373004133,
0.0011647430648450833,
0.0011666607281624409,
0.001167289338245963,
0.0011664926502503977,
0.0011660626138147714,
0.0011665122751159675,
0.0011660541843609388,
0.0011695834528481289,
0.0011726658169848997,
0.0011710650756217582,
0.0011722419052837944,
0.001175090047936201,
0.001176369837056838,
0.0011755832600650394,
0.0011728806324486159,
0.0011722540748417619,
0.0011718664936835248,
0.0011743471295683112,
0.0011742260526698813,
0.0011735383109354694,
0.001174746624532739,
0.0011763664134236639,
0.0011779821316344552,
0.001178348358632516,
0.001178868961962879,
0.0011774205542064277,
0.0011787436643556192,
0.0011802561462371127,
0.0011826346361542646,
0.0011805204775739457,
0.0011798732697144924,
0.0011787484962089523,
0.0011779034223365688,
0.0011785991148351945,

0.001179962714057764,
0.0011792817967621752,
0.0011821294173855852,
0.0012576657060255575,
0.001255355156826834,
0.0012543181836340278,
0.0012525180209108822,
0.0012496070033770179,
0.0012502587047047875,
0.0012494285986309364,
0.0012509235297426357,
0.0012501489214270726,
0.0012504140952287915,
0.0012489251987657353,
0.0012499627691645906,
0.001254079879143056,
0.0012538058577866757,
0.0012554340381671584,
0.0012542264604010463,
0.0012554709540002445,
0.0012551025222685872,
0.001252881894504738,
0.0012491270792165349,
0.001248242578380364,
0.001245982538854176,
0.0012463214220879816,
0.001248208378255727,
0.001249020994411128,
0.001249266962240813,
0.0012512965697519319,
0.0012541446653315743,
0.0012537280850132809,
0.0012544555455401532,
0.0012545167392596483,
0.001253197531335885,
0.0012546453227596454,
0.0012564668979195338,
0.0012562982320797262,
0.0012574791378436312,
0.0012593209940958893,
0.001261426811846879,
0.0012621760469972612,
0.001261042497872599,
0.0012613004991704397,
0.0012592915328970065,
0.0012670644024143224,
0.0012712115656138767,

0.001269678875070034,
0.001271144093063626,
0.001272592426002249,
0.0012767458283207398,
0.0012800676135380517,
0.0012805665602876881,
0.0012800589925155844,
0.0012797407681085474,
0.0012796551140179353,
0.001276093134397113,
0.0012775881454002115,
0.001279540670692374,
0.0012772296178862155,
0.0012754654947056254,
0.0012747399669324469,
0.0012735429556689631,
0.0012761901117453562,
0.0012756269786255126,
0.001273651662617185,
0.0012742927728825973,
0.0012751025794672096,
0.0012770819518567599,
0.0012795349798314616,
0.0012772733369374742,
0.0012777051355135946,
0.0012770879279239526,
0.001275867016393229,
0.0012767032597594333,
0.001279024064491577,
0.0012772902219253678,
0.0012792176854705493,
0.0012792175852359485,
0.0012789240231765515,
0.0012779543599024535,
0.001272485498258204,
0.0012711741934846113,
0.0012660600699502316,
0.0012667865274590847,
0.0012645769700027705,
0.0012629399070622572,
0.0012634006326963613,
0.0012624959993871618,
0.00126275797227053,
0.0012639449824465633,
0.0012635875295066979,
0.001260078656683385,
0.001258561641349993,

0.0012589236193055328,
0.0012607288234403652,
0.001260417226148599,
0.001260609114144417,
0.0012598314434371161,
0.0012554451404480607,
0.0012547737392134594,
0.0012559171359333347,
0.0012562321449520522,
0.0012552566113590824,
0.0012555013919723,
0.0012568981730064661,
0.0012573609236113848,
0.0012583545044920674,
0.0012589876430044674,
0.0012615037043774487,
0.0012614717590148023,
0.0012624679747287517,
0.0012623127395231103,
0.001262187046463415,
0.0012638952598101386,
0.0012629154828086102,
0.0012603497917879954,
0.0012590152942501729,
0.0012580291687736746,
0.0012547456450879518,
0.0012557894445808123,
0.0012558800664218936,
0.0012562917792586928,
0.0012530511222319496,
0.0012496591127679744,
0.0012498656756950357,
0.0012485148176654942,
0.0012483342766589876,
0.0012479942953857444,
0.0012489531384583862,
0.0012492620835140185,
0.0012492523955588031,
0.0012467604044819269,
0.0012468783189658816,
0.0012455328281854292,
0.0012438646419056078,
0.0012416444192373565,
0.0012422207284668342,
0.0012427548650870996,
0.0012412182463126594,
0.0012420366308484416,

0.0012406498908404042,
0.0012420934140150292,
0.001241907430251297,
0.0012406931718044658,
0.0012410812742635917,
0.0012401614273138486,
0.001241816550630159,
0.0012409975800698734,
0.0012392419201393643,
0.0012397934033948623,
0.0012387767494834699,
0.001238980883130201,
0.001240136917492326,
0.0012402680443029924,
0.001240728525367452,
0.0012408403315615597,
0.0012409650808029038,
0.0012403862423492847,
0.0012417448180302032,
0.0012439958353783278,
0.0012487198501672148,
0.0012440690977638567,
0.0012457349867730637,
0.0012432956259586085,
0.001243755711651664,
0.0012437512269191904,
0.0012434968202101066,
0.0012425520829756646,
0.001246603806627651,
0.0012453497580310312,
0.0012430618437188736,
0.0012412497832456578,
0.0012397570899168417,
0.001238583765120415,
0.0012370653901072495,
0.0012319438447979743,
0.0012342532337450444,
0.0012341733619588681,
0.0012351228593150175,
0.001237526912684062,
0.001238435158010062,
0.0012372548676621883,
0.0012369989224648395,
0.0012373727433643707,
0.0012376241598723396,
0.001236320108212923,
0.0012369785546160852,

0.0012372289381416904,
0.001236485100448418,
0.0012328754616901124,
0.0012358959019287536,
0.0012349100947880972,
0.0012339506882237282,
0.0012343485443673877,
0.0012371328801557592,
0.0012367537807427443,
0.0012363093829938904,
0.0012349004264608791,
0.0012290178950521745,
0.0012289144642486341,
0.0012322671270408902,
0.0012333369367453556,
0.001231907141625031,
0.0012333989773528249,
0.0012339239163748053,
0.00123399432928666,
0.0012308583908930463,
0.0012307404476323814,
0.0012282151829925026,
0.0012303878785916529,
0.0012284564354056433,
0.0012282517714154598,
0.0012300321033673278,
0.00123042400961845,
0.0012289666897658438,
0.0012266346445164568,
0.00122610384486809,
0.001228343372807069,
0.001226500618152781,
0.0012301731695937264,
0.00122711147122795,
0.0012241456980367472,
0.0012281093776638342,
0.0012280065874517108,
0.00122614504385335,
0.0012260620416003265,
0.0012239196724640954,
0.001228263316649062,
0.00122841613298943,
0.0012289926940295879,
0.0012300696474157454,
0.0012314881277640489,
0.0012333871871408086,
0.001235641835316496,

0.001235863616439985,
0.0012363457905872272,
0.0012373315466505746,
0.0012403352790050066,
0.00124046826775721,
0.0012411099477649015,
0.0012421026429980506,
0.0012388069027410166,
0.0012394240934280566,
0.0012449624098140094,
0.0012418905451816434,
0.0012472559310003177,
0.0012513912045867173,
0.001250517555697525,
0.001249814573772964,
0.0012496655599731757,
0.0012527921401417799,
0.0012492593037321306,
0.0012530410189142576,
0.0012592748965412326,
0.0012600875662463688,
0.0012601051467632368,
0.0012566023564738683,
0.0012569485361438614,
0.0012571161005867427,
0.001254199519655714,
0.0012570588303144991,
0.001256904269423151,
0.0012584260038414807,
0.0012582467080366046,
0.0012615606653988453,
0.0012570821625969711,
0.0012513043488336197,
0.001250162094676039,
0.0012522250347213621,
0.0012519005585157207,
0.0012526609906295175,
0.0012551992174357268,
0.0012593214846435313,
0.0012575807578822339,
0.0012563802542126003,
0.0012595078723906085,
0.0012603012174516055,
0.0012545054739746323,
0.001259011341959435,
0.001259273887138667,
0.001260576551398022,

0.0012596897362625499,
0.0012542949274398582,
0.0012544392960133347,
0.0012564934409782166,
0.0012536719460132482,
0.0012534280848239701,
0.0012542747727178059,
0.0012541328148372084,
0.0012577124702710068,
0.0012605508755664943,
0.001261875335502207,
0.00125990884208625,
0.0012594650980829473,
0.0012591711623871759,
0.0012596052394193047,
0.0012644163317790166,
0.0012569695907814575,
0.0012560719979237912,
0.0012546478465745962,
0.0012510174910890437,
0.0012564250748786224,
0.0012565055570105286,
0.0012586961197864328,
0.0012572756656215561,
0.0012595387871696337,
0.0012648903764958589,
0.0012621607520086737,
0.0012644651861622527,
0.001266322098425014,
0.0012695342177076938,
0.001268906979779833,
0.001266184780031469,
0.001270212735087606,
0.0012697995904770725,
0.0012730180624606132,
0.0012758396290470952,
0.0012757185544609224,
0.0012729520050528036,
0.0012737719221887843,
0.0012718782898479264,
0.0012728709523120115,
0.0012716100334235964,
0.001276013586051632,
0.0012755943327416078,
0.0012711393586632873,
0.0012694333457970767,
0.0012626204325344,

0.001261828763543077,
0.0012633931139426219,
0.0012602539496013323,
0.0012641088209851522,
0.0012633315116909573,
0.0012650248134481751,
0.0012611316172008167,
0.001261686731785672,
0.0012606575044171154,
0.0012648856525180083,
0.001263707933892741,
0.0012543163053910097,
0.001256064072233127,
0.0012520788069322886,
0.0012575157945002684,
0.0012562968228609238,
0.0012556574681462948,
0.0012528887358837849,
0.0012537802163096546,
0.0012572648600692171,
0.0012641031068116849,
0.0012713623503120986,
0.0012838626579591362,
0.0012870389741340064,
0.0012832442033770869,
0.0012721357591179627,
0.0012676346766850647,
0.0012699868685156486,
0.0012777005666510933,
0.0012764173244516177,
0.0012791761564090798,
0.0012774044705090937,
0.001277304171728032,
0.0012782708175778934,
0.0012745794945084588,
0.0012761018233859447,
0.0012699455437582094,
0.001267923461173086,
0.0012679012517839024,
0.0012661305802378544,
0.001263800774929939,
0.0012624605697941112,
0.001263490397940564,
0.0012594149894564642,
0.0012603306021340115,
0.0012689533580570909,
0.001271703903208634,

```
0.001269994398557727,  
0.0012677734269451132,  
0.0012668141848318456,  
0.001275163234373984,  
0.001276192030811618,  
0.0012781768246578572,  
0.001279392207035434,  
0.0012775617402423234,  
0.0012772541385313438,  
0.0012759245432991233,  
0.0012773740128732153,  
0.0012772531908744826,  
0.0012765246375612707,  
0.0012811251566741725,  
0.0012770925435425066,  
0.0012709752777473058,  
0.0012675097494822157,  
0.0012661914822870365,  
0.0012692459988888983,  
0.0012717376654133004,  
0.0012777880613103428,  
0.0012774135648426382,  
0.0012807491086782293,  
0.0012821308505694513,  
0.001278089390767581,  
0.001279449658141267,  
0.0012812348003644403,  
0.0012827308075784838,  
0.0012772420967924888,  
0.0012750923036806095,  
0.0012756073616722776,  
0.0012711135276548015,  
0.0012725878922223565,  
0.0012775512415452472,  
0.0012759986309198808,  
0.001274862378430297,  
0.001277811099540837,  
0.0012845548529406593,  
0.0012779729415548417,  
0.0012788528751441794,  
...]
```

```
[388]: #rw = 63  
rw_63 = []  
for i in secdata_rnd_100['Ticker'].unique():  
    key = i
```

```

    value = list(secdata_rnd_100.loc[secdata_rnd_100['Ticker'] == i].Returns.
    ↪rolling(63).mean().dropna().reset_index(drop=True))
    rw_63[key] = value

```

[389]: rw63_df = pd.DataFrame.from_dict(rw_63, orient='index')
rw_63_cov = rw63_df.T.cov()
rw_63_cov

	27	73	114	116	120	\
27	1.023024e-05	1.163266e-05	4.136221e-06	2.650148e-06	-1.234322e-06	
73	1.163266e-05	4.768518e-05	5.964398e-06	9.797562e-06	-4.403993e-06	
114	4.136221e-06	5.964398e-06	7.165261e-06	9.710804e-07	-1.117416e-07	
116	2.650148e-06	9.797562e-06	9.710804e-07	6.483392e-06	-1.242878e-06	
120	-1.234322e-06	-4.403993e-06	-1.117416e-07	-1.242878e-06	8.198665e-06	
123	5.640092e-06	1.573978e-05	5.116628e-06	2.531922e-06	-1.805882e-07	
127	5.192381e-06	9.645545e-06	2.961022e-06	2.505897e-06	-8.738437e-07	
131	4.045717e-07	-1.286333e-06	3.474321e-07	-7.311951e-07	2.368371e-07	
167	1.958892e-06	2.075277e-06	6.384162e-07	5.102002e-07	3.584668e-08	
184	3.076432e-06	1.144225e-06	2.064481e-06	-7.750982e-07	-1.857718e-06	
197	4.477018e-06	8.035886e-06	2.808677e-06	2.294535e-06	-7.743363e-07	
204	7.768331e-06	2.757951e-05	4.222301e-06	8.308236e-06	-3.124585e-06	
205	5.991732e-06	1.304747e-05	4.354976e-06	3.178658e-06	-6.052344e-08	
221	1.211149e-05	2.643944e-05	8.318518e-06	8.914339e-06	-2.377328e-06	
227	1.513030e-06	5.732767e-06	2.110254e-07	2.617847e-06	-1.522913e-06	
243	1.077465e-06	7.739827e-07	1.117217e-06	-4.979067e-07	-9.973114e-07	
278	7.634240e-06	2.319883e-05	3.262231e-06	8.744761e-06	-1.891483e-07	
299	3.552963e-06	9.159230e-06	8.302061e-07	1.848787e-06	-3.082775e-06	
300	1.632790e-06	3.473156e-06	1.634012e-06	1.327447e-06	4.300089e-06	
327	3.740811e-06	1.268742e-05	5.027494e-06	5.198394e-06	-1.961266e-06	
330	6.143684e-07	-2.033420e-06	-8.076879e-07	-1.074154e-06	8.232304e-07	
359	1.581534e-06	1.808978e-06	8.454864e-07	5.282482e-07	1.869035e-07	
367	6.262072e-06	9.617408e-06	3.783278e-06	3.302553e-06	7.178189e-07	
374	2.452197e-06	1.335394e-05	4.126038e-07	5.864417e-06	-3.054696e-06	
376	3.087449e-06	6.655234e-06	3.088498e-06	2.429638e-06	-1.424276e-06	
380	2.286437e-06	5.873860e-06	2.189676e-06	1.159872e-06	-1.080103e-06	
412	2.678281e-06	6.258872e-06	1.801407e-06	1.419243e-06	-1.045357e-07	
448	1.363117e-06	6.245876e-06	9.396669e-07	2.279591e-06	-1.467848e-07	
449	9.664295e-07	4.391878e-06	-3.025678e-07	2.279385e-06	-4.367799e-07	
472	1.634339e-06	3.888014e-06	1.576627e-06	8.974005e-07	-9.844831e-07	
...	
1484	1.981088e-06	5.835794e-06	1.540009e-06	7.195888e-07	2.110926e-06	
1487	5.655558e-06	1.564290e-05	3.055530e-06	4.486960e-06	-7.327029e-07	
1493	2.238053e-06	2.190892e-06	1.372210e-06	3.049565e-08	-2.815602e-07	
1505	9.826855e-06	1.953136e-05	4.867323e-06	5.271012e-06	-1.922132e-06	
1506	2.960231e-06	5.133193e-06	1.219054e-06	1.203664e-06	-1.025578e-06	
1512	3.262153e-06	5.888896e-06	1.484505e-06	1.384790e-06	-1.127225e-07	
1564	8.624965e-06	1.728677e-05	8.965126e-06	3.099029e-06	5.222911e-07	

1571	1.316642e-06	-9.491107e-07	1.033040e-06	-7.138681e-09	3.390284e-07
1588	1.161417e-07	7.961193e-07	5.944956e-07	2.238859e-06	2.008235e-06
1600	3.541073e-06	7.128712e-06	2.390907e-06	3.291818e-06	4.539374e-07
1620	2.806699e-06	5.802341e-06	2.378371e-06	1.843732e-06	-1.255024e-06
1657	7.960205e-06	1.507782e-05	7.345538e-06	3.640397e-06	-2.709570e-06
1667	3.604926e-06	1.916788e-05	-2.207538e-07	4.993105e-06	9.149620e-07
1670	3.151830e-06	7.925093e-06	2.124017e-06	2.457884e-06	3.102173e-08
1672	4.038329e-06	9.080840e-06	1.935317e-06	2.236930e-06	-4.558052e-07
1679	2.129839e-06	1.077972e-05	1.649257e-06	2.996565e-06	-1.214823e-06
1681	5.062368e-06	1.497168e-05	2.680318e-06	2.223888e-06	4.021032e-07
1688	8.100878e-06	2.078603e-05	5.983701e-06	5.899320e-06	-3.573175e-06
1690	9.820254e-06	2.362954e-05	6.131044e-06	5.860499e-06	-3.571572e-06
1694	6.640193e-06	1.198145e-05	3.630811e-06	5.653936e-06	-3.508664e-06
1704	5.336298e-06	3.411391e-06	2.932128e-06	-2.291468e-06	-1.210523e-06
1721	3.771030e-06	4.424052e-06	1.209422e-06	7.053721e-07	-7.277018e-07
1725	4.604610e-07	2.197435e-06	-4.086936e-07	1.575537e-06	6.785330e-08
1744	2.574514e-06	2.103797e-06	2.860451e-06	3.370953e-07	3.379275e-06
1775	6.085906e-06	1.214302e-05	1.424949e-06	3.430650e-06	9.170867e-08
1780	4.485383e-06	5.523542e-06	2.385599e-06	1.241378e-06	1.333335e-06
1782	7.296883e-06	1.909834e-05	5.664553e-06	5.165766e-06	-1.945620e-06
1803	5.780729e-06	1.733731e-05	2.195592e-06	5.636617e-06	-1.420645e-06
1814	6.619907e-06	1.405102e-05	4.832838e-06	4.164389e-06	-1.616989e-06
1835	3.594075e-06	1.199478e-05	1.613818e-06	3.379085e-06	-4.409208e-06

	123	127	131	167	184	\
27	5.640092e-06	5.192381e-06	4.045717e-07	1.958892e-06	3.076432e-06	
73	1.573978e-05	9.645545e-06	-1.286333e-06	2.075277e-06	1.144225e-06	
114	5.116628e-06	2.961022e-06	3.474321e-07	6.384162e-07	2.064481e-06	
116	2.531922e-06	2.505897e-06	-7.311951e-07	5.102002e-07	-7.750982e-07	
120	-1.805882e-07	-8.738437e-07	2.368371e-07	3.584668e-08	-1.857718e-06	
123	2.302412e-05	3.263524e-06	1.174898e-06	2.207847e-06	2.451598e-07	
127	3.263524e-06	6.251223e-06	5.429291e-07	9.049255e-07	2.777122e-06	
131	1.174898e-06	5.429291e-07	2.318773e-06	4.390710e-07	2.489604e-06	
167	2.207847e-06	9.049255e-07	4.390710e-07	2.457197e-06	-4.816783e-08	
184	2.451598e-07	2.777122e-06	2.489604e-06	-4.816783e-08	7.567580e-06	
197	2.190743e-06	3.136758e-06	7.393288e-07	7.294201e-07	2.869480e-06	
204	9.402799e-06	6.041365e-06	-1.343457e-06	2.463347e-06	3.479130e-08	
205	7.481122e-06	4.350095e-06	1.390133e-06	1.701455e-06	3.433201e-06	
221	9.253731e-06	9.424561e-06	4.464017e-07	7.093453e-07	7.244740e-06	
227	5.916559e-06	9.729360e-07	-6.426581e-09	9.697392e-07	-8.390179e-07	
243	3.444758e-07	7.777740e-07	1.598971e-06	6.945190e-07	2.674760e-06	
278	6.531759e-06	5.610542e-06	-1.768335e-06	1.340776e-06	-5.506286e-07	
299	4.817746e-06	1.884024e-06	4.640600e-07	1.143008e-06	9.101156e-07	
300	6.300328e-06	1.076612e-06	2.665852e-07	1.556659e-06	-1.975685e-06	
327	4.282459e-06	2.808006e-06	3.928882e-07	7.500128e-07	2.394096e-06	
330	1.587240e-06	5.887325e-07	1.522634e-06	1.254027e-06	1.302144e-06	
359	2.787609e-06	8.144920e-07	-1.886482e-07	7.398591e-07	1.174783e-06	

367	5.946668e-06	4.435766e-06	5.850037e-07	1.969491e-06	1.438320e-06
374	1.543658e-06	2.385059e-06	-1.060633e-06	-4.187121e-07	-5.074041e-07
376	2.525202e-06	3.017655e-06	6.865808e-07	2.791664e-07	3.093156e-06
380	2.573217e-06	1.817172e-06	5.554375e-07	2.668176e-07	2.374381e-06
412	2.106916e-06	2.043860e-06	8.610405e-07	1.315129e-06	1.825987e-06
448	1.208444e-06	1.359701e-06	-2.401840e-07	4.504394e-07	4.801397e-07
449	1.543852e-07	1.431610e-06	-3.631797e-07	1.680935e-07	-2.610411e-07
472	2.597155e-06	2.074634e-06	1.351628e-06	2.447223e-07	2.979952e-06
...
1484	7.322835e-06	1.900367e-06	1.242010e-06	1.908392e-06	8.845911e-07
1487	7.887722e-06	4.705725e-06	-2.859125e-07	1.986008e-06	5.299089e-07
1493	6.076057e-07	1.571854e-06	7.024662e-07	4.040380e-07	2.337847e-06
1505	6.141366e-06	6.840917e-06	4.881271e-08	6.332624e-07	6.168185e-06
1506	3.339342e-06	1.800664e-06	9.739570e-07	1.362769e-06	2.057326e-06
1512	2.714755e-06	2.158294e-06	1.558119e-07	4.908845e-07	1.181447e-06
1564	1.259479e-05	5.821956e-06	1.448349e-06	2.322341e-06	3.123538e-06
1571	-1.933345e-06	1.669430e-06	6.658969e-07	1.636679e-07	1.688823e-06
1588	-1.820970e-06	3.879952e-07	-4.842217e-07	6.825375e-07	-7.185912e-07
1600	2.852197e-06	3.397266e-06	1.058122e-06	1.349872e-08	2.981772e-06
1620	3.557030e-06	2.449433e-06	7.090167e-07	8.298691e-07	2.037751e-06
1657	1.137129e-05	5.240377e-06	1.145310e-06	2.429766e-06	5.068543e-06
1667	7.804830e-06	2.172373e-06	-2.262238e-06	1.796792e-06	-4.079909e-06
1670	3.852565e-06	2.794875e-06	1.727656e-07	1.094998e-07	1.519827e-06
1672	1.226547e-06	2.983862e-06	-5.029744e-09	6.364544e-07	1.814130e-06
1679	1.861606e-06	2.384841e-06	-9.573066e-07	-6.905745e-08	3.412414e-07
1681	7.191176e-06	3.116240e-06	1.655297e-06	1.219060e-06	2.962659e-06
1688	1.200294e-05	6.320006e-06	-6.798176e-08	2.276757e-06	1.583013e-06
1690	6.667022e-06	7.391324e-06	2.363064e-06	1.651369e-06	7.887318e-06
1694	6.826288e-06	3.307311e-06	-1.060701e-06	3.891495e-06	-4.920789e-07
1704	-1.395704e-06	4.728009e-06	3.787697e-06	-3.519490e-07	1.090858e-05
1721	2.456329e-06	2.006224e-06	1.506424e-06	8.789452e-07	2.840231e-06
1725	1.064797e-06	2.004572e-07	-5.794862e-07	4.644895e-07	-1.042388e-06
1744	3.581354e-06	2.226345e-06	1.164890e-06	-4.577627e-07	2.252379e-06
1775	2.099173e-06	4.229535e-06	1.549335e-06	8.294566e-07	3.676783e-06
1780	5.487210e-06	2.042583e-06	5.194661e-07	1.914076e-06	5.673413e-07
1782	9.417810e-06	6.094713e-06	5.105733e-07	9.666679e-07	3.815215e-06
1803	9.482794e-06	3.621491e-06	-6.434979e-08	1.700758e-06	-4.366424e-07
1814	5.375287e-06	5.227683e-06	1.078630e-06	1.453073e-06	5.045559e-06
1835	4.718902e-06	3.521497e-06	5.434165e-07	1.040913e-06	3.198329e-06

...	1704	1721	1725	1744	\
27	...	5.336298e-06	3.771030e-06	4.604610e-07	2.574514e-06
73	...	3.411391e-06	4.424052e-06	2.197435e-06	2.103797e-06
114	...	2.932128e-06	1.209422e-06	-4.086936e-07	2.860451e-06
116	...	-2.291468e-06	7.053721e-07	1.575537e-06	3.370953e-07
120	...	-1.210523e-06	-7.277018e-07	6.785330e-08	3.379275e-06
123	...	-1.395704e-06	2.456329e-06	1.064797e-06	3.581354e-06

127	...	4.728009e-06	2.006224e-06	2.004572e-07	2.226345e-06
131	...	3.787697e-06	1.506424e-06	-5.794862e-07	1.164890e-06
167	...	-3.519490e-07	8.789452e-07	4.644895e-07	-4.577627e-07
184	...	1.090858e-05	2.840231e-06	-1.042388e-06	2.252379e-06
197	...	5.174804e-06	2.359620e-06	9.959044e-07	2.864602e-06
204	...	1.968603e-06	3.130499e-06	2.039664e-06	-3.295759e-07
205	...	3.807994e-06	6.108074e-06	2.040460e-06	5.716200e-06
221	...	8.566600e-06	6.949484e-06	2.442724e-06	8.360442e-06
227	...	-1.497976e-06	1.225228e-06	1.207891e-06	-9.778558e-08
243	...	4.252221e-06	1.448463e-06	-6.076743e-07	6.858605e-07
278	...	-8.620293e-08	2.521222e-06	3.477930e-06	3.341155e-06
299	...	2.498372e-07	1.226755e-06	1.102411e-06	3.659513e-07
300	...	-2.969235e-06	3.523120e-06	2.255450e-06	6.781514e-06
327	...	1.564413e-06	4.408109e-06	2.124373e-06	5.213950e-06
330	...	3.330144e-06	7.476018e-08	2.715100e-07	1.570638e-06
359	...	2.864110e-06	7.769744e-07	1.405536e-06	1.416970e-06
367	...	3.079859e-06	2.439010e-06	4.885960e-07	2.950785e-06
374	...	6.714340e-08	6.126056e-07	2.153087e-06	1.018183e-07
376	...	4.384589e-06	8.732207e-07	9.717630e-07	3.142413e-06
380	...	3.175109e-06	1.294334e-06	4.362169e-07	2.649208e-06
412	...	4.209231e-06	3.008707e-06	6.385559e-07	2.427341e-06
448	...	1.045243e-06	9.050047e-07	8.772911e-07	3.374980e-07
449	...	-2.247123e-07	2.891503e-07	1.109757e-06	2.438077e-07
472	...	3.579891e-06	-1.439553e-07	-8.682399e-08	6.796311e-07
...
1484	...	1.900793e-06	7.410884e-07	6.692343e-07	3.405285e-06
1487	...	2.516919e-06	4.368874e-06	2.607308e-06	3.055327e-06
1493	...	4.259263e-06	1.977311e-06	2.601083e-07	1.969631e-06
1505	...	1.132699e-05	7.720122e-06	2.802016e-06	6.651120e-06
1506	...	3.267511e-06	1.319596e-06	5.749560e-07	1.310231e-06
1512	...	1.334565e-06	2.011486e-06	9.680847e-07	2.469360e-06
1564	...	4.729036e-06	4.226060e-06	3.705264e-06	1.026397e-05
1571	...	3.676281e-06	-6.089429e-08	4.897793e-08	1.862575e-06
1588	...	9.178019e-07	-9.182355e-07	1.030045e-06	2.756812e-06
1600	...	1.210312e-06	1.880032e-06	9.254118e-07	5.737371e-06
1620	...	3.263434e-06	2.528302e-06	4.479629e-07	2.040974e-06
1657	...	4.7077783e-07	5.822951e-06	2.154932e-06	4.879657e-06
1667	...	-9.130051e-06	1.690453e-07	1.387091e-06	-1.301068e-06
1670	...	2.015177e-06	1.683921e-06	9.834969e-07	2.495889e-06
1672	...	4.171683e-06	2.695608e-06	8.578664e-07	2.086031e-06
1679	...	-4.393967e-07	5.770955e-07	9.246242e-07	7.330960e-07
1681	...	6.494468e-06	7.544108e-06	2.331101e-06	5.560418e-06
1688	...	-4.164543e-07	2.474801e-06	1.193042e-06	5.055444e-07
1690	...	1.384646e-05	8.399359e-06	1.383318e-06	5.713630e-06
1694	...	-1.263469e-06	6.149084e-07	2.261127e-06	-2.442554e-06
1704	...	2.504739e-05	5.751245e-06	-1.522155e-06	5.656143e-06
1721	...	5.751245e-06	8.100491e-06	1.313006e-06	3.704669e-06

1725	...	-1.522155e-06	1.313006e-06	3.515727e-06	1.445014e-06		
1744	...	5.656143e-06	3.704669e-06	1.445014e-06	1.055412e-05		
1775	...	8.395387e-06	4.362112e-06	2.506587e-06	4.381406e-06		
1780	...	2.006741e-06	2.532788e-06	1.530593e-06	3.682976e-06		
1782	...	6.434863e-06	5.051213e-06	1.756698e-06	4.656413e-06		
1803	...	-1.888953e-06	2.680337e-06	1.553990e-06	2.817981e-07		
1814	...	5.924951e-06	3.581730e-06	8.967293e-07	3.774430e-06		
1835	...	2.319462e-06	1.058757e-06	2.253605e-06	-5.922489e-07		
		1775	1780	1782	1803	1814	\
27	6.085906e-06	4.485383e-06	7.296883e-06	5.780729e-06	6.619907e-06		
73	1.214302e-05	5.523542e-06	1.909834e-05	1.733731e-05	1.405102e-05		
114	1.424949e-06	2.385599e-06	5.664553e-06	2.195592e-06	4.832838e-06		
116	3.430650e-06	1.241378e-06	5.165766e-06	5.636617e-06	4.164389e-06		
120	9.170867e-08	1.333335e-06	-1.945620e-06	-1.420645e-06	-1.616989e-06		
123	2.099173e-06	5.487210e-06	9.417810e-06	9.482794e-06	5.375287e-06		
127	4.229535e-06	2.042583e-06	6.094713e-06	3.621491e-06	5.227683e-06		
131	1.549335e-06	5.194661e-07	5.105733e-07	-6.434979e-08	1.078630e-06		
167	8.294566e-07	1.914076e-06	9.666679e-07	1.700758e-06	1.453073e-06		
184	3.676783e-06	5.673413e-07	3.815215e-06	-4.366424e-07	5.045559e-06		
197	6.303186e-06	3.323466e-06	6.283546e-06	4.020926e-06	6.953601e-06		
204	1.039203e-05	5.446145e-06	1.578605e-05	1.478440e-05	1.196959e-05		
205	9.751338e-06	6.584410e-06	1.267244e-05	9.886961e-06	1.363952e-05		
221	1.584859e-05	7.167753e-06	2.080151e-05	1.452177e-05	2.136737e-05		
227	2.694896e-06	2.224524e-06	4.228784e-06	5.422213e-06	3.252642e-06		
243	1.491595e-06	1.550415e-07	7.901486e-07	-3.976225e-07	1.841016e-06		
278	1.075813e-05	5.511048e-06	1.266221e-05	1.203400e-05	1.083415e-05		
299	4.785403e-06	2.799864e-06	5.302926e-06	6.058302e-06	5.006594e-06		
300	1.595068e-06	5.258114e-06	4.694112e-06	2.910615e-06	1.810995e-06		
327	7.949807e-06	5.335584e-06	1.251895e-05	9.113588e-06	1.329473e-05		
330	1.141439e-06	1.619782e-06	-5.884052e-07	-1.144735e-06	-1.866314e-07		
359	1.235584e-06	1.236209e-06	1.737646e-06	-1.434792e-07	4.646590e-07		
367	5.934085e-06	4.367541e-06	6.832848e-06	5.945159e-06	4.973800e-06		
374	4.866244e-06	1.053886e-06	5.839588e-06	5.547780e-06	3.916367e-06		
376	4.550114e-06	2.264496e-06	5.662117e-06	2.512748e-06	5.847812e-06		
380	2.505831e-06	1.716685e-06	3.648665e-06	1.751690e-06	4.686577e-06		
412	3.726008e-06	2.576445e-06	4.634773e-06	2.700388e-06	4.659949e-06		
448	2.607574e-06	5.359217e-07	3.790968e-06	2.405217e-06	3.097814e-06		
449	1.564919e-06	5.512702e-07	1.284438e-06	1.192599e-06	6.148572e-07		
472	2.747479e-06	-1.637125e-08	2.485574e-06	9.782207e-07	2.741619e-06		
...	
1484	3.262058e-06	3.634037e-06	3.891735e-06	3.337541e-06	4.263043e-06		
1487	5.629787e-06	4.638307e-06	9.344680e-06	6.566976e-06	4.505962e-06		
1493	2.177451e-06	1.261094e-06	2.075715e-06	4.046103e-07	2.800358e-06		
1505	1.324236e-05	5.570941e-06	1.661392e-05	9.656645e-06	1.351973e-05		
1506	4.000493e-06	2.336341e-06	3.339162e-06	2.676550e-06	4.013548e-06		
1512	3.396444e-06	2.396039e-06	3.793427e-06	2.984545e-06	3.921802e-06		

1564	1.104016e-05	7.519292e-06	1.285215e-05	7.299198e-06	1.146915e-05
1571	1.818787e-06	7.598184e-07	-4.746324e-08	-1.029691e-06	1.324993e-06
1588	7.608187e-07	2.209831e-06	-3.908151e-07	-7.368761e-07	1.624535e-06
1600	6.150018e-06	2.832141e-06	6.766838e-06	4.996584e-06	9.365680e-06
1620	2.885432e-06	1.702409e-06	5.093475e-06	3.021795e-06	4.431684e-06
1657	7.771291e-06	5.422894e-06	1.422145e-05	1.086337e-05	1.546299e-05
1667	3.053375e-06	2.541129e-06	4.932094e-06	1.061258e-05	6.494817e-06
1670	4.015499e-06	2.394347e-06	6.256789e-06	4.732414e-06	5.166454e-06
1672	4.910621e-06	2.816981e-06	5.603119e-06	3.754371e-06	5.515664e-06
1679	4.349181e-06	2.426326e-06	7.518667e-06	6.222851e-06	6.365379e-06
1681	8.090180e-06	4.436288e-06	9.324764e-06	6.828080e-06	8.325652e-06
1688	5.049097e-06	3.928441e-06	1.261122e-05	1.125590e-05	8.846220e-06
1690	1.562202e-05	6.156256e-06	1.810648e-05	1.368671e-05	1.844716e-05
1694	5.872792e-06	5.578088e-06	8.008627e-06	9.043431e-06	7.074353e-06
1704	8.395387e-06	2.006741e-06	6.434863e-06	-1.888953e-06	5.924951e-06
1721	4.362112e-06	2.532788e-06	5.051213e-06	2.680337e-06	3.581730e-06
1725	2.506587e-06	1.530593e-06	1.756698e-06	1.553990e-06	8.967293e-07
1744	4.381406e-06	3.682976e-06	4.656413e-06	2.817981e-07	3.774430e-06
1775	1.536192e-05	5.267744e-06	1.044066e-05	7.252357e-06	8.779849e-06
1780	5.267744e-06	6.491891e-06	5.459662e-06	4.413437e-06	4.380094e-06
1782	1.044066e-05	5.459662e-06	1.748029e-05	1.025713e-05	1.121838e-05
1803	7.252357e-06	4.413437e-06	1.025713e-05	1.286298e-05	8.473727e-06
1814	8.779849e-06	4.380094e-06	1.121838e-05	8.473727e-06	1.678904e-05
1835	6.529378e-06	1.956466e-06	7.872095e-06	6.622432e-06	8.157317e-06

	1835
27	3.594075e-06
73	1.199478e-05
114	1.613818e-06
116	3.379085e-06
120	-4.409208e-06
123	4.718902e-06
127	3.521497e-06
131	5.434165e-07
167	1.040913e-06
184	3.198329e-06
197	4.063782e-06
204	9.543300e-06
205	7.451122e-06
221	1.170208e-05
227	3.190490e-06
243	1.094524e-06
278	7.177462e-06
299	6.625088e-06
300	-9.941419e-07
327	6.533016e-06
330	2.291388e-07

```
359  2.194971e-06
367  2.269230e-06
374  4.704314e-06
376  4.823454e-06
380  2.682309e-06
412  2.026377e-06
448  2.116692e-06
449  1.515737e-06
472  3.427049e-06
...
...
1484 1.092744e-06
1487 4.827306e-06
1493 1.336021e-06
1505 7.620563e-06
1506 3.221122e-06
1512 2.621733e-06
1564 7.902513e-06
1571 9.106039e-07
1588 -8.735631e-07
1600 4.327343e-06
1620 2.586471e-06
1657 9.995732e-06
1667 3.491809e-06
1670 2.939776e-06
1672 3.227216e-06
1679 5.186300e-06
1681 3.847765e-06
1688 8.360659e-06
1690 1.074149e-05
1694 6.196019e-06
1704 2.319462e-06
1721 1.058757e-06
1725 2.253605e-06
1744 -5.922489e-07
1775 6.529378e-06
1780 1.956466e-06
1782 7.872095e-06
1803 6.622432e-06
1814 8.157317e-06
1835 1.223511e-05
```

[100 rows x 100 columns]

```
[390]: port_std_63 = []
for i in np.arange(len(weight63)):
    port_std_63.append(np.sqrt(weight63[i] @ rw_126_cov.to_numpy() @
                             weight63[i].T))
```

port_std_63

[390]: [0.0012033334378557408,
0.0012021890376004375,
0.001203660281668617,
0.001200735004470146,
0.0012019317728846767,
0.0011996281277128905,
0.0011960723232719637,
0.0011918013280346291,
0.0011918331841000358,
0.001190317665000806,
0.0011919970047254804,
0.0011933552146692443,
0.0011911956947531284,
0.0011881789372743105,
0.0011854929544488065,
0.0011849634393607724,
0.0011856373823022693,
0.001184814479572988,
0.0011909135783943197,
0.0011890586060230113,
0.0011898893851911975,
0.0011905255830511002,
0.0011885296995382973,
0.001189656072631835,
0.0011880913337226125,
0.0011905538979091093,
0.0011893498298244064,
0.0011884669506464103,
0.00118757048771758,
0.0011887902096762418,
0.0011881111808268823,
0.0011905316258026364,
0.001191555565709594,
0.001193005272056373,
0.0011962152402788331,
0.0011955498312692066,
0.0011959787053709382,
0.0011995074923110756,
0.0011990198013225647,
0.001196219662851061,
0.0011957699863931037,
0.0011968836359312592,
0.001196637763779335,
0.001199253004725949,
0.0011975272797445174,

0.001198757268783252,
0.0012001753935936776,
0.001199887828395483,
0.0012001107540136706,
0.0012009553054713109,
0.0012027068599517955,
0.0012024841668628547,
0.0012014196661806246,
0.0012002545721003944,
0.00119607513228334,
0.0011960090229487332,
0.0011980790099812841,
0.0011986458277973777,
0.0011981341091399633,
0.0011987643120531819,
0.0011996720327920182,
0.001201255658567071,
0.0012025549064717327,
0.001200482403249036,
0.0012016068244023231,
0.001200163151995053,
0.0011999906623133296,
0.0011996865889845848,
0.0011993168462325814,
0.0011966273268963256,
0.0011928115509270653,
0.0011907932369448293,
0.0011967299806786207,
0.001198114090894283,
0.001201579477221827,
0.0012011631003264172,
0.0012008748899597708,
0.0011984239601304531,
0.0012002963876204384,
0.0011993492890065966,
0.0011967718923943296,
0.0011964261937425927,
0.0011968875683527958,
0.0011977020522633164,
0.0011999051104306605,
0.0011990803204218975,
0.001198608370900137,
0.0011948257075217745,
0.0011975830957119196,
0.0011943244928712276,
0.0011926466367167294,
0.0011920200208047221,

0.0011967613978456965,
0.0011983047622491194,
0.001199515671689268,
0.0012002483651241673,
0.0011993921443988528,
0.0012000799906395415,
0.0011991114397240387,
0.0011999868485974008,
0.0011994337984786358,
0.0012001216349827107,
0.0011977706642870508,
0.0011944068416853298,
0.0011911925405998967,
0.0011892548894222902,
0.0011869618333279178,
0.0011882309773232126,
0.001187907644852207,
0.001187847649214648,
0.0011902394935152099,
0.0011881649465617533,
0.0011917217206339334,
0.0011921572452638376,
0.0011926217457148027,
0.0011927749955266307,
0.001192745450704044,
0.001187982053871545,
0.0011881022235939237,
0.0011914703334203955,
0.001189714557404893,
0.00118687831520633,
0.0011837686813679915,
0.001183993767758933,
0.0011843648788962939,
0.0011898740717873196,
0.0011919094097364953,
0.0011908628346308232,
0.0011879930240533824,
0.001188544623546859,
0.001185919307061889,
0.001187761690487281,
0.0011897603355588832,
0.0011906908077564155,
0.0011885168683958254,
0.0011871965252267464,
0.0011899048872017538,
0.0011921346788422787,
0.0011878956415934513,

0.0011873626548110584,
0.001188815123328492,
0.0011886398594496894,
0.0011865143965923604,
0.0011888717972379553,
0.0011908898019142942,
0.0011809233739367038,
0.001180541647298677,
0.0011818870298242867,
0.0011831772234364823,
0.0011820454367886992,
0.0011773770338826043,
0.001178971421358354,
0.001183111776686196,
0.0011841713236350484,
0.0011845645808729384,
0.001183143173297186,
0.001185258892028091,
0.0011859462935481535,
0.001184583105264249,
0.001186204984636494,
0.001186285299886854,
0.0011864452673569462,
0.0011909397444357793,
0.0011927555803733125,
0.0011914771827150796,
0.0011911786861234152,
0.0011902062039710222,
0.0011956967130686807,
0.001198510268067901,
0.001195891645755528,
0.001197211915640608,
0.0011996776437068538,
0.0011970361220458414,
0.0011969318159482135,
0.0011985597507122756,
0.001202162884303217,
0.001207200483130251,
0.0012069418614231201,
0.0012083189125317226,
0.0012069888687198146,
0.00120614619982053,
0.001204763494406826,
0.0012030808980350845,
0.001200879248345092,
0.0012047500747537016,
0.0012042997257499925,

0.001202406765786676,
0.0012028225215190318,
0.0012034969997320006,
0.0012054224729603142,
0.001204405734765153,
0.0012028815720798458,
0.0012019702190568032,
0.001201774082567394,
0.0012010129423091764,
0.0011971047969148736,
0.0011959569406308295,
0.0011965200381365143,
0.001197105610274709,
0.001197072549253452,
0.0011954632885188307,
0.001196027035177921,
0.0011969146717627234,
0.0011939063707365456,
0.0011905855583775246,
0.001188643630546706,
0.0011872363188061453,
0.0011870114298084833,
0.0011866353816710519,
0.001185883591624078,
0.0011863392594153915,
0.0011852030105485958,
0.0011819214639003162,
0.0011830473808811684,
0.001183173290692067,
0.0011842743732237227,
0.0011823976260389344,
0.0011819045150483535,
0.001179654881222468,
0.0011803218500628053,
0.0011774126323963032,
0.0011791546782898487,
0.0011764730432473928,
0.0011762902908884574,
0.0011761916852131107,
0.0011725704185300962,
0.0011692949447036874,
0.0011699393205527324,
0.001175184426571818,
0.0011757309744208964,
0.0011755586694561276,
0.0011747808863567795,
0.0011759309501351953,

0.0011742428226460585,
0.0011759032406548047,
0.0011784924139766123,
0.0011779166370454973,
0.0011774701050764169,
0.0011824643901274911,
0.0011812662792626463,
0.0011852306785026274,
0.0011845641494595363,
0.0011829851244497135,
0.0011812915237554237,
0.0011803059301060408,
0.0011792441362404587,
0.00117903764987748,
0.0011751531377989827,
0.0011756154099848255,
0.0011819763185609042,
0.0011807441163828813,
0.0011840818707518697,
0.0011880067792224868,
0.0011835601034935483,
0.0011851258731240247,
0.0011878675873467253,
0.0011857708996259027,
0.0011875579012922133,
0.0011884717967155626,
0.0011896152116344224,
0.0011898208781214868,
0.0011924156000999565,
0.0011910215454969183,
0.001191603607794955,
0.001194004618966735,
0.0011923561316404495,
0.0011921994873849966,
0.0011932429976794488,
0.0011940836378305211,
0.0011926549394920924,
0.0011895575372082789,
0.0011873541099689485,
0.0011870702123440865,
0.0011915103974468448,
0.0011899337263041895,
0.0011918207301391355,
0.0011921667131303795,
0.0011902643862464184,
0.0011892783538983082,
0.001193023079835169,

0.0011941044619596844,
0.0011944157641567749,
0.0011924417700107076,
0.0011947766766553863,
0.0011967638776257696,
0.00119669662626341,
0.001194115687463079,
0.001195108815474916,
0.0011935260894955792,
0.0011933580283000156,
0.0011927301211293116,
0.0011961539114396134,
0.0011948349133916612,
0.0011916093721017064,
0.001192250551828359,
0.001190138504807022,
0.0011894759787228664,
0.0011881235075999902,
0.0011861842532514106,
0.0011862187732348726,
0.0011874239737494734,
0.001185402309325962,
0.0011840127267922804,
0.0011823748994544492,
0.0011808227633125121,
0.0011834430531847628,
0.0011868073873379592,
0.0011873918069740784,
0.0011864509631468443,
0.0011876228393747695,
0.0011842761497330224,
0.0011851578656959917,
0.001184712998113339,
0.0011896887725344756,
0.001186629448495253,
0.0011822672827047206,
0.0011837471841088028,
0.0011809865866582187,
0.0011820493155692828,
0.0011807699986285728,
0.0011821883907439665,
0.0011818863204045142,
0.0011844316620321777,
0.0011849462097827666,
0.0011849019059343134,
0.0011848068277633022,
0.0011860172203820307,

0.0011864797449832184,
0.0011847775995200364,
0.0011837874728488221,
0.0011863068829511881,
0.0011869881994619076,
0.001188829573126252,
0.0011885002628779873,
0.0011878178218211117,
0.001189209154439177,
0.0011874810872083686,
0.001190074410756111,
0.0011956430622769118,
0.0011943169253174977,
0.0011990041858681722,
0.0011955084827265084,
0.0011963256933690339,
0.0011955094593986244,
0.0011978279358159797,
0.0011991428143069895,
0.0012000888944946476,
0.0011995673939368503,
0.0011987229560914978,
0.0011973304213479497,
0.001197009696395606,
0.001195764666695942,
0.0011964348597920818,
0.0011968623512661587,
0.001196206607634431,
0.0011978508831297242,
0.0011965918613199074,
0.0011956108648876924,
0.0011952532101162843,
0.0011955401391082524,
0.001196565159718006,
0.0011961191730270096,
0.001194273696638086,
0.0011930305863576893,
0.0011942626284501248,
0.001193903065754581,
0.0011994207146025675,
0.0012003792404141856,
0.001198482178316307,
0.00119792053957164,
0.0011948791102815454,
0.0011956983582238467,
0.0011949762205264826,
0.0011919119730238999,

0.0011909084981735324,
0.0011911816627099235,
0.0011930590871824323,
0.0011946997122825426,
0.001195909363397597,
0.001198574578848975,
0.0011982302810783579,
0.0011997003515744468,
0.001198637038250089,
0.0012003912395203986,
0.0011971029298155761,
0.0011960323096614183,
0.001198388271163707,
0.0012006194349314888,
0.0011995624452473242,
0.0011974680712469464,
0.0011956565959198586,
0.0011944609321937563,
0.0011929315930931262,
0.001193929418304019,
0.0011923363570073488,
0.0011949729078353688,
0.0011976827042436623,
0.00119599900764923,
0.0011985658961685464,
0.0011952928775449598,
0.0011958202103238824,
0.0011925795212829925,
0.0011936403901357283,
0.001194112814662748,
0.0011938151742941494,
0.0011957606194517567,
0.001193968307769547,
0.0011942066321526208,
0.001194478836395465,
0.001193235369248921,
0.0011930509447642269,
0.001194586412857052,
0.0011946230105390296,
0.0011931609564321155,
0.001194208476554463,
0.0011962644447194007,
0.0011963984874125285,
0.001196694271790865,
0.0011947724506528286,
0.0011895921389452541,
0.0011887116537963249,

0.0011888360859001422,
0.001188586293992196,
0.0011889942524141422,
0.001189590690001964,
0.0011858804147453093,
0.001185224478916586,
0.001185962204165298,
0.0011900235880547626,
0.0011897983630127437,
0.0011892812268740876,
0.0011921009815589847,
0.001192936460279484,
0.0011906078199585648,
0.0011881731796880388,
0.001188946740472952,
0.0011884766509711634,
0.0011897618606790347,
0.0011879508198097586,
0.001188513045063359,
0.0011874572015801606,
0.0011853073461938297,
0.001185795756340944,
0.0011883520318861352,
0.0011846943202410147,
0.0011840886299389524,
0.0011830228999473865,
0.0011829876033910042,
0.001182726647413908,
0.0011812906323667132,
0.001180105955155008,
0.001180335192626697,
0.0011818620720400988,
0.0011819167232898485,
0.0011813683007134638,
0.0011840082284724116,
0.0011851356430099458,
0.0011880329106164,
0.0011885713935262433,
0.0011904905189502762,
0.0011912834537072398,
0.0011969304984942423,
0.0011983471683837189,
0.001201495262793048,
0.0012017872654297439,
0.0012021139051987288,
0.00120227258944055,
0.0011991822534217678,

0.0011995297582465684,
0.0011995714483051434,
0.0011998811528585395,
0.0011993082006007292,
0.001199146454582797,
0.0011956581545721082,
0.0011935365498244072,
0.0011921952313236031,
0.0011901392804552218,
0.001188560229182168,
0.001190345078451273,
0.001186686501738166,
0.0011867400200359644,
0.0011870863750601019,
0.0011877882983091694,
0.0011875303122334954,
0.001187214079760695,
0.0011862794868667593,
0.0011870068722147837,
0.0011876120612490933,
0.0011848326921649031,
0.0011837802163934615,
0.0011820423478971394,
0.0011789476853748134,
0.0011780174181674203,
0.0011791108457004928,
0.001178768355447439,
0.0011790739558740465,
0.0011784673719074871,
0.0011769224053222083,
0.0011754647937706132,
0.0011741169947201372,
0.0011738167672394485,
0.0011761744109111418,
0.001177767699596105,
0.0011773355563879323,
0.0011764508250457439,
0.0011753641359605244,
0.0011727783942833032,
0.0011736749369371442,
0.001175214179136234,
0.0011748337154058597,
0.0011746641156478916,
0.0011754859018841349,
0.0011752542137578785,
0.0011763772305600497,
0.0011775816224401277,

0.001175081312455925,
0.0011706268459666254,
0.0011706668298856768,
0.0011729511752542423,
0.001173728323832833,
0.001177006250684841,
0.0011739862326353373,
0.0011729437854167612,
0.00117279633209156,
0.0011720831762027828,
0.0011712577537181833,
0.0011711409124141247,
0.0011693268582093068,
0.0011687973803674082,
0.00116982662544164,
0.0011717123401775982,
0.0011743729155619111,
0.001174251876782978,
0.0011759859630313162,
0.001179024944066653,
0.001178643244690147,
0.0011786954386609546,
0.001178822272287274,
0.0011793626566303898,
0.0011802714880938647,
0.0011792802133994875,
0.0011783925815759791,
0.001177703648076261,
0.0011688671399691,
0.001169389523481624,
0.0011694788690317602,
0.0011707408314971116,
0.0011724465289920964,
0.001175693386503727,
0.0011717643242305177,
0.0011716295601525582,
0.0011697024517317099,
0.001167961804588002,
0.0011676781323615645,
0.0011681058159048487,
0.001168018702527352,
0.0011706344653840124,
0.0011699311390960738,
0.0011700617972810973,
0.0011692128953149157,
0.0011687957786286902,
0.0011687518211972508,

0.0011675770379555245,
0.0011670319852030715,
0.0011663603259917741,
0.0011677478815443423,
0.0011671401727520497,
0.001164739163286732,
0.0011628620004642566,
0.0011669989041383387,
0.0011655656498159653,
0.001163339070534516,
0.001162810411093207,
0.0011594417298995989,
0.0011565997950381077,
0.0011573744681236172,
0.001158002472328861,
0.0011597289439700628,
0.0011600851855599458,
0.0011603856584187567,
0.0011604100477996709,
0.001163355326374996,
0.0011608664803018731,
0.0011606121567785698,
0.0011631045176494022,
0.0011647076280442393,
0.0011629911795368185,
0.001166328250176221,
0.0011662369663529685,
0.0011640014293385656,
0.0011622801772314631,
0.0011599353605912272,
0.0011569658686024914,
0.001158182585015037,
0.0011582181959990923,
0.00116094491858115,
0.0011615829161187865,
0.001164048925336018,
0.001165033486860844,
0.0011640534521673818,
0.0011647360839102006,
0.0011658077058797826,
0.0011674007438140228,
0.0011644334562038931,
0.001164554388425851,
0.001165575096150013,
0.0011666079154735534,
0.0011677110130123025,
0.0011622015277159914,

0.0011629208403779595,
0.0011627098582780028,
0.0011633906601200023,
0.0011637756373004133,
0.0011647430648450833,
0.0011666607281624409,
0.001167289338245963,
0.0011664926502503977,
0.0011660626138147714,
0.0011665122751159675,
0.0011660541843609388,
0.0011695834528481289,
0.0011726658169848997,
0.0011710650756217582,
0.0011722419052837944,
0.001175090047936201,
0.001176369837056838,
0.0011755832600650394,
0.0011728806324486159,
0.0011722540748417619,
0.0011718664936835248,
0.0011743471295683112,
0.0011742260526698813,
0.0011735383109354694,
0.001174746624532739,
0.0011763664134236639,
0.0011779821316344552,
0.001178348358632516,
0.001178868961962879,
0.0011774205542064277,
0.0011787436643556192,
0.0011802561462371127,
0.0011826346361542646,
0.0011805204775739457,
0.0011798732697144924,
0.0011787484962089523,
0.0011779034223365688,
0.0011785991148351945,
0.001179962714057764,
0.0011792817967621752,
0.0011821294173855852,
0.0012576657060255575,
0.001255355156826834,
0.0012543181836340278,
0.0012525180209108822,
0.0012496070033770179,
0.0012502587047047875,

0.0012494285986309364,
0.0012509235297426357,
0.0012501489214270726,
0.0012504140952287915,
0.0012489251987657353,
0.0012499627691645906,
0.001254079879143056,
0.0012538058577866757,
0.0012554340381671584,
0.0012542264604010463,
0.0012554709540002445,
0.0012551025222685872,
0.001252881894504738,
0.0012491270792165349,
0.001248242578380364,
0.001245982538854176,
0.0012463214220879816,
0.001248208378255727,
0.001249020994411128,
0.001249266962240813,
0.0012512965697519319,
0.0012541446653315743,
0.0012537280850132809,
0.0012544555455401532,
0.0012545167392596483,
0.001253197531335885,
0.0012546453227596454,
0.0012564668979195338,
0.0012562982320797262,
0.0012574791378436312,
0.0012593209940958893,
0.001261426811846879,
0.0012621760469972612,
0.001261042497872599,
0.0012613004991704397,
0.0012592915328970065,
0.0012670644024143224,
0.0012712115656138767,
0.001269678875070034,
0.001271144093063626,
0.001272592426002249,
0.0012767458283207398,
0.0012800676135380517,
0.0012805665602876881,
0.0012800589925155844,
0.0012797407681085474,
0.0012796551140179353,

0.001276093134397113,
0.0012775881454002115,
0.001279540670692374,
0.0012772296178862155,
0.0012754654947056254,
0.0012747399669324469,
0.0012735429556689631,
0.0012761901117453562,
0.0012756269786255126,
0.001273651662617185,
0.0012742927728825973,
0.0012751025794672096,
0.0012770819518567599,
0.0012795349798314616,
0.0012772733369374742,
0.0012777051355135946,
0.0012770879279239526,
0.001275867016393229,
0.0012767032597594333,
0.001279024064491577,
0.0012772902219253678,
0.0012792176854705493,
0.0012792175852359485,
0.0012789240231765515,
0.0012779543599024535,
0.001272485498258204,
0.0012711741934846113,
0.0012660600699502316,
0.0012667865274590847,
0.0012645769700027705,
0.0012629399070622572,
0.0012634006326963613,
0.0012624959993871618,
0.00126275797227053,
0.0012639449824465633,
0.0012635875295066979,
0.001260078656683385,
0.001258561641349993,
0.0012589236193055328,
0.0012607288234403652,
0.001260417226148599,
0.001260609114144417,
0.0012598314434371161,
0.0012554451404480607,
0.0012547737392134594,
0.0012559171359333347,
0.0012562321449520522,

0.0012552566113590824,
0.0012555013919723,
0.0012568981730064661,
0.0012573609236113848,
0.0012583545044920674,
0.0012589876430044674,
0.0012615037043774487,
0.0012614717590148023,
0.0012624679747287517,
0.0012623127395231103,
0.001262187046463415,
0.0012638952598101386,
0.0012629154828086102,
0.0012603497917879954,
0.0012590152942501729,
0.0012580291687736746,
0.0012547456450879518,
0.0012557894445808123,
0.0012558800664218936,
0.0012562917792586928,
0.0012530511222319496,
0.0012496591127679744,
0.0012498656756950357,
0.0012485148176654942,
0.0012483342766589876,
0.0012479942953857444,
0.0012489531384583862,
0.0012492620835140185,
0.0012492523955588031,
0.0012467604044819269,
0.0012468783189658816,
0.0012455328281854292,
0.0012438646419056078,
0.0012416444192373565,
0.0012422207284668342,
0.0012427548650870996,
0.0012412182463126594,
0.0012420366308484416,
0.0012406498908404042,
0.0012420934140150292,
0.001241907430251297,
0.0012406931718044658,
0.0012410812742635917,
0.0012401614273138486,
0.001241816550630159,
0.0012409975800698734,
0.0012392419201393643,

0.0012397934033948623,
0.0012387767494834699,
0.001238980883130201,
0.001240136917492326,
0.0012402680443029924,
0.001240728525367452,
0.0012408403315615597,
0.0012409650808029038,
0.0012403862423492847,
0.0012417448180302032,
0.0012439958353783278,
0.0012487198501672148,
0.0012440690977638567,
0.0012457349867730637,
0.0012432956259586085,
0.001243755711651664,
0.0012437512269191904,
0.0012434968202101066,
0.0012425520829756646,
0.001246603806627651,
0.0012453497580310312,
0.0012430618437188736,
0.0012412497832456578,
0.0012397570899168417,
0.001238583765120415,
0.0012370653901072495,
0.0012319438447979743,
0.0012342532337450444,
0.0012341733619588681,
0.0012351228593150175,
0.001237526912684062,
0.001238435158010062,
0.0012372548676621883,
0.0012369989224648395,
0.0012373727433643707,
0.0012376241598723396,
0.001236320108212923,
0.0012369785546160852,
0.0012372289381416904,
0.001236485100448418,
0.0012328754616901124,
0.0012358959019287536,
0.0012349100947880972,
0.0012339506882237282,
0.0012343485443673877,
0.0012371328801557592,
0.0012367537807427443,

0.0012363093829938904,
0.0012349004264608791,
0.0012290178950521745,
0.0012289144642486341,
0.0012322671270408902,
0.0012333369367453556,
0.001231907141625031,
0.0012333989773528249,
0.0012339239163748053,
0.00123399432928666,
0.0012308583908930463,
0.0012307404476323814,
0.0012282151829925026,
0.0012303878785916529,
0.0012284564354056433,
0.0012282517714154598,
0.0012300321033673278,
0.00123042400961845,
0.0012289666897658438,
0.0012266346445164568,
0.00122610384486809,
0.001228343372807069,
0.001226500618152781,
0.0012301731695937264,
0.00122711147122795,
0.0012241456980367472,
0.0012281093776638342,
0.0012280065874517108,
0.00122614504385335,
0.0012260620416003265,
0.0012239196724640954,
0.001228263316649062,
0.00122841613298943,
0.0012289926940295879,
0.0012300696474157454,
0.0012314881277640489,
0.0012333871871408086,
0.001235641835316496,
0.001235863616439985,
0.0012363457905872272,
0.0012373315466505746,
0.0012403352790050066,
0.00124046826775721,
0.0012411099477649015,
0.0012421026429980506,
0.0012388069027410166,
0.0012394240934280566,

0.0012449624098140094,
0.0012418905451816434,
0.0012472559310003177,
0.0012513912045867173,
0.001250517555697525,
0.001249814573772964,
0.0012496655599731757,
0.0012527921401417799,
0.0012492593037321306,
0.0012530410189142576,
0.0012592748965412326,
0.0012600875662463688,
0.0012601051467632368,
0.0012566023564738683,
0.0012569485361438614,
0.0012571161005867427,
0.001254199519655714,
0.0012570588303144991,
0.001256904269423151,
0.0012584260038414807,
0.0012582467080366046,
0.0012615606653988453,
0.0012570821625969711,
0.0012513043488336197,
0.001250162094676039,
0.0012522250347213621,
0.0012519005585157207,
0.0012526609906295175,
0.0012551992174357268,
0.0012593214846435313,
0.0012575807578822339,
0.0012563802542126003,
0.0012595078723906085,
0.0012603012174516055,
0.0012545054739746323,
0.001259011341959435,
0.001259273887138667,
0.001260576551398022,
0.0012596897362625499,
0.0012542949274398582,
0.0012544392960133347,
0.0012564934409782166,
0.0012536719460132482,
0.0012534280848239701,
0.0012542747727178059,
0.0012541328148372084,
0.0012577124702710068,

0.0012605508755664943,
0.001261875335502207,
0.00125990884208625,
0.0012594650980829473,
0.0012591711623871759,
0.0012596052394193047,
0.0012644163317790166,
0.0012569695907814575,
0.0012560719979237912,
0.0012546478465745962,
0.0012510174910890437,
0.0012564250748786224,
0.0012565055570105286,
0.0012586961197864328,
0.0012572756656215561,
0.0012595387871696337,
0.0012648903764958589,
0.0012621607520086737,
0.0012644651861622527,
0.001266322098425014,
0.0012695342177076938,
0.001268906979779833,
0.001266184780031469,
0.001270212735087606,
0.0012697995904770725,
0.0012730180624606132,
0.0012758396290470952,
0.0012757185544609224,
0.0012729520050528036,
0.0012737719221887843,
0.0012718782898479264,
0.0012728709523120115,
0.0012716100334235964,
0.001276013586051632,
0.0012755943327416078,
0.0012711393586632873,
0.0012694333457970767,
0.0012626204325344,
0.001261828763543077,
0.0012633931139426219,
0.0012602539496013323,
0.0012641088209851522,
0.0012633315116909573,
0.0012650248134481751,
0.0012611316172008167,
0.001261686731785672,
0.0012606575044171154,

```
0.0012648856525180083,  
0.001263707933892741,  
0.0012543163053910097,  
0.001256064072233127,  
0.0012520788069322886,  
0.0012575157945002684,  
0.0012562968228609238,  
0.0012556574681462948,  
0.0012528887358837849,  
0.0012537802163096546,  
0.0012572648600692171,  
0.0012641031068116849,  
0.0012713623503120986,  
0.0012838626579591362,  
0.0012870389741340064,  
...]
```

```
[391]: np.shape(port_std_63)
```

```
[391]: (1448,)
```

```
[392]: def computeMktVar(windowSize):  
    MktVarMatrix = np.zeros(dateSize - windowSize)  
    for i in range(dateSize - windowSize):  
        MktVarMatrix[i] = np.var(ffMatrix[:,0][i + 1:i + windowSize])  
    return MktVarMatrix
```

```
[393]: def profolioVar(windowSize):  
    profolioVarRes = np.zeros(dateSize - windowSize)  
    mktVar = computeMktVar(windowSize)  
    beta, weight, idiosyncratic =  
    ↪betaAndWeightAndidiosyncraticMatrix(windowSize)  
    onedayAheadPro = np.zeros(dateSize - windowSize)  
    for windowNum in range(dateSize - windowSize):  
        oneday = np.zeros(100);  
        idx = 0  
        for stockidx in stockListSet.keys():  
            if (windowNum + windowSize + 1 < 1511):  
                oneday[idx] = secMatrix[stockidx][windowNum + windowSize + 1][1]  
            else:  
                oneday[idx] = secMatrix[stockidx][windowNum + windowSize][1]  
            idx += 1  
        onedayAheadPro[windowNum] = np.sum(oneday * weight[windowNum])  
        profolioVarRes[windowNum] = np.square(np.sum(beta[windowNum] *  
    ↪weight[windowNum])) * mktVar[windowNum] + np.sum(weight[windowNum] *  
    ↪idiosyncratic[windowNum] * weight[windowNum])  
        onedayAheadPro = onedayAheadPro - np.sum(onedayAheadPro) / 1007
```

```
    return (profolioVarRes, onedayAheadPro, onedayAheadPro/np.  
→sqrt(profolioVarRes))
```

```
[394]: def problemThree_3_4_5():  
    WindowList = [504, 252, 126, 63]  
    ans3List = []  
    ans4List = []  
    ans5List = []  
    ans6List = []  
    for windowSize in WindowList:  
        (ans3, ans4, ans5) = profolioVar(windowSize)  
        ans3List.append(ans3)  
        ans4List.append(ans4)  
        ans5List.append(ans5)  
        ans6List.append(np.sqrt(np.var(ans5)))  
    return ans3List, ans4List, ans5List, ans6List
```

```
[395]: ans3List, ans4List, ans5List, ans6List = problemThree_3_4_5()
```

```
[396]: print(ans6List)
```

```
[1.3274856981776428, 1.133968910244764, 1.064211870389402, 1.0466144075363761]
```

```
[ ]:
```

Problem3_final_version

December 18, 2020

0.1 Problem 3

```
[161]: import numpy as np
from sklearn.linear_model import LinearRegression
import statsmodels.api as sm
from sklearn.metrics import mean_squared_error

stockSize = 1877
dateSize = 1511
ffMatrix = np.loadtxt('./data/ffdata.txt', usecols=range(4))
secMatrix = np.loadtxt('./data/seadata.txt', usecols=range(3))
secMatrix = secMatrix.reshape(stockSize, dateSize, 3)

[162]: stockList = np.genfromtxt('./data/100.csv', delimiter=',', skip_header=1)[:,1]
stockListSet = {}
for Stockidx in stockList:
    stockListSet[int(Stockidx)] = 1
stockSize = 100

[189]: def computeBetaAndidiosyncratic(startdate, enddate, stockNum):
    X = (ffMatrix[:,0] - ffMatrix[:,3])[startdate: enddate+1].reshape(-1, 1)
    y_true = (secMatrix[stockNum][:,1] - ffMatrix[:,3])[startdate: enddate+1].
    ↪reshape(-1, 1)
    model = LinearRegression().fit(X, y_true)
    y_pred = model.predict(X)
    idiosyncratic = mean_squared_error(y_pred, y_true)
    beta = float(model.coef_)
    return beta, idiosyncratic

[190]: def betaAndWeightAndidiosyncraticMatrix(windowSize):
    betaMatrixRes = np.zeros((dateSize - windowSize, stockSize))
    weightMatrix = np.zeros((dateSize - windowSize, stockSize))
    idiosyncraticMatrix = np.zeros((dateSize - windowSize, stockSize))
    for windowidx in range(dateSize - windowSize):
        idx = 0
        totalweight = 0
        for stockidx in stockListSet.keys():
```

```

        betaMatrixRes[windowidx][idx], idiosyncraticMatrix[windowidx][idx] = computeBetaAndidiosyncratic(windowidx + 1, windowidx +WindowSize, stockidx)
        weightMatrix[windowidx][idx] = secMatrix[stockidx][windowidx +WindowSize][2]
        totalweight += weightMatrix[windowidx][idx]
        idx += 1
    for i in range(100):
        weightMatrix[windowidx][i] /= totalweight
    return betaMatrixRes, weightMatrix, idiosyncraticMatrix

```

[191]:

```

def computeMktVar(windowSize):
    MktVarMatrix = np.zeros(dateSize - windowSize)
    for i in range(dateSize - windowSize):
        MktVarMatrix[i] = np.var(ffMatrix[:,0][i + 1:i + windowSize])
    return MktVarMatrix

```

[192]:

```

def profolioVar(windowSize):
    profolioVarRes = np.zeros(dateSize - windowSize)
    mktVar = computeMktVar(windowSize)
    beta, weight, idiosyncratic = betaAndWeightAndidiosyncraticMatrix(windowSize)
    onedayAheadPro = np.zeros(dateSize - windowSize)
    for windowNum in range(dateSize - windowSize):
        oneday = np.zeros(100);
        idx = 0
        for stockidx in stockListSet.keys():
            if (windowNum + windowSize + 1 < 1511):
                oneday[idx] = secMatrix[stockidx][windowNum + windowSize + 1][1]
            else:
                oneday[idx] = secMatrix[stockidx][windowNum + windowSize][1]
            idx += 1
        onedayAheadPro[windowNum] = np.sum(oneday * weight[windowNum])
        profolioVarRes[windowNum] = np.square(np.sum(beta[windowNum] * weight[windowNum])) * mktVar[windowNum] + np.sum(weight[windowNum] * idiosyncratic[windowNum]) * weight[windowNum]
        onedayAheadPro = onedayAheadPro - np.sum(onedayAheadPro) / 1007
    return (profolioVarRes, onedayAheadPro, onedayAheadPro / np.sqrt(profolioVarRes))

```

[196]:

```

def problemThree_3_4_5():
    WindowList = [504, 252, 126, 63]
    ans3List = []
    ans4List = []
    ans5List = []
    ans6List = []
    forWindowSize in WindowList:

```

```
(ans3, ans4, ans5) = profolioVar(windowSize)
ans3List.append(ans3)
ans4List.append(ans4)
ans5List.append(ans5)
ans6List.append(np.sqrt(np.var(ans5)))
return ans3List, ans4List, ans5List, ans6List
```

```
[197]: ans3List, ans4List, ans5List, ans6List = problemThree_3_4_5()
```

```
[198]: print(ans6List)
```

```
[1.3274856981776428, 1.133968910244764, 1.064211870389402, 1.0466144075363761]
```

```
[ ]:
```

```
[ ]:
```

Problem4_final_version

December 18, 2020

0.1 Problem 4

```
[1]: import numpy as np
from sklearn.linear_model import LinearRegression
import statsmodels.api as sm
from sklearn.metrics import mean_squared_error

stockSize = 1877
dateSize = 1511
ffMatrix = np.loadtxt('./data/ffdata.txt', usecols=range(4))
secMatrix = np.loadtxt('./data/secdatas.txt', usecols=range(3))
secMatrix = secMatrix.reshape(stockSize, dateSize, 3)

[2]: stockList = np.genfromtxt('./data/100.csv', delimiter=',', skip_header=1)[:,1]
stockListSet = {}
for Stockidx in stockList:
    stockListSet[int(Stockidx)] = 1
stockSize = 100

[121]: def computeBetaAndIdiosyncraticAndCov(startdate, enddate, stockNum):
    X1 = (ffMatrix[:,0] - ffMatrix[:,3])[startdate:enddate+1]
    X2 = (ffMatrix[:,1])[startdate:enddate+1]
    X3 = (ffMatrix[:,2])[startdate:enddate+1]
    X = np.zeros((enddate - startdate + 1, 3))
    for i in range(enddate - startdate + 1):
        X[i][0] = X1[i]
        X[i][1] = X2[i]
        X[i][2] = X3[i]
    y_true = (secMatrix[stockNum][:,1] - ffMatrix[:,3])[startdate:enddate + 1].
    ↪reshape(-1, 1)
    model = LinearRegression().fit(X, y_true)
    y_pred = model.predict(X)
    loss = mean_squared_error(y_pred, y_true)
    beta = model.coef_
    return (beta, loss, np.cov(np.array([X1, X2, X3])))

[122]: def getAllParameterMatrix(windowSize):
    betaMatrixRes = np.zeros((dateSize - windowSize, stockSize, 3))
```

```

weightMatrix = np.zeros((dateSize - windowSize, stockSize))
idiosyncraticMatrix = np.zeros((dateSize - windowSize, stockSize))
covMatrix = np.zeros((dateSize - windowSize, 3, 3))
for windowidx in range(dateSize - windowSize):
    idx = 0
    totalweight = 0
    for stockidx in stockListSet.keys():
        betaMatrixRes[windowidx][idx], idiosyncraticMatrix[windowidx][idx], ↵
        covMatrix[windowidx] = computeBetaAndIdiosyncraticAndCov(windowidx + 1, ↵
        ↵windowidx + windowSize, stockidx)
        weightMatrix[windowidx][idx] = secMatrix[stockidx][windowidx + ↵
        ↵windowSize][2]
        totalweight += weightMatrix[windowidx][idx]
        idx += 1
    for i in range(100):
        weightMatrix[windowidx][i] /= totalweight
return betaMatrixRes, weightMatrix, idiosyncraticMatrix, covMatrix

```

```

[132]: def profolioVar(windowSize):
    profolioVarRes = np.zeros(dateSize - windowSize)
    beta, weight, idiosyncratic, cov = getAllParameterMatrix(windowSize)
    onedayAheadPro = np.zeros(dateSize - windowSize)
    for windowNum in range(dateSize - windowSize):
        oneday = np.zeros(100);
        idx = 0
        for stockidx in stockListSet.keys():
            if (windowNum + windowSize + 1 < 1511):
                oneday[idx] = secMatrix[stockidx][windowNum + windowSize + 1][1]
            else:
                oneday[idx] = secMatrix[stockidx][windowNum + windowSize][1]
            idx += 1
        onedayAheadPro[windowNum] = np.sum(oneday * weight[windowNum])
        profolioVarRes[windowNum] = (weight[windowNum] @ beta[windowNum]) @ ↵
        ↵cov[windowNum] @ np.transpose(beta[windowNum]) @ weight[windowNum].
        ↵reshape(-1, 1) + np.sum(weight[windowNum] * idiosyncratic[windowNum] * ↵
        ↵weight[windowNum])
        onedayAheadPro = onedayAheadPro - np.sum(onedayAheadPro) / 1007
    return (profolioVarRes, onedayAheadPro, onedayAheadPro/np.
        ↵sqrt(profolioVarRes))

```

```

[136]: def problemFour_3_4_5():
    WindowList = [504, 252, 126, 63]
    ans3List = []
    ans4List = []
    ans5List = []
    ans6List = []
    for windowSize in WindowList:

```

```
(ans3, ans4, ans5) = profolioVar(windowSize)
ans3List.append(ans3)
ans4List.append(ans4)
ans5List.append(ans5)
ans6List.append(np.sqrt(np.var(ans5)))
return ans3List, ans4List, ans5List, ans6List
```

```
[137]: ans3List, ans4List, ans5List, ans6List = problemFour_3_4_5()
```

```
[138]: print(ans6List)
```

```
[1.3274405499597957, 1.1327296775088582, 1.0608752735153486, 1.0406873087236521]
```

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

Problem5_1_2

December 18, 2020

0.1 Problem 5 (a) & (b)

```
[1]: #!pip install statsmodels
import numpy as np
from sklearn.linear_model import LinearRegression
import statsmodels.api as sm
from sklearn.metrics import mean_squared_error

stockSize = 1877
dateSize = 1511
ffMatrix = np.loadtxt('./ffdata.txt', usecols=range(4))
secMatrix = np.loadtxt('./secdatas.txt', usecols=range(3))
secMatrix = secMatrix.reshape(stockSize, dateSize, 3)
days = [503, 1005, 1510]
```

```
[2]: StockList = np.zeros((50, 100))
for i in range(50):
    StockList[i] = np.random.choice(np.arange(stockSize), 100)
```

```
[3]: def computeBetaAndIdiosyncratic(startdate, enddate, stockNum):
    X = (ffMatrix[:,0] - ffMatrix[:,3])[startdate: enddate+1].reshape(-1, 1)
    y_true = (secMatrix[stockNum][:,1] - ffMatrix[:,3])[startdate: enddate+1].
    ↵reshape(-1, 1)
    model = LinearRegression().fit(X, y_true)
    y_pred = model.predict(X)
    idiosyncratic = mean_squared_error(y_pred, y_true)
    beta = float(model.coef_)
    alpha = float(model.intercept_)
    return (beta, alpha, idiosyncratic)
```

```
[4]: def computeBetaAndIdiosyncraticAndCov(startdate, enddate, stockNum):
    X1 = (ffMatrix[:,0] - ffMatrix[:,3])[startdate: enddate+1]
    X2 = (ffMatrix[:,1])[startdate: enddate+1]
    X3 = (ffMatrix[:,2])[startdate: enddate+1]
    X = np.zeros((enddate - startdate + 1, 3))
    for i in range(enddate - startdate + 1):
        X[i][0] = X1[i]
        X[i][1] = X2[i]
```

```

        X[i][2] = X3[i]
y_true = (secMatrix[stockNum][:,1] - ffMatrix[:,3])[startdate:enddate + 1].
↪reshape(-1, 1)
model = LinearRegression().fit(X, y_true)
y_pred = model.predict(X)
loss = mean_squared_error(y_pred, y_true)
beta = model.coef_
alpha = float(model.intercept_)
return (beta, alpha, loss, np.cov(np.array([X1, X2, X3])))

```

[5]:

```

def p5_1():
    ansbeta1 = np.zeros((50, 3, 100))
    ansbeta2 = np.zeros((50, 3, 100, 3))
    ansalpha1 = np.zeros((50, 3, 100))
    ansalpha2 = np.zeros((50, 3, 100, 3))
    answeight = np.zeros((50, 3, 100))
    for i in range(50):
        idxforday = 0
        for day in days:
            idx = 0
            totalweight = 0
            for stockid in StockList[i]:
                stockid = int(stockid)
                answeight[i][idxforday][idx] = secMatrix[stockid][day][2]
                ansbeta1[i][idxforday][idx] = computeBetaAndidiosyncratic(day - ↵
                    62, day, stockid)[0]
                    ansalpha1[i][idxforday][idx] = computeBetaAndidiosyncratic(day ↵
                    - 62, day, stockid)[1]
                    ansbeta2[i][idxforday][idx] = ↵
                    computeBetaAndidiosyncraticAndCov(day - 62, day, stockid)[0]
                    ansalpha2[i][idxforday][idx] = ↵
                    computeBetaAndidiosyncraticAndCov(day - 62, day, stockid)[1]
                    idx += 1
                    totalweight = np.sum(answeight[i][idxforday])
                    answeight[i][idxforday] /= totalweight
                    idxforday += 1
    return ansbeta1, ansbeta2, ansalpha1, ansalpha2, answeight

```

[6]:

```
ansbeta1, ansbeta2, ansalpha1, ansalpha2, answeight = p5_1()
```

[7]:

```
print(ansbeta1)
```

```

[[[ 0.49826424  0.53839287  0.98205938 ...  1.23027078  1.40343363
  2.44392945]
 [ 0.9787171   1.72498917  0.41844885 ...  1.62419067  1.09151321
  1.20387204]
 [ 0.97843449  2.74983794  1.06334286 ...  0.73073421  0.74995778

```

```
1.70024823]]
```

```
[[ 1.42396699  1.70501903  0.42383663 ...  1.57603048  0.34384132  
 1.67499794]
```

```
[ 0.9231525   1.12594038  0.64107541 ...  0.57221021  0.74686869  
1.84325008]
```

```
[ 0.80561847  1.87731478  1.15594714 ...  2.12441924  0.70395328  
1.30719672]]
```

```
[[ 1.24578012  1.09547236  0.80740517 ... -0.11097113  0.59597182  
0.46033228]
```

```
[ 0.98051381  1.54320912  0.40231543 ...  0.08723506  0.58624197  
1.32071707]
```

```
[ 1.09194452  1.63727396  0.44508489 ...  0.90647609  1.0155143  
1.50615912]]
```

```
...
```

```
[[ 2.45328181  1.28108129  1.72503502 ...  1.68574659  1.59505705  
1.17692602]
```

```
[ 1.35457631  0.8071793   0.67391122 ... -0.11207618  0.77882215  
1.069729 ]
```

```
[ 1.63078265  0.84208323  1.35473836 ...  1.42001121  0.92116499  
1.34400713]]
```

```
[[ 1.49109303  1.0920288   0.57076986 ...  1.20513581  1.25610056  
1.48143886]
```

```
[ 1.51035364  1.44030773  1.15950605 ...  0.73545676  0.95192663  
0.88304059]
```

```
[ 1.089338    1.67015536  0.74500382 ...  1.14113803  1.30911725  
0.69308625]]
```

```
[[ 0.79636922  1.36761172  0.97232271 ...  1.02055584  1.22887394  
1.25675141]
```

```
[ 0.75860081  1.16231387  0.37927738 ...  1.33865058  0.89413572  
0.62874763]
```

```
[ 1.00815689  1.48878115  0.61069205 ...  2.04600941  1.04370832  
0.71898134]]]
```

```
[8]: print(ansbeta2)
```

```
[[[[ 2.29194393e-01  5.68265123e-01  1.15002429e+00]
```

```
 [ 5.24246102e-01 -7.09955772e-02  5.84514039e-01]
```

```
 [ 5.07851592e-01  9.39224492e-01  2.35037331e+00]
```

```
...
```

```
 [ 9.15736502e-01  8.85218202e-01  1.96558990e-01]
```

```
 [ 9.76075618e-01  7.28895286e-01  2.72879123e+00]
```

```
 [ 1.89805807e+00  4.55521365e-01  5.95586449e+00]]
```

```

[[ 1.01683608e+00 -3.94046078e-01  1.16533859e-01]
 [ 1.61663186e+00  1.64423175e+00  6.25256962e-01]
 [ 4.47164306e-01 -6.77703597e-01 -6.07298323e-01]

...
[ 1.62104144e+00  1.51854789e+00  2.70233939e+00]
[ 1.07024749e+00  4.70781891e-01  3.92981656e-01]
[ 1.17638885e+00  2.31284895e-01 -1.80409635e-01]]]

[[ 1.32114253e+00  8.49380738e-02 -7.16603839e-01]
 [ 2.08317547e+00  3.17389178e+00 -1.61418254e-01]
 [ 6.94401765e-01  1.65286996e+00 -4.10683186e-02]

...
[ 8.57590017e-01  7.62642591e-01 -6.05860886e-01]
[ 6.05589022e-01 -3.84752831e-01  4.64431976e-01]
[ 1.72352958e+00 -9.53778174e-02 -1.56517245e-03]]]

[[[ 1.48083399e+00  2.29156741e-01 -2.05749720e+00]
 [ 1.65954794e+00  3.24835219e-01 -9.94312558e-01]
 [ 7.59640904e-02  1.02596644e+00 -2.63725828e-02]

...
[ 1.39830842e+00  6.35627594e-01 -5.92623141e-01]
[ 5.60846774e-02  7.43963379e-01  5.22145817e-01]
[ 1.25265545e+00  1.04862882e+00  9.91263099e-01]]]

[[ 8.71711070e-01  3.84638589e-01 -4.25768371e-01]
 [ 1.09890967e+00  1.08192857e+00  1.38195125e+00]
 [ 6.15950455e-01  2.66797460e-01 -6.38993476e-02]

...
[ 4.04496283e-01  1.42446958e+00 -1.07707772e+00]
[ 7.57354321e-01 -2.38135815e-02  1.86414299e-01]
[ 1.90807709e+00 -9.70936413e-01 -3.50786905e-01]]]

[[ 8.71336905e-01 -1.50811299e-02 -1.22805329e-01]
 [ 1.40823465e+00  9.01649494e-01  5.06691529e-01]
 [ 1.32138132e+00  7.70921412e-01 -6.85930953e-01]

...
[ 1.90442894e+00  1.84277881e+00 -4.23791127e-01]
[ 6.52231879e-01 -1.89523844e-01  1.90461481e-01]
[ 1.19808114e+00  8.20943648e-01 -1.66844059e-01]]]

[[[ 1.61093830e+00 -8.49184232e-01 -1.15557330e+00]
 [ 1.16528493e+00 -5.46577132e-02 -7.80408851e-01]
 [ 7.64528177e-01  1.29181424e-01 -1.74127338e-02]

...
[ 6.63454894e-02 -4.38998700e-01 -4.22710734e-01]

```

```

[ 1.96843721e-01  9.45351866e-01  1.17387469e+00]
[ 5.45297313e-01 -2.13486889e-01 -1.86283190e-01]]]

[[ 7.18885081e-01  1.87230244e+00 -2.31865160e+00]
[ 1.49065109e+00  1.32935114e+00  1.27387124e+00]
[ 4.24194707e-01 -2.13768636e-01  8.95234583e-02]
...
[-3.12591832e-03  1.35252476e+00  4.87416470e-01]
[ 7.52362755e-01  1.03814415e-02  3.66078256e+00]
[ 1.49483934e+00 -5.68913002e-01  2.77897410e+00]]]

[[ 7.69549501e-01  3.07478062e-01  4.93681042e-01]
[ 8.28693464e-01  4.04549267e-01  1.40894973e+00]
[ 4.26276161e-01 -1.47462288e-01  1.05847816e-01]
...
[ 1.79875905e+00  7.21193616e-01 -2.09869639e+00]
[ 1.38613817e+00  1.39188118e-01 -7.97023549e-01]
[ 7.55505164e-01 -2.58476816e-01  1.60336016e+00]]]

...
[[[ 2.50342901e+00  2.49148155e-01 -2.05890527e+00]
[ 1.08865917e+00  9.77870876e-01 -2.14650857e+00]
[ 1.39525148e+00  3.49895022e-01  3.21012994e+00]
...
[ 2.33634415e-01  4.12119226e+00  7.28740184e-01]
[ 1.09973675e+00  1.60252738e+00 -7.73698360e-01]
[ 5.16342314e-01  1.87767360e+00  3.16485903e-01]]]

[[ 1.33119897e+00  9.32286337e-02 -3.42353088e-01]
[ 7.08968600e-01  2.55019472e-01 -1.68764015e+00]
[ 6.94851419e-01  9.61705540e-02  6.34581344e-01]
...
[-9.36140661e-02 -1.10487065e+00 -1.61166880e+00]
[ 6.37661470e-01  2.08723401e+00  7.14602226e-01]
[ 9.46467270e-01  1.77599085e+00  5.38972850e-01]]]

[[ 8.70417501e-01  5.19339897e-01  1.26022650e+00]
[ 5.43745741e-01  6.12757875e-01  3.03950177e-01]
[ 1.35218254e+00 -1.13135459e-01  5.77493415e-02]
...
[ 4.70192446e-02  1.38621349e+00  2.06670147e+00]
[ 9.08147080e-01  1.00169147e+00 -4.40885275e-01]
[ 1.24939257e+00  9.14188376e-01 -2.38926394e-01]]]

```

```

[[[ [ 8.96209006e-01  1.69560866e+00  2.60680969e-01]
  [ 4.92126640e-01  1.27954686e+00  2.49868825e+00]
  [ 1.13405384e-01  1.65861367e+00  -1.64374975e+00]

  ...
  [ 8.95161686e-01  1.22250871e+00  -1.62523760e+00]
  [ 1.20778700e+00  3.25192077e-01  -9.52830187e-01]
  [ 1.58230988e+00  -1.91051742e-01  -5.45340005e-01]]]

[[ [ 1.47314666e+00  1.12736512e-01  -6.09935587e-01]
  [ 1.01081961e+00  3.62961343e+00  -2.79147643e+00]
  [ 1.10889315e+00  1.54575725e+00  1.71145947e+00]

  ...
  [ 7.15003033e-01  8.59931213e-02  -2.91464345e-01]
  [ 1.03848617e+00  7.93665727e-01  3.34608479e+00]
  [ 8.58210186e-01  -2.01352256e-01  -9.11824190e-01]]]

[[ [ 5.94488945e-01  1.71929612e+00  1.76727411e-01]
  [ 1.31138103e+00  1.21190289e+00  1.44255757e-01]
  [ 4.32087278e-01  1.72652300e+00  -1.86056572e-01]

  ...
  [ 1.00085128e+00  5.95218786e-01  -1.17693543e-04]
  [ 1.10378861e+00  8.30948625e-01  1.85696092e-02]
  [ 9.58956803e-01  -2.59778173e-01  -4.04233198e-01]]]

[[[ [ 5.92412914e-01  3.76299389e-01  1.15459162e+00]
  [ 1.48168256e+00  7.00125412e-02  -2.10285089e+00]
  [ 9.08381320e-01  3.13998412e-01  -6.56415264e-01]

  ...
  [ 1.32251887e+00  -2.01955256e-01  -3.55454637e+00]
  [ 1.10806732e+00  3.76412282e-01  -1.13696204e-01]
  [ 9.64001541e-01  6.84800482e-01  9.05632291e-01]]]

[[ [ 6.93708978e-01  1.11520199e+00  6.12653256e-01]
  [ 1.14209548e+00  1.72495495e+00  2.70483223e+00]
  [ 3.72529100e-01  4.27906377e-01  6.32996030e-01]

  ...
  [ 1.13609823e+00  2.09792032e+00  -6.11773563e-01]
  [ 8.80386336e-01  -2.92495997e-01  -8.35236251e-01]
  [ 5.82976887e-01  7.49579204e-01  3.64572782e-01]]]

[[ [ 1.11736055e+00  2.47850156e-01  -3.31190094e-01]
  [ 1.28813375e+00  2.19055140e+00  -6.24001737e-01]
  [ 1.09688802e+00  -4.26362203e-01  -7.61900741e-01]

  ...
  [ 7.84396379e-01  1.92650510e+00  1.59499039e+00]
  [ 1.13520616e+00  -1.28320244e-01  -1.20985484e-01]
  [ 9.16465745e-01  4.09817178e-01  -5.81040185e-01]]]]

```

```
[9]: print(ansalpha1)
```

```
[[[ 1.15621388e-04 -2.30429096e-03  5.20199160e-04 ...  1.27808687e-03
   -4.05333484e-03  5.10404632e-04]
  [-1.98482122e-05 -1.42666039e-03  1.60612990e-03 ...  2.53313980e-03
   -1.75574449e-03  4.59211452e-03]
  [-1.25425329e-03 -3.20847487e-03 -1.10378563e-03 ...  1.96082493e-04
   -3.59021130e-04 -1.03700906e-03]]

[[ 8.25058634e-04 -1.98502302e-03  2.70665684e-03 ...  4.32284634e-03
   -1.98557212e-03 -2.56704625e-05]
[-3.12466928e-03 -3.61951570e-03 -4.87513478e-04 ... -5.43140005e-05
   -1.96312464e-03  4.92176324e-03]
[-3.51876908e-04  9.04005483e-04 -1.54555249e-03 ... -1.63552431e-03
   7.82134290e-04 -4.03729198e-03]]

[[ 1.09845617e-03  6.83299376e-04  3.61650393e-04 ... -1.21912988e-03
   1.49536871e-03  3.61810300e-04]
[-1.67522395e-03  7.81713895e-05  1.06683006e-03 ... -1.77845705e-03
   -1.21641664e-03 -1.22185263e-02]
[ 1.76638129e-03 -5.92906460e-04 -9.15902813e-04 ...  3.44354330e-03
   1.33777472e-03  3.53396464e-03]]

...
[[ 3.08992389e-03 -1.98338070e-04 -2.84930055e-03 ...  2.29004945e-03
   -7.35411915e-04 -1.64227619e-03]
[-3.74561046e-03 -3.71477903e-04  2.30287623e-03 ... -1.12758466e-02
   -1.89009063e-04  1.50089949e-03]
[-2.79814306e-03 -3.11968770e-04  1.37765662e-04 ... -5.01530118e-03
   -2.66162507e-04 -3.36209841e-04]]

[[ -2.67917556e-03  4.40322235e-03 -1.17977710e-03 ... -7.32635964e-04
   1.09795794e-03  1.31672726e-03]
[ 7.67483667e-05  2.60044189e-04  5.19840981e-03 ...  1.44285565e-03
   -5.45578049e-04  2.70277756e-03]
[-5.14864632e-04 -4.11708732e-03  4.38193150e-04 ...  5.95017543e-04
   -1.89602045e-03  1.39398102e-03]]

[[ 2.35418132e-05 -5.63560536e-04  2.17553322e-04 ...  1.11001694e-02
   2.34921959e-03 -4.73794919e-04]
[ 1.87371856e-03 -1.98276815e-03 -5.12246271e-03 ... -6.29910717e-03
   -2.38064224e-03  1.42075028e-03]
[ 9.56653435e-04  2.29804632e-03  8.21188273e-04 ... -1.01665425e-03
   -9.85575441e-04  1.04475432e-03]]]
```

```
[10]: print(ansalpha2)
```

```

[[[ [ 5.34722397e-04  5.34722397e-04  5.34722397e-04]
  [-2.12495131e-03 -2.12495131e-03 -2.12495131e-03]
  [ 1.35594915e-03  1.35594915e-03  1.35594915e-03]

  ...
  [ 1.42347104e-03  1.42347104e-03  1.42347104e-03]
  [-3.11686128e-03 -3.11686128e-03 -3.11686128e-03]
  [ 2.44810162e-03  2.44810162e-03  2.44810162e-03]]]

[[[-1.23284466e-04 -1.23284466e-04 -1.23284466e-04]
  [-4.15527455e-04 -4.15527455e-04 -4.15527455e-04]
  [ 1.00710277e-03  1.00710277e-03  1.00710277e-03]

  ...
  [ 4.57485662e-03  4.57485662e-03  4.57485662e-03]
  [-1.35468056e-03 -1.35468056e-03 -1.35468056e-03]
  [ 4.59442611e-03  4.59442611e-03  4.59442611e-03]]]

[[[-1.94240800e-03 -1.94240800e-03 -1.94240800e-03]
  [-1.93181982e-03 -1.93181982e-03 -1.93181982e-03]
  [-3.95341686e-04 -3.95341686e-04 -3.95341686e-04]

  ...
  [-7.22190331e-05 -7.22190331e-05 -7.22190331e-05]
  [-6.26505975e-05 -6.26505975e-05 -6.26505975e-05]
  [-1.08187981e-03 -1.08187981e-03 -1.08187981e-03]]]

[[[ [ 1.91838932e-04  1.91838932e-04  1.91838932e-04]
  [-2.27099922e-03 -2.27099922e-03 -2.27099922e-03]
  [ 2.79427923e-03  2.79427923e-03  2.79427923e-03]

  ...
  [ 4.19376685e-03  4.19376685e-03  4.19376685e-03]
  [-1.74981022e-03 -1.74981022e-03 -1.74981022e-03]
  [ 3.87869318e-04  3.87869318e-04  3.87869318e-04]]]

[[[-3.18638259e-03 -3.18638259e-03 -3.18638259e-03]
  [-2.44816140e-03 -2.44816140e-03 -2.44816140e-03]
  [-4.09657703e-04 -4.09657703e-04 -4.09657703e-04]

  ...
  [-2.23217852e-05 -2.23217852e-05 -2.23217852e-05]
  [-1.87585430e-03 -1.87585430e-03 -1.87585430e-03]
  [ 4.33428962e-03  4.33428962e-03  4.33428962e-03]]]

[[[-4.83256511e-04 -4.83256511e-04 -4.83256511e-04]
  [ 1.82701478e-03  1.82701478e-03  1.82701478e-03]
  [-1.89129522e-03 -1.89129522e-03 -1.89129522e-03]

  ...
  [-1.22901286e-03 -1.22901286e-03 -1.22901286e-03]
  [ 8.89271270e-04  8.89271270e-04  8.89271270e-04]
  [-3.83393340e-03 -3.83393340e-03 -3.83393340e-03]]]

```

```

[[[ 6.51300094e-04  6.51300094e-04  6.51300094e-04]
 [ 4.29869800e-04  4.29869800e-04  4.29869800e-04]
 [ 3.68199198e-04  3.68199198e-04  3.68199198e-04]

...
[-1.39471328e-03 -1.39471328e-03 -1.39471328e-03]
[ 1.95734774e-03  1.95734774e-03  1.95734774e-03]
[ 2.82558858e-04  2.82558858e-04  2.82558858e-04]]]

[[[-2.10395960e-03 -2.10395960e-03 -2.10395960e-03]
 [ 1.29627310e-03  1.29627310e-03  1.29627310e-03]
 [ 1.02443083e-03  1.02443083e-03  1.02443083e-03]

...
[-9.60743132e-04 -9.60743132e-04 -9.60743132e-04]
[ 6.96578322e-04  6.96578322e-04  6.96578322e-04]
[-1.10066773e-02 -1.10066773e-02 -1.10066773e-02]]]

[[[ 2.40655513e-03  2.40655513e-03  2.40655513e-03]
 [ 1.01948391e-03  1.01948391e-03  1.01948391e-03]
 [-8.75483673e-04 -8.75483673e-04 -8.75483673e-04]

...
[ 1.64256267e-03  1.64256267e-03  1.64256267e-03]
[ 5.92686483e-04  5.92686483e-04  5.92686483e-04]
[ 5.04261597e-03  5.04261597e-03  5.04261597e-03]]]

...
[[[ 2.45812703e-03  2.45812703e-03  2.45812703e-03]
 [-7.89812415e-04 -7.89812415e-04 -7.89812415e-04]
 [-1.79514041e-03 -1.79514041e-03 -1.79514041e-03]

...
[ 2.90760026e-03  2.90760026e-03  2.90760026e-03]
[-8.31620764e-04 -8.31620764e-04 -8.31620764e-04]
[-1.36585540e-03 -1.36585540e-03 -1.36585540e-03]]]

[[[-3.88526005e-03 -3.88526005e-03 -3.88526005e-03]
 [-1.14512045e-03 -1.14512045e-03 -1.14512045e-03]
 [ 2.67380934e-03  2.67380934e-03  2.67380934e-03]

...
[-1.25765314e-02 -1.25765314e-02 -1.25765314e-02]
[ 1.05330151e-03  1.05330151e-03  1.05330151e-03]
[ 2.52194805e-03  2.52194805e-03  2.52194805e-03]]]

[[[-1.28447810e-03 -1.28447810e-03 -1.28447810e-03]
 [ 2.74340356e-04  2.74340356e-04  2.74340356e-04]

```

```

[ 1.44986535e-04  1.44986535e-04  1.44986535e-04]
...
[-2.29040133e-03 -2.29040133e-03 -2.29040133e-03]
[-2.58680910e-04 -2.58680910e-04 -2.58680910e-04]
[-1.63633709e-04 -1.63633709e-04 -1.63633709e-04]]]

[[[-2.43754938e-03 -2.43754938e-03 -2.43754938e-03]
 [ 5.31801259e-03  5.31801259e-03  5.31801259e-03]
 [-1.54757461e-03 -1.54757461e-03 -1.54757461e-03]
 ...
 [-1.13535551e-03 -1.13535551e-03 -1.13535551e-03]
 [ 8.25214212e-04  8.25214212e-04  8.25214212e-04]
 [ 1.12532884e-03  1.12532884e-03  1.12532884e-03]]]

[[[-1.94285406e-04 -1.94285406e-04 -1.94285406e-04]
 [ 3.17039458e-04  3.17039458e-04  3.17039458e-04]
 [ 6.73483674e-03  6.73483674e-03  6.73483674e-03]
 ...
 [ 1.32672361e-03  1.32672361e-03  1.32672361e-03]
 [ 1.52972552e-03  1.52972552e-03  1.52972552e-03]
 [ 2.14346665e-03  2.14346665e-03  2.14346665e-03]]]

[[[ 4.44588646e-04  4.44588646e-04  4.44588646e-04]
 [-3.42082394e-03 -3.42082394e-03 -3.42082394e-03]
 [ 1.03303057e-03  1.03303057e-03  1.03303057e-03]
 ...
 [ 8.65015143e-04  8.65015143e-04  8.65015143e-04]
 [-1.50009541e-03 -1.50009541e-03 -1.50009541e-03]
 [ 8.66162063e-04  8.66162063e-04  8.66162063e-04]]]

[[[ 4.26131211e-04  4.26131211e-04  4.26131211e-04]
 [-1.22610442e-03 -1.22610442e-03 -1.22610442e-03]
 [ 3.80768767e-05  3.80768767e-05  3.80768767e-05]
 ...
 [ 9.95026580e-03  9.95026580e-03  9.95026580e-03]
 [ 2.34826921e-03  2.34826921e-03  2.34826921e-03]
 [-1.21550000e-04 -1.21550000e-04 -1.21550000e-04]]]

[[[ 2.65783880e-03  2.65783880e-03  2.65783880e-03]
 [ 1.46256129e-04  1.46256129e-04  1.46256129e-04]
 [-4.61412521e-03 -4.61412521e-03 -4.61412521e-03]
 ...
 [-5.74389327e-03 -5.74389327e-03 -5.74389327e-03]
 [-2.93800019e-03 -2.93800019e-03 -2.93800019e-03]
 [ 1.92317432e-03  1.92317432e-03  1.92317432e-03]]]

```

```

[[ 7.33274153e-04  7.33274153e-04  7.33274153e-04]
 [ 2.65934935e-03  2.65934935e-03  2.65934935e-03]
 [-1.44935353e-04 -1.44935353e-04 -1.44935353e-04]

...
[ 1.47507865e-03  1.47507865e-03  1.47507865e-03]
[-1.16649874e-03 -1.16649874e-03 -1.16649874e-03]
[ 6.41507084e-04  6.41507084e-04  6.41507084e-04]]]

[11]: print(answeight)

[[[0.01050926 0.00089495 0.00014885 ... 0.00305312 0.00097377 0.00694317]
 [0.00681212 0.00054069 0.00022424 ... 0.0018755 0.00147787 0.01151106]
 [0.0054931 0.00030905 0.00020101 ... 0.00152167 0.00220678 0.01371706]]

[[0.08116541 0.00481804 0.00022515 ... 0.00065217 0.00605036 0.00663295]
 [0.0579924 0.00250642 0.00026894 ... 0.00068983 0.0039262 0.01616938]
 [0.05652961 0.00291495 0.00020942 ... 0.00077326 0.00653108 0.00726805]]

[[0.02223076 0.02646867 0.01177723 ... 0.00015543 0.01298365 0.07296013]
 [0.02484033 0.02782518 0.01165831 ... 0.00018005 0.0063606 0.02613206]
 [0.04337626 0.03020865 0.01931834 ... 0.00018271 0.00988979 0.01736643]]

...
[[0.00961493 0.00438443 0.00467729 ... 0.00167947 0.00156231 0.0018405 ]
 [0.01873266 0.00495611 0.00673518 ... 0.00057952 0.00129082 0.00156229]
 [0.01317801 0.00387242 0.00617224 ... 0.00024111 0.00122905 0.00110942]]

[[0.00060319 0.00065047 0.00167573 ... 0.00832746 0.00877693 0.03020535]
 [0.00093811 0.00054244 0.00191368 ... 0.00598291 0.00364601 0.06310892]
 [0.00085364 0.00061884 0.00268259 ... 0.00776617 0.00426295 0.05463901]]

[[0.00313583 0.00221336 0.02128874 ... 0.01239833 0.00618144 0.00384986]
 [0.00269449 0.00087622 0.00648171 ... 0.00815986 0.00632385 0.0036997 ]
 [0.00263845 0.00220788 0.00848301 ... 0.00755496 0.00916018 0.00447561]]]

```

```

[12]: BetaM = np.zeros((50, 3))
BetaF= np.zeros((50, 3, 3))
for i in range(50):
    for j in range(3):
        BetaM[i][j] = answeight[i][j] @ ansbeta1[i][j].reshape(-1, 1)
        BetaF[i][j] = answeight[i][j] @ ansbeta2[i][j]

```

```
[13]: print(BetaM)
```

```
[[1.12854875 1.06937854 1.02106735]
 [1.03244372 1.00248465 0.96500852]
 [1.25365541 1.10260787 1.28510386]
```

[0.92944131 1.03948309 0.98732143]
[1.00983431 1.02622014 1.03967435]
[1.27908273 0.97512139 0.96309698]
[1.10375937 0.97677776 1.07731586]
[0.94432815 0.86221079 0.64406743]
[1.16159417 1.14986298 1.04391418]
[0.86119091 1.01151557 0.77980873]
[0.99834 0.8296741 0.87338365]
[0.84600319 0.9124081 0.86163754]
[0.9477637 0.6881267 0.9426049]
[1.18115618 1.17592577 0.96993169]
[1.25376418 1.15003915 1.16167339]
[1.26360536 1.07384392 1.14199654]
[1.32445347 0.97048286 0.91559752]
[1.20222969 1.05147857 0.92019141]
[0.77265145 0.83040462 0.78374611]
[1.0270082 0.92836193 0.94107294]
[1.1112997 1.18073502 1.07272694]
[1.06117936 0.91474002 0.82245782]
[1.21302762 1.00927537 1.04153399]
[1.14410814 0.98231666 0.92799045]
[1.28853607 0.90786401 1.02768479]
[1.17783326 0.91672179 1.03470502]
[1.18308588 1.006154 0.99178117]
[1.17365848 1.14809458 1.09666913]
[0.81601555 0.8407727 0.87556136]
[1.19264561 1.06516173 1.26940628]
[1.10112822 0.85216687 0.92150246]
[1.0445358 0.85651574 0.83935659]
[0.84752252 0.89356206 0.89042674]
[0.85298973 0.97557295 1.03951321]
[0.82301394 0.76580727 0.82281133]
[0.93602067 1.08878028 1.01370574]
[1.19636646 1.03332402 0.97212981]
[1.07054736 1.08684486 0.93356544]
[1.13292522 1.1218394 0.98248163]
[1.23182969 0.98064677 1.13154925]
[0.82700528 0.94745935 0.92445312]
[0.9641565 0.95750067 0.97491583]
[1.16269786 0.85962465 1.03410174]
[0.87491172 1.0267545 0.87117213]
[0.94115222 0.90001912 0.65730334]
[1.19719522 1.04324039 1.04661779]
[0.99835997 1.03345893 0.93144432]
[1.19948874 0.95275324 0.86760714]
[1.24220873 1.13049304 1.13707856]
[1.0885199 0.99481791 0.97087189]]

```
[14]: print(BetaF)
```

```
[[[ 1.07212562  0.01431941  0.78583646]
 [ 1.07211061  0.02173433  0.09956034]
 [ 1.00346673  0.08348308 -0.00411668]]]

[[ 0.98465701  0.19348737 -0.27663773]
 [ 0.97859203 -0.04197178 -0.600393  ]
 [ 1.10109765  0.10611581 -0.31828184]]]

[[ 1.12568005  0.2501025   0.65179596]
 [ 1.09261177  0.1778799   0.10549147]
 [ 1.15497677  0.18072289  0.17288974]]]

[[ 1.02803512 -0.17586981 -0.58949395]
 [ 1.05354178  0.10348464  0.49706761]
 [ 0.88195585 -0.02733447  0.22088825]]]

[[ 1.00941576  0.03583763 -0.17980043]
 [ 1.01531254  0.02667818 -0.19043726]
 [ 1.09397218  0.03535407 -0.12373678]]]

[[ 1.21362786  0.02233129  0.88191155]
 [ 0.99914719 -0.16968237  0.21703974]
 [ 1.04182686  0.08229064 -0.19386737]]]

[[ 0.92175396  0.4182708   0.60188061]
 [ 0.93371563  0.02349187 -0.90117037]
 [ 1.06603057  0.21267057 -0.07677044]]]

[[ 0.90322258  0.15500708 -0.17858786]
 [ 0.8752827  -0.00852879  0.27100801]
 [ 0.84218511 -0.12105726 -0.33500199]]]

[[ 1.20377404 -0.04929577 -0.38697645]
 [ 1.13506589  0.45632313  0.50840451]
 [ 1.02251653  0.19028767 -0.04636663]]]

[[ 0.91551695 -0.0880475  -0.37083628]
 [ 0.99001775 -0.04691866 -0.55692042]
 [ 1.018096   -0.19706161 -0.37895525]]]

[[ 1.15440108 -0.42456313 -0.17364326]
 [ 0.82443044 -0.07813203 -0.25754822]
 [ 1.10917912 -0.0016704  -0.4650487 ]]]
```

```
[[ 0.81140452  0.12705522 -0.13257822]
```

```

[ 0.90575003 -0.03688267 -0.21327539]
[ 1.00627096  0.05234068 -0.31011229]

[[ 1.16858256 -0.64129935 -0.03496572]
 [ 0.69953779  0.02666739  0.29883179]
 [ 0.91036865  0.05574068  0.03771962]]

[[ 1.17517075  0.15477686 -0.71283385]
 [ 1.13115508  0.03464695 -0.91826841]
 [ 0.98658387 -0.11936844  0.02270631]]

[[ 1.22450868  0.04158522  0.22998873]
 [ 1.14625122  0.02893147 -0.0302416 ]
 [ 1.07768999  0.09358137  0.12232218]]

[[ 1.24143042  0.08682088 -0.1129674 ]
 [ 1.05722531  0.1623369  -0.06805866]
 [ 1.07342311  0.17883645  0.05216585]]

[[ 1.33282032 -0.02782622  0.01700005]
 [ 0.98566881 -0.11107393  0.13020683]
 [ 0.95684031  0.22399079 -0.18581564]]

[[ 1.17842517  0.01302165  0.29527474]
 [ 1.04442464 -0.14352259 -0.41657351]
 [ 0.98223413 -0.22540975 -0.01756955]]

[[ 0.87986419 -0.2405002  -0.38513402]
 [ 0.82803366  0.10232403  0.13476517]
 [ 0.95764934 -0.08962826 -0.30180512]]

[[ 0.96901208  0.11475394  0.28804659]
 [ 0.92897476 -0.11631074 -0.19883444]
 [ 1.10513444  0.02615688 -0.33629669]]

[[ 1.09352974  0.12079165 -0.35660882]
 [ 1.19364061  0.10676735  0.47777947]
 [ 0.93449484 -0.07341366  0.30728222]]

[[ 1.11466594 -0.05374294 -0.53625485]
 [ 0.91394752 -0.03523543 -0.08167937]
 [ 1.00309989 -0.06277024 -0.32762895]]

[[ 1.03243464  0.42363121  0.55249851]
 [ 0.98906181  0.24982743  0.01280174]
 [ 0.99248357  0.19549204  0.00583867]]

[[ 1.1668249  -0.04934692 -0.08997568]

```

```

[ 0.96972338 -0.08233988 -0.42635193]
[ 1.08936745  0.05068492 -0.34241886]

[[ 1.18542289  0.263493   0.20318118]
 [ 0.90034816  0.10132573  0.02015262]
 [ 0.97388536  0.11624309  0.05213592]]

[[ 1.21243263 -0.143865   0.21989681]
 [ 0.89833171  0.18577498 -0.06411952]
 [ 0.83054226  0.34523744  0.24251788]]

[[ 1.09560849  0.16124844  0.49597281]
 [ 1.01607342 -0.0665104  0.09607891]
 [ 1.07963271  0.07148361 -0.20685364]]

[[ 1.1354844   0.10585592  0.03206609]
 [ 1.1368925   0.22800886  0.17053948]
 [ 1.02337294  0.19983486  0.05171456]]

[[ 0.74430231  0.24764856 -0.1932286 ]
 [ 0.8163611   -0.05543163 -0.63633504]
 [ 0.98919256  0.05292415 -0.24913748]]

[[ 1.14817925  0.08825867  0.21941837]
 [ 1.04830501  0.15086085 -0.09422284]
 [ 1.15590035  0.31080976  0.07945732]]

[[ 1.06044227  0.20178308 -0.42799335]
 [ 0.83923557  0.21064189  0.10093507]
 [ 0.97315138  0.12482779 -0.16018189]]

[[ 0.98664127  0.11981175  0.26022164]
 [ 0.86020747  0.10731227  0.27678016]
 [ 0.92205026  0.11007491 -0.21464038]]

[[ 1.0239938   -0.44820139 -0.36201352]
 [ 0.86847988  0.10410402 -0.35988029]
 [ 1.12975308 -0.13735205 -0.40882158]]

[[ 1.03627264 -0.4098755  -0.66497223]
 [ 0.97612571  0.01273296  0.03535606]
 [ 0.85488424 -0.04467682  0.38555572]]

[[ 0.97038145 -0.25741711 -0.90944856]
 [ 0.75699925  0.15028914  0.08118383]
 [ 0.8532659   -0.02299521 -0.04945316]]

[[ 0.92063151  0.10008116 -0.28531267]

```

```

[[ 1.08253058  0.16256892  0.15968035]
 [ 0.95599185  0.06779338  0.08243775]]]

[[[ 1.23217093 -0.08636262 -0.09720926]
 [ 1.04040706  0.02395563  0.19899963]
 [ 0.96244242  0.18061562 -0.06499549]]]

[[[ 1.1451478  -0.24757352  0.14882054]
 [ 1.10815929 -0.1315032   0.22727645]
 [ 0.99786808  0.0131801  -0.13317285]]]

[[[ 1.11390088  0.19494378 -0.72271545]
 [ 1.07067973  0.13782101 -0.87003819]
 [ 1.07728179 -0.10187782 -0.13982665]]]

[[[ 1.17406951  0.16364251  0.03046622]
 [ 0.97314555  0.18396717  0.17129578]
 [ 1.03995618  0.14450787  0.11363319]]]

[[[ 1.01199511 -0.45735208 -0.44434826]
 [ 0.93369294  0.13747784 -0.05089869]
 [ 1.00132047 -0.19478305 -0.06112278]]]

[[[ 1.06233728 -0.30943969  0.11071798]
 [ 0.92595018  0.10615329 -0.49794401]
 [ 1.05455384 -0.02019167 -0.14792365]]]

[[[ 1.16960836 -0.10525918  0.44147891]
 [ 0.87089664 -0.06437417  0.12962973]
 [ 0.92777643  0.2859581   0.07684787]]]

[[[ 1.00186671 -0.33256633 -0.20782793]
 [ 1.04184575 -0.13975944  0.07577927]
 [ 0.98046167 -0.30404808 -0.07427729]]]

[[[ 1.07432215 -0.40874187  0.09316181]
 [ 0.92314969 -0.20292879  0.13673835]
 [ 0.98739072 -0.17811763 -0.56913574]]]

[[[ 1.12437084  0.11218941  0.52744157]
 [ 1.05317309  0.03497873  0.28158967]
 [ 1.0767015   0.08380163 -0.09846805]]]

[[[ 1.0545474  -0.04166658 -0.64017053]
 [ 1.00349523  0.16355069 -0.35840551]
 [ 1.01497145  0.1879741  -0.25257354]]]

[[[ 1.23226944 -0.09529716 -0.00469266]

```

```
[ 0.96523892 -0.03011697  0.21875723]
[ 0.90100059  0.03035054 -0.08010832]

[[ 1.10936787  0.24767721  0.73857514]
 [ 1.1584212  -0.14314835  0.35101541]
 [ 1.09836739  0.05053601  0.05293561]]

[[ 1.07991331  0.08179769 -0.29373443]
 [ 0.97609565  0.26751875  0.07778212]
 [ 0.97746189 -0.06051995  0.01517218]]]
```

```
[15]: def p5_2():
    RM = np.zeros(3)
    RSMB = np.zeros(3)
    RHML = np.zeros(3)
    idx = 0
    for day in days:
        RM[idx] = np.sum((ffMatrix[:,0] - ffMatrix[:,3])[day - 62: day+1])/63
        RSMB[idx] = np.sum((ffMatrix[:,1][day - 62: day+1])/63
        RHML[idx] = np.sum((ffMatrix[:,2][day - 62: day+1])/63
        idx += 1
    RP = np.zeros((50, 3))
    for i in range(50):
        idx = 0
        for day in days:
            totalforstock = 0
            for stockid in StockList[i]:
                stockid = int(stockid)
                single = np.sum((secMatrix[stockid][:,1] - ffMatrix[:,3])[day - 62: day+1])/63
                totalforstock += single
            totalforstock /= 100
            RP[i][idx] = totalforstock
            idx += 1
    return RM, RSMB, RHML, RP
```

```
[16]: RM, RSMB, RHML, RP = p5_2()
```

```
[17]: print(RM)
```

```
[ 8.36507937e-05 -8.86349206e-04  1.37936508e-03]
```

```
[18]: print(RSMB)
```

```
[-6.50793651e-05 -4.90476190e-04 -1.28571429e-04]
```

```
[19]: print(RHML)
```

```
[ -0.0003127 -0.00048095 -0.00031587]
```

```
[20]: print(RP)
```

```
[[ 3.76435079e-04 -1.14849254e-03  1.21796905e-03]
 [-9.08695238e-05 -1.06781968e-03  1.63166048e-03]
 [ 4.54103651e-04 -1.34159778e-03  1.54306143e-03]
 [ 4.30072540e-04 -1.00047921e-03  1.31551238e-03]
 [ 7.11447937e-04 -8.41170476e-04  1.09416778e-03]
 [ 2.85202698e-04 -6.81376349e-04  2.08171825e-03]
 [ 9.45119048e-05 -1.39065063e-03  1.70521746e-03]
 [ 4.53862063e-04 -1.38642571e-03  1.90813254e-03]
 [ 4.73625238e-04 -1.73042365e-03  9.42619841e-04]
 [ 4.18744603e-04 -1.13735635e-03  1.36752159e-03]
 [ 9.34119206e-04 -1.28440127e-03  1.43878524e-03]
 [ 2.63243492e-04 -1.18739746e-03  2.12556175e-03]
 [ 1.10342857e-04 -9.84169048e-04  1.56720222e-03]
 [ 7.23901746e-04 -1.20248968e-03  1.62846365e-03]
 [ 5.29922381e-04 -1.28622587e-03  1.25992905e-03]
 [ 3.35299048e-04 -1.51929063e-03  1.41008048e-03]
 [ 1.75448889e-04 -1.33731778e-03  1.26799810e-03]
 [ 2.62645397e-04 -9.59989683e-04  1.41364603e-03]
 [ 7.87543016e-04 -9.57070159e-04  1.35668429e-03]
 [ 2.08256984e-04 -1.16828984e-03  1.40354651e-03]
 [ 6.64561905e-04 -7.86701587e-04  1.45531619e-03]
 [ 3.73815397e-04 -1.13180857e-03  1.39889000e-03]
 [ 7.67489206e-04 -1.11083556e-03  1.28951841e-03]
 [ 5.89965079e-05 -1.23050095e-03  1.75973825e-03]
 [ 3.33246032e-04 -9.80226984e-04  1.19694159e-03]
 [ 5.98284127e-04 -5.41046190e-04  1.34126397e-03]
 [ 1.67560952e-04 -1.46684825e-03  1.84354444e-03]
 [ 3.91406349e-04 -1.08688159e-03  9.67331111e-04]
 [ 1.43151270e-04 -1.66529413e-03  1.77500333e-03]
 [ 3.64746032e-04 -7.86905873e-04  1.13967730e-03]
 [ 2.28054127e-04 -1.29715984e-03  1.15485238e-03]
 [ 4.22555079e-04 -1.31686635e-03  1.28405254e-03]
 [ 3.77526984e-04 -1.69963651e-03  1.66255063e-03]
 [ 2.13244921e-04 -1.10919698e-03  1.21986937e-03]
 [ 4.67799365e-04 -1.22945444e-03  1.42536540e-03]
 [ 7.35192540e-04 -1.46077841e-03  1.38104302e-03]
 [ 2.57388095e-04 -1.43517444e-03  9.23469683e-04]
 [ 4.85101429e-04 -1.07680000e-03  1.44934714e-03]
 [ 5.29072857e-04 -1.65663063e-03  1.66925714e-03]
 [ 2.19719048e-04 -1.06995429e-03  1.96751794e-03]
 [ 1.10373016e-04 -1.00668095e-03  1.48890492e-03]
 [ 1.62399524e-04 -1.38977810e-03  1.65447841e-03]
 [-8.24539683e-05 -1.43532825e-03  1.50939397e-03]
 [ 2.65755238e-04 -1.43699238e-03  1.46982937e-03]]
```

```
[ 4.27008413e-04 -9.18010317e-04  1.57063349e-03]
[ 3.15587143e-04 -8.73838254e-04  1.53838921e-03]
[ 6.22366032e-04 -1.06906587e-03  1.66754238e-03]
[ 3.43687619e-04 -1.51564460e-03  1.50903270e-03]
[ 3.90684127e-04 -1.28327063e-03  7.52736349e-04]
[ 3.74582381e-04 -1.00914000e-03  1.29568381e-03]]
```

[]: