Table of Contents

Q1 PCA and Factor Modelling

I imported the data from the file 'Tsay_FM_data.txt' as column vectors. The names of the columns are in the first row of the file and become the names of the 5 separate vectors. I then saved the workspace with command: save lab5.mat

```
load lab5.mat
Tsay_data = [BAC HPQ IBM INTC JPM]; % combine all columns into one
 matrix
```

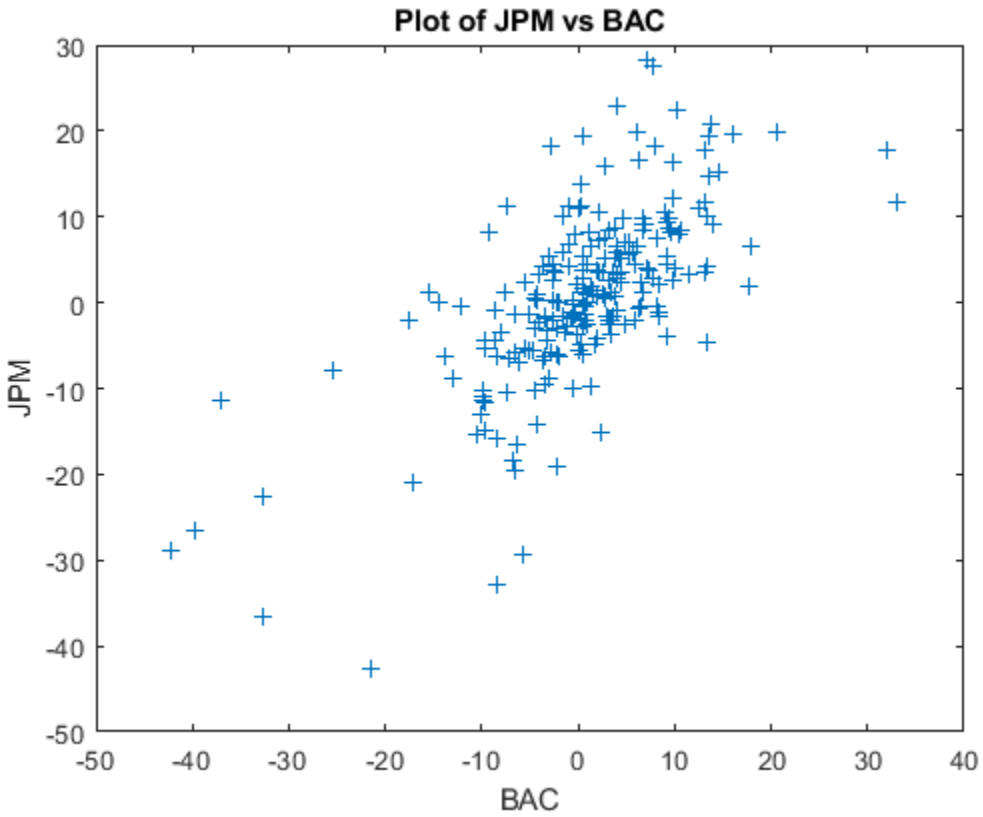
Q1(a) Estimate the sample correlation matrix

Estimate the sample correlation matrix showing all pairwise correlations.

```
corr(Tsay_data)

% Scatterplot of BAC vs JPM
figure;plot(BAC,JPM,'+');title('Plot of JPM vs BAC')
;xlabel('BAC');ylabel('JPM');
% relationship seems roughly linear.

% Calculate (and test) correlation between BAC and INTC (least
 significant)
[pc,p]=corr(BAC,INTC)
```

```
ans =

    1.0000    0.2591    0.2545    0.2521    0.6836
    0.2591    1.0000    0.4620    0.5495    0.3889
    0.2545    0.4620    1.0000    0.4593    0.3384
    0.2521    0.5495    0.4593    1.0000    0.3578
    0.6836    0.3889    0.3384    0.3578    1.0000


pc =
```

```
    0.2521

p =

   1.1885e-04
```



Q1(b) PCA analysis

```
% Plot the 5 data series
plot(Tsay_data);title('5 US return series');
legend('BAC','HPQ','IBM','INTC','JPM','location','southwest');
xlim([0 length(Tsay_data)]);

% Perform PCA on Tsay_data
[pc_ret,score_ret,latent_ret] = princomp(Tsay_data)

% Percentage variance explained per component
latent_ret./sum(latent_ret)

% Cumulative percentage variance explained
cumsum(latent_ret)./sum(latent_ret)

% create vector/cell array of labels for biplot
```

```
vbls = {'BAC','HPQ','IBM','INTC','JPM'};

% Biplot of components 1 and 2
figure;biplot(pc_ret(:,1:2),'varlabels',vbls);

% Biplot of components 1, 2 and 3
figure;biplot(pc_ret(:,1:3),'varlabels',vbls);
```

Warning: princomp will be removed in a future release. Use pca instead.

pc_ret =

0.3474	0.6097	-0.1188	-0.0093	0.7024
0.4826	-0.2786	0.7009	-0.4298	0.1159
0.3298	-0.1393	0.2643	0.8954	0.0144
0.5808	-0.4781	-0.6516	-0.0962	0.0163
0.4476	0.5502	-0.0128	-0.0642	-0.7019

score_ret =

-5.2700	-19.3402	-10.2933	6.3489	3.4297
1.6848	3.1452	-2.7567	6.9079	4.8249
-3.7548	-15.4312	4.1713	-0.5679	-4.3327
-7.2229	2.6503	1.1769	4.9572	-1.8301
25.6322	-2.8917	-4.4779	2.6274	-7.4108
-7.6691	-2.4346	0.9805	-0.9903	0.8062
-17.3816	-2.2491	-3.6063	0.4307	3.0531
-37.1433	12.4725	2.8307	5.3095	-4.4915
-30.1689	-40.8887	4.1436	7.7261	-9.5699
-40.5297	-29.4257	-15.4483	12.8775	12.0351
31.0625	16.2028	0.8430	-0.6249	17.1387
-0.0922	-6.5144	3.0040	-3.2809	1.0296
37.5882	8.4406	2.9605	-1.4163	3.3963
21.7761	7.7637	9.8182	-7.5226	-10.9485
5.4851	15.5081	0.9551	-14.5235	8.7401
8.4674	11.4657	-5.4852	-11.5970	-6.8428
16.0050	2.5014	-4.5020	-0.4753	7.5112
-23.2937	3.2014	6.7514	-3.3921	-12.6413
9.9836	5.7973	4.4951	-0.0160	-13.8326
4.7647	7.5364	-6.8166	-2.9916	5.7332
-16.2624	1.8648	8.6187	10.5405	-4.0729
-4.5516	3.9212	1.8005	-5.0618	5.3273
-15.1396	-12.0813	-3.8930	-1.2979	4.8016
22.4506	-0.6881	-2.7728	-12.8610	13.3431
26.9863	9.2915	-11.3566	-4.4653	-13.0188
21.8160	6.8277	9.0141	-12.7421	-4.6433
-8.4475	1.5751	15.4489	-6.4081	-0.2175
3.4734	7.5879	3.1604	7.5067	-1.3824
-7.0836	5.2152	1.3916	3.7881	-5.0985
5.7984	-1.1092	-13.6824	9.3923	-0.1731
-1.1138	-8.9271	1.0823	-5.7503	2.8791
-23.4989	2.0319	-16.7930	4.7181	-2.2961

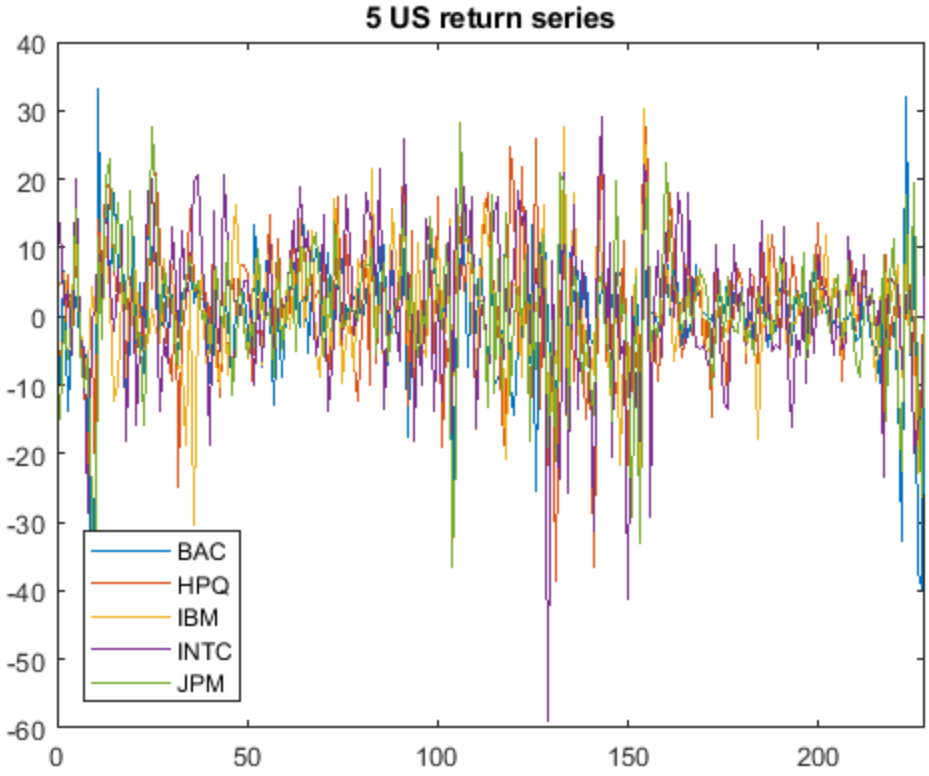
```
 3.7233   -1.3266  -12.1012   -6.6549    1.4861
-1.7772    6.3811   -5.9872  -18.4132   -0.6097
17.3645    3.0825    6.9519   -4.5551    2.5562
 4.3486   -3.1194  -17.4602  -31.6200   -0.6026
16.0275   -5.1950  -11.3471   -1.6844    0.4907
 6.1400   -5.9553   -2.2932    3.8687    0.5481
-2.0005    2.8222    1.1133   -7.3984    2.0465
-20.9170   1.5260   11.1107   -1.1190   -3.3666
13.8402  -13.8129    0.4468    2.0955   -1.4919
-0.8184    9.3256   -3.7838   -5.2713   -1.6252
-13.0185   8.7932   -7.9510   -3.8661   -1.0389
12.9578   -9.9144  -10.9332   -0.2320    4.0613
 2.0488    5.0007  -14.1217   -6.0060   -8.4062
-10.3917 -10.1388   16.1300    6.8335    2.0166
 0.7317   -1.8137    6.0292   14.9769    4.6288
 7.2256    2.3590    5.2050    0.6966    0.2388
 5.2903   -3.0841    1.5233   -3.7352    4.6799
-1.5656   -8.0538   -0.3738   -8.2747    2.9813
-9.4051   -1.4412   -3.8696    7.3105   -4.6458
-4.5996   10.5567    4.7237    6.6891   12.3281
 8.3239    7.8709   -1.5623    8.5179   -2.2362
-11.9249   1.5907    0.6149   -4.0170   -6.6909
 4.7931    2.7954    1.6417    3.0847    6.5723
15.3999   -9.2497    6.1249    2.0332    2.0609
-14.9323  -8.8819    4.6572    3.8285   -3.0247
10.4729    0.7505    8.7576    0.5067   -3.4820
-7.6124   -7.5266   -1.3501   -4.0773   -2.9565
 1.3327   -1.2900    1.8542    2.2213    1.0103
 7.4877    2.9280   -6.0334   -3.3601   -3.2385
18.1546   -4.5334    0.5810   -3.3248    5.4392
 5.3042   -6.9557    1.4476    5.4283    5.6228
22.2124   -8.7114   -1.9038    6.1698   -6.3677
11.9502    9.6992   -8.2676   -2.9108    2.6156
11.2966  -11.4055    2.2446   -3.7738   -3.6915
11.9173    4.1467    3.9731    8.4015   -2.8067
 3.2168   15.5118    2.9689   -5.9283   -1.3304
 1.3115    9.1559    0.7170  -10.1388    3.8204
 9.3178  -14.8363   -1.2556   -3.0151    4.2212
-9.7561   18.4902   -0.0063    5.2352    1.3457
-9.1462    1.2780    4.1980   -4.6885   -0.3059
 9.1335    6.6339    6.8308   14.1987   -9.0050
19.3169   -1.8702   10.4625    2.5860    2.0886
-8.0771    9.2175   -6.0115   -5.5701    6.1218
12.1975  -11.9140   -4.0223   -9.5497    2.4722
 5.6459   -3.2792   -7.0453   -1.9750    0.4626
-7.8336    6.4390   -5.0459   -3.8301    0.4006
-2.7951    3.4307   -8.5465   12.4664    2.2402
 6.1520   -0.2943   -2.6271    5.0301   -5.2046
20.8811   -6.8288   -2.1045    0.5840   -1.4876
 8.8146    4.8244  -16.3579    5.5195   -0.2242
30.7657   -4.0474    8.9776    8.4217    2.8438
-9.2892   -4.9025   -7.4612   -1.5749   -0.3691
19.2497   -3.4249  -11.1208   -1.3136    5.3311
-2.2342   16.7569    9.6350   -9.7203    2.3110
```

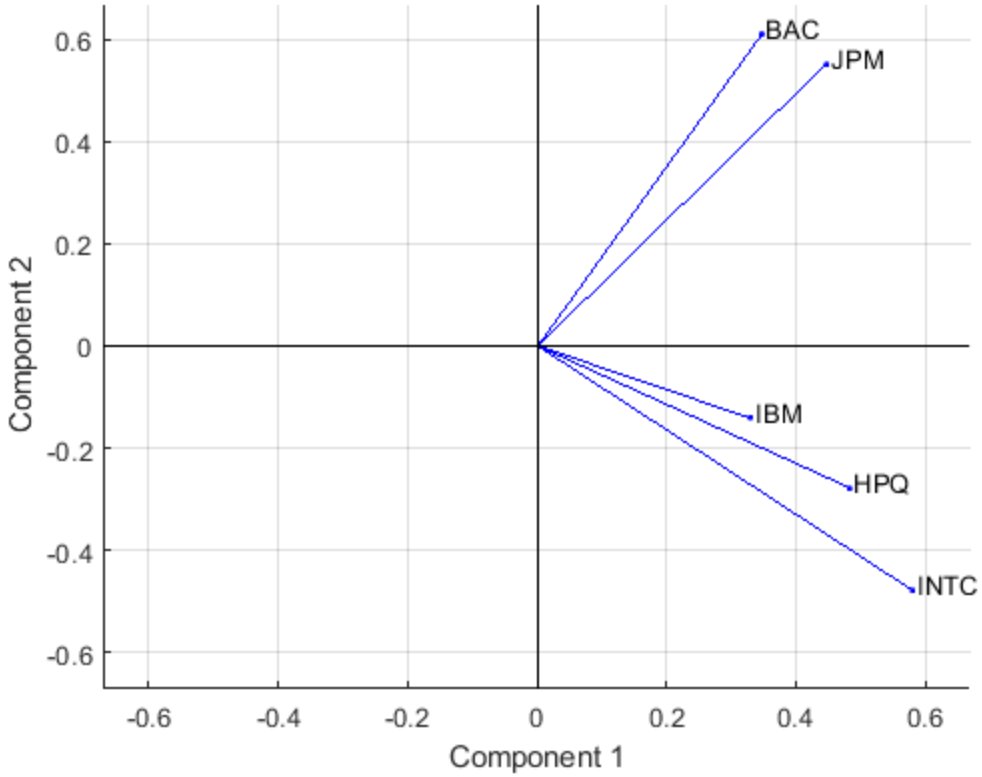
```
-12.2788   -4.7801   -2.4112   -1.4429   -1.0447
 10.4203   -1.6116   -4.3137   13.7651    7.1006
 -0.6458    0.0761    1.6190    7.6800   -3.5368
  4.3906    7.8109   10.2460    0.4335    6.0573
 39.7736   -5.6601    1.5659    0.9471   -1.1575
-16.3217   -7.5959   -8.2902    2.1925  -12.2269
  9.7795    1.7609    9.2299   -1.8570    0.3194
-22.6117   10.3108    1.7472    0.4839   -2.8756
 -0.8113   -4.4479    1.7376   10.2630    4.7018
 -7.1719    6.5361    6.6091   -4.1776    1.0051
  1.4630   -6.5609  -13.2379   -4.8859   -0.1287
 22.3586    7.7954    0.6571   -1.5437    0.8411
 -6.6298   17.1823    4.2066    2.5160   -1.7987
 14.9617   -3.5090   12.1963    1.7228    3.0031
-18.8235    9.7630   -4.8222   10.8777   -1.3597
  3.0899    6.8687   -6.0441   -1.5519   -6.1916
  8.3625   -3.1295  -10.5300   14.7291    1.9862
-51.2410  -25.6854    1.8066   -4.3843    0.7296
  6.4902  -27.7686   -1.3979    7.4717   10.9140
 26.5109   12.6512    9.0764    5.1048  -12.8085
 23.6798    2.4115   -8.4581    5.3347    2.1165
 14.1932   -6.7154    3.6247    4.3772  -11.5509
 22.0578   -0.6052   -3.2052   -8.7935    3.5206
-21.0039   14.0374   -2.8802    1.6849   -6.2113
  4.0090    5.7787    2.2535    2.7250    4.8718
 13.8235   -5.8319   12.8619    7.8962    1.7987
 -6.3662  -13.6640   24.6524    3.7663    4.2642
 22.9042   10.1503   -0.6459    4.6649   -2.0792
 -0.6478  -19.7147   -6.2453   -4.9135    1.5739
  8.7897   -9.3226  -10.2157   -3.1602  -11.8030
-23.1278   -0.7446   -3.5683    5.4266    0.3142
 -4.2852   23.9902  -24.2782  -11.5216   -2.7706
  2.5127  -19.0830   20.4017   -5.2975    4.3542
  7.5123  -17.6570   11.0763   -4.3460   -7.5658
  8.3809   -7.5287  -14.0812    3.6464   -5.5800
 11.0356  -14.8366    4.8277  -18.3251    0.0577
 20.0620    4.7663   -9.0284   10.6267    3.9693
-15.8640  -11.7213    3.1979   -4.1681    8.2679
 -3.5296   14.7767   -9.6807    1.5089    5.5693
  2.9469  -30.3352   17.1632   -9.2531   -9.1004
 -0.5747   14.1151   -9.9276    7.4535   -0.3372
 24.7904    4.1949    2.0666    8.1099    2.7705
-61.1619   24.8226   19.3659    1.9018    8.2267
 -7.0545   -6.2131  -10.6489  -10.7543   -5.8796
-47.2405   -2.3389  -15.2198   15.1118   -1.9457
 -4.5713   32.7721   10.9425   -7.7901   -5.2898
 41.0674    2.7117    2.4307   14.6031    0.0964
-42.0005    8.0669   -2.3966    3.9631    3.7963
 -2.4522    5.8559    9.0898   -6.0515   10.0649
 12.8481   -1.8975  -12.8111   18.1310   -4.0030
 -5.7796   11.5261    9.3051   -2.8065    3.1765
 -1.8922   -7.6497   -6.5250    1.7178    7.7725
 -9.2763    6.8019  -14.2129   -0.1538    3.9626
-15.5639   -1.6065   -0.9525   -0.6475    3.5127
```

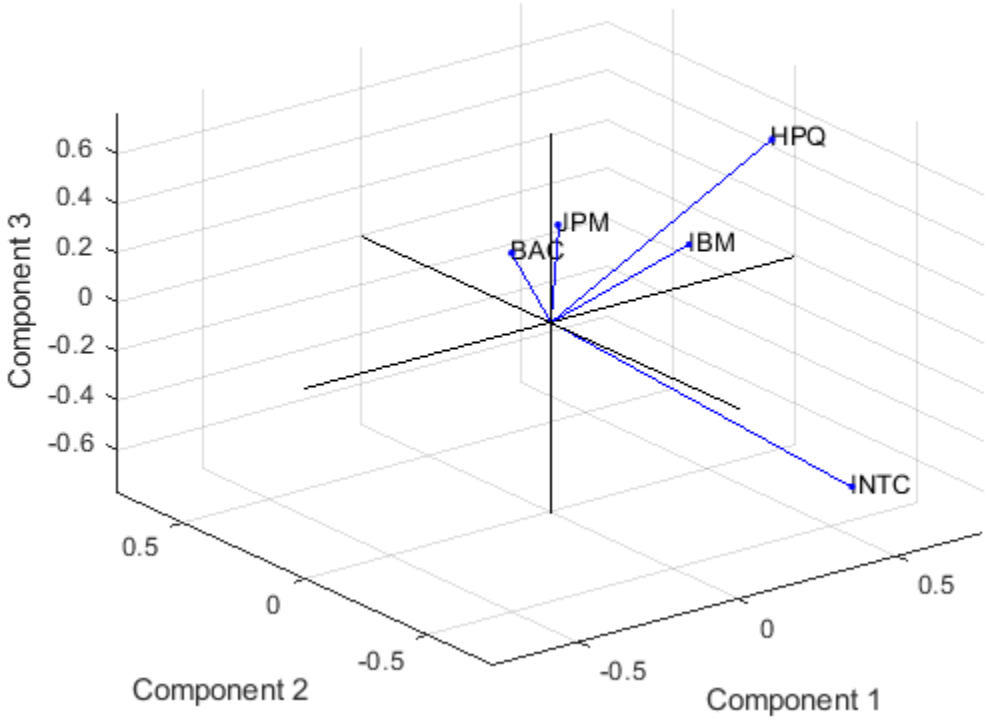
```
-48.3698   16.1141   -6.7185   11.8854    2.3676
 18.4557   -8.8173   -4.1446   10.6118   -1.1871
 34.4455  -16.1174    0.9773   -8.6481    2.0744
 -6.1612    3.2879   -1.2519    7.3674    4.4414
  1.7125   -8.3587   -4.8847  -14.1217    4.9908
-27.3768    7.0232    4.0927   -1.4335   10.9245
  9.3524   14.1309  -11.3247    7.9832  -10.5001
-12.9658   11.0551   -5.8908  -16.7854    4.0541
  2.7605    3.4138    8.3452   -8.0708    2.7862
-44.9649   20.3732    9.5801    3.7855   -3.7720
-19.8155  -18.2189   -6.8001    2.9228   15.8852
 -4.6646   12.6650    5.1885    9.2420   -0.8049
-45.1079   -7.0161   -2.8779  -13.3316   15.1165
 43.2665  -11.6648   13.6988   11.2006    3.4045
 31.1868   -5.1278    4.6163   -3.3150  -10.2506
-30.1430   16.4443    8.3361   -2.4224    1.6911
 -1.3563   -0.6815   -0.2048    0.6496    1.6309
 -2.6042   -3.9984  -12.7248    3.1614    0.4084
 -4.6861    4.2129    3.2027    1.4200   -5.0285
 23.6154   10.6691   -4.0158    2.3407   -7.5883
 20.4493   -4.9774    5.1453   -6.2619   -5.3024
  4.5923    5.1082    3.8317  -10.1221    3.3503
 10.7660   -3.3506  -13.1011   -3.1218    0.9806
  1.1373   -8.7151  -12.5287    2.4233   -1.5113
 -2.9178    1.5842    2.7225    8.0370   -0.6874
 17.1972  -11.3535   -1.2011   -7.0208   -3.8088
 -2.4153   -1.1178   -2.6241    2.2106    0.6010
  3.2668    7.0035    6.7147   -0.3237    3.3986
  2.5806    5.0496    7.1775    4.6113   -3.1567
 -4.9260    7.2257   -1.3312   -0.3198   -3.8476
 -6.2771    5.1949    3.9140   -4.3191   -1.6281
-18.3298    1.6872   -7.6611    3.8582    4.9079
  8.2722   -6.1458   -1.8078   -3.5724    4.9002
 -0.9491    6.4728    1.4492   -0.3836   -1.6246
-12.8758    6.3237    4.4727    2.2181    1.7352
-11.6741   16.9714   -1.0914    3.6469   -1.6205
 -3.2611    0.0472    8.0713   -0.5561   -1.5045
  5.6586   -4.3220   -6.3156    3.3650    4.0631
  3.5369   -2.1292    5.3428    1.5902    5.0673
  7.0611   -0.4477    1.5205    1.1250    0.1393
-11.3789    2.1140   -3.3550   -1.2886    0.7328
  4.0568   -5.4563   -0.6088   -3.7829    2.8490
 -5.5159   -5.4511    6.3275   -2.9453    1.3485
 -8.1554    7.2843  -10.7417  -13.4697   -1.8670
 11.7994   -6.8486   -3.0277   -6.2710    2.9185
 -3.0437   -0.1260    5.1652   -3.2363    1.0594
  5.2762   -7.1967    4.0877    8.1238   -2.5640
 -1.7971   -2.3254   10.8911   -7.3484    3.8382
 -2.6779   -0.4109    6.5941   -2.3469   -0.9300
 -0.8121   10.4046    0.2119    3.4195   -3.6919
 15.1385   -2.7394   -3.0629    3.5226    2.2094
 -8.1037    7.8120   -0.1865   -5.2359   -2.6541
 -8.5174    3.6605   16.6135   -3.1640   -2.8313
  1.4475    4.3183    4.5054   -3.1739    0.7924
```

```
   -3.3812    3.3535    4.6939    2.6670   -0.4049
    6.3062   10.1096   -3.9305   -0.5468   -0.0767
  -12.0949    0.6716    5.7636   -0.9116    2.8378
   -1.9591   -2.4164   -5.7894   -3.1272    0.5761
    1.9746   11.6743    3.2609    0.2198   -1.3332
   11.7849   -7.8318    4.8864   -2.3895    2.5545
    4.2968    1.5150   -3.0799    0.0916    1.1491
    7.7513   -3.4009    4.4453    7.8515    0.1854
   -1.4044   -1.3557    0.6631   -0.8499    2.8077
    0.4964    2.6776    8.1995    3.2586   -2.9452
    5.2896   -0.7187    1.8298   -1.0345   -4.4572
  -13.5058    2.9708   -4.8788   -0.7606   -0.5778
   -3.3623    0.3163    4.2901    0.7805    2.0711
   13.4127   -3.5361   -2.1749    3.4906   -4.8050
    5.6434   -4.2374    4.4349    0.2525    2.0871
   -3.7517   -8.1478   -5.8492   -0.3993    2.1453
   -4.0333   -7.7571    4.2699    3.7501    4.5691
   11.4072   -2.1365   -0.3756    1.0320    5.0442
    0.5987    1.4724    0.5787    0.1355   -1.4142
    1.7973   -3.1031    0.0617   -3.4756   -4.5658
  -10.0028   -1.2951   -0.9457   -7.6273   -1.2600
   -5.6184   -9.1563   -0.3751    3.0890   -3.5728
  -16.3403   24.6578    3.9620    6.9301   -3.5053
   -8.8655  -15.6676   12.4987    3.4992    4.5779
    1.1846   -0.3439   -6.3287    1.9452   -6.2444
    7.9180    2.3403   -1.0072    2.3598   -8.0667
   -4.0739  -15.1035    1.2487    6.2170    0.7750
  -33.6498  -25.5950    2.5282   -2.8141   -7.9714
   22.2757   26.6237   -3.2399    4.5098   10.4799
   -3.4213   -8.4711    0.3459   -6.0856    0.6107
   -2.1069   29.5703    9.1649   -2.5042   -4.4764
  -45.6423  -12.7555   -4.6626   -9.8867  -20.5687
  -43.7040  -27.8350    5.1173   -4.2442  -10.5225
   -0.2971  -11.5231    0.4134    0.9844   -7.5593


latent_ret =

  284.1675
  112.9316
   57.4371
   46.8064
   29.8740


ans =

    0.5349
    0.2126
    0.1081
    0.0881
    0.0562
```

```
ans =

    0.5349
    0.7475
    0.8557
    0.9438
    1.0000
```



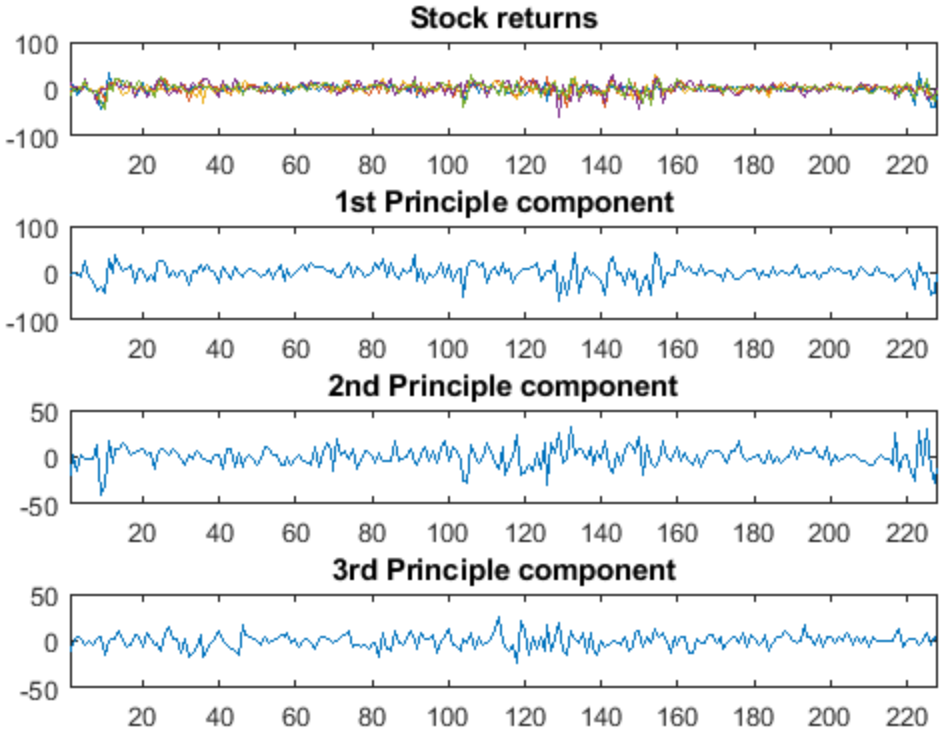

BAC
JPM
IBM
HPQ
INTC
Component 2
Component 1
0.6
0.4
0.2
0
-0.2
-0.4
-0.6

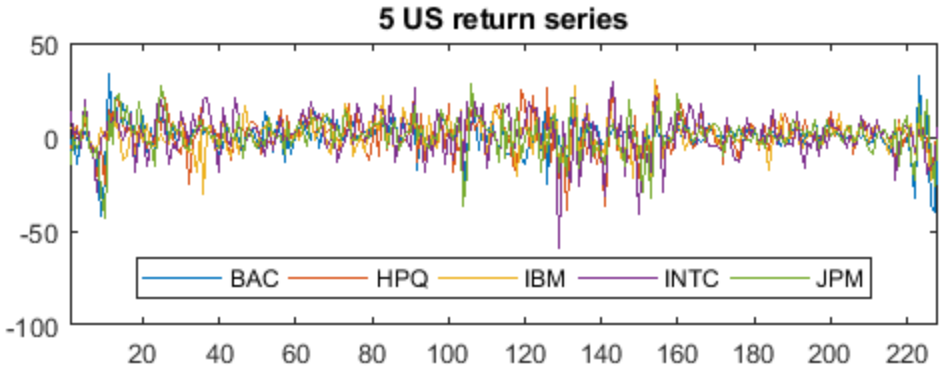

HPQ
JPM
BAC
IBM
INTC
Component 3
Component 2
Component 1
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0.5
0
-0.5

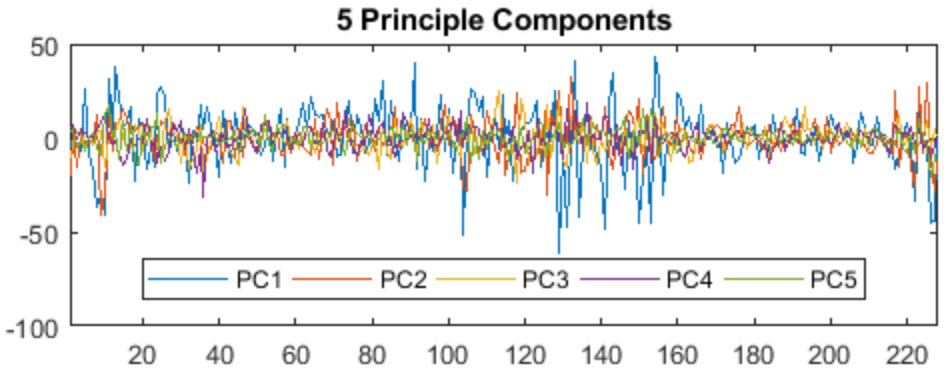
Q1(c) Describe PCs

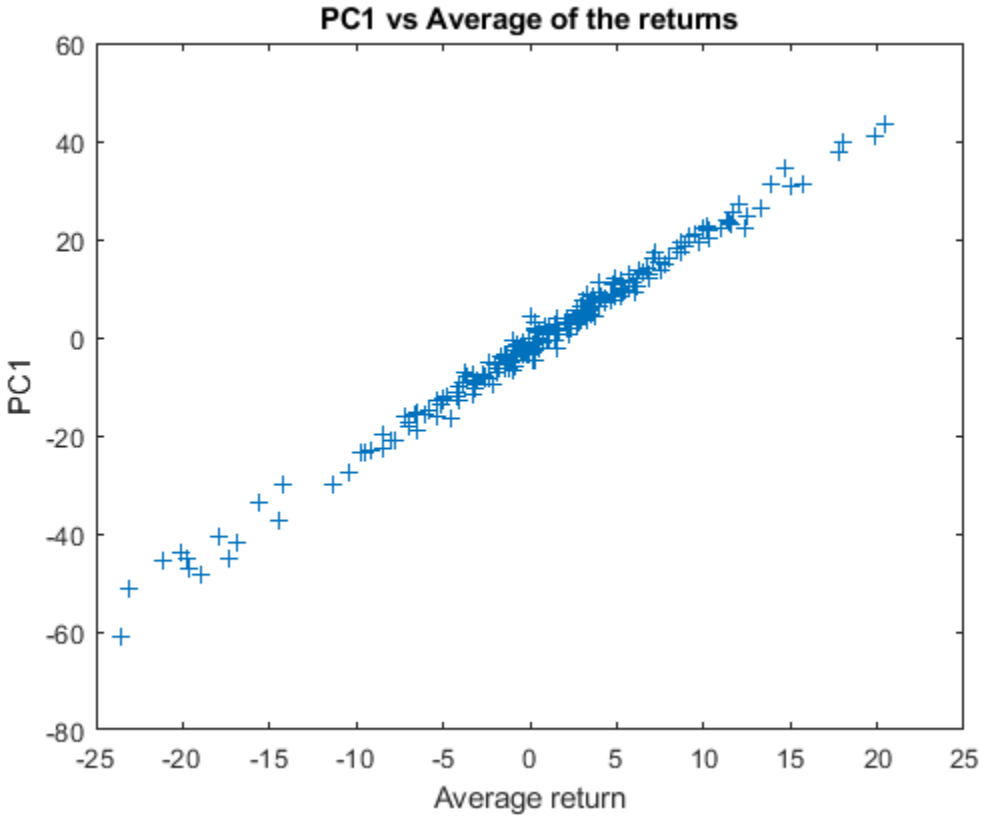
```
% sample covariance matrix
cov(Tsay_data)

% Plot of 5 return series together along with first 3 components
figure;subplot(4,1,1);plot(Tsay_data);xlim([0 length(Tsay_data)]);
title('Stock returns');xlim([1 length(Tsay_data)]);
subplot(4,1,2);plot(score_ret(:,1));
title('1st Principle component');xlim([1 length(score_ret)]);
subplot(4,1,3);plot(score_ret(:,2));xlim([0 length(Tsay_data)]);
title('2nd Principle component');xlim([1 length(score_ret)]);
subplot(4,1,4);plot(score_ret(:,3));xlim([0 length(Tsay_data)]);
title('3rd Principle component');xlim([1 length(score_ret)]);

% Correlation matrix of all 5 components
corr(score_ret)   %  note the zero correlations of the PCs

% Plot of 5 return series together along with first 5 components
 together
figure;subplot(2,1,1);plot(Tsay_data);title('5 US return series');
xlim([1 length(Tsay_data)]);
legend('BAC','HPQ','IBM','INTC','JPM','location','south','Orientation','horizontal
subplot(2,1,2);plot(score_ret);title('5 Principle Components');
legend('PC1','PC2','PC3','PC4','PC5','location','south','Orientation','horizontal'
xlim([1 length(Tsay_data)]);

% Correlation between the average of the returns along with the first
 component
corrcoef(mean(Tsay_data'),score_ret(:,1));

% Scatter plot of the average of the returns and the first component
figure;plot(mean(Tsay_data'),score_ret(:,1),'+');
title('PC1 vs Average of the returns');
xlabel('Average return');ylabel('PC1');

% Plot of the daily average of the returns and the first component
figure;plot(mean(Tsay_data')); %transpose to take average of 5 returns
 each period
hold on;plot(score_ret(:,1),'r');xlim([0 length(Tsay_data)]);
legend('Average returns','PC1','location','southeast');
title('Average Returns and PC1');


ans =

   91.8261   26.2997   21.0695   29.2428   67.4529
   26.2997  112.2189   42.2812   70.4519   42.4237
   21.0695   42.2812   74.6379   48.0269   30.1030
   29.2428   70.4519   48.0269  146.4969   44.5942
   67.4529   42.4237   30.1030   44.5942  106.0369
```

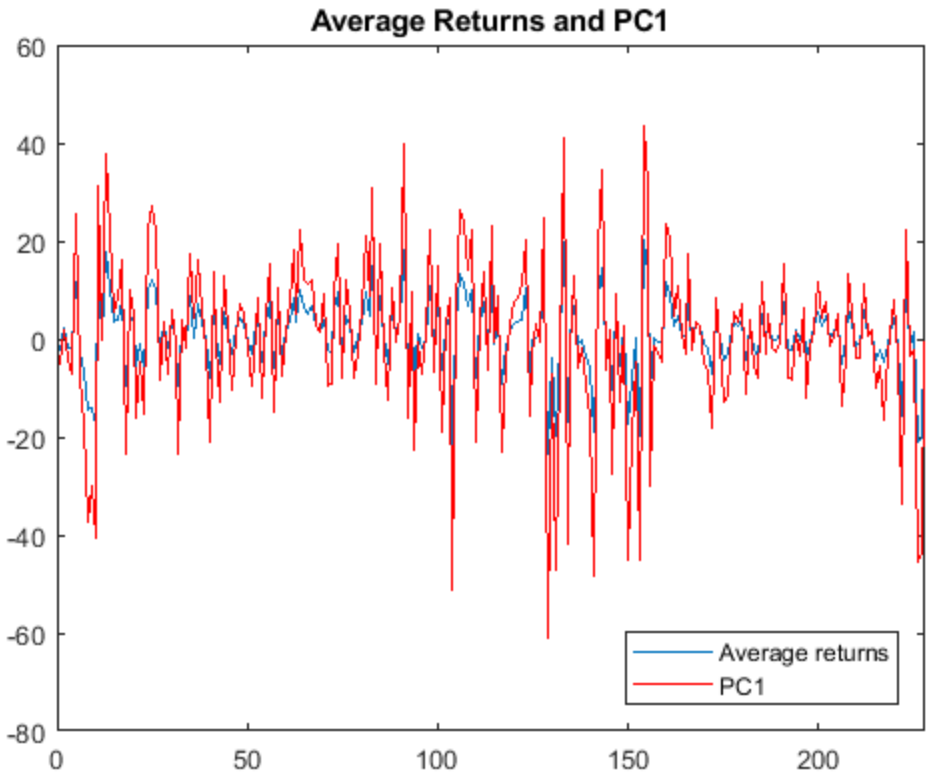
```
ans =

    1.0000    0.0000    0.0000   -0.0000    0.0000
    0.0000    1.0000    0.0000    0.0000    0.0000
    0.0000    0.0000    1.0000    0.0000    0.0000
   -0.0000    0.0000    0.0000    1.0000   -0.0000
    0.0000    0.0000    0.0000   -0.0000    1.0000
```




5 US return series
50
0
-50
-100
BAC
HPQ
IBM
INTC
JPM
20
40
60
80
100
120
140
160
180
200
220


5 Principle Components
50
0
-50
-100
PC1
PC2
PC3
PC4
PC5
20
40
60
80
100
120
140
160
180
200
220


PC1 vs Average of the returns
PC1
60
40
20
0
-20
-40
-60
-80
-25
-20
-15
-10
-5
0
5
10
15
20
25
Average return



Q1(d) Perform Factor Analysis m=1

```
ymat=Tsay_data;  % rows are observations over time, columns are
 variables
size(ymat)   % should be T by n

[lam1_rets,psi1_rets,T1_ret,stats1_ret,F1_ret] = factoran(ymat,1);  %
 fit 1 factor model

% show standardised factor loadings and specific error variances
[lam1_rets psi1_rets]

% factor loadings (regression coefficients)
lam1_ret=lam1_rets.*(std(ymat))'; % std(ymat) gives stds, transpose
 give 5x1 vector, dot multiply another 5x1

%  specific error variances (SER^2)
psi1_ret=(psi1_rets.*(var(ymat))');

[lam1_ret psi1_ret sqrt(psi1_ret) (1-psi1_ret'./var(ymat))']
%  above code displays actual factor loadings (regression
 coefficients),
%  specific error variances (SER^2), SER and adjusted R-squared for
 each industry series
```

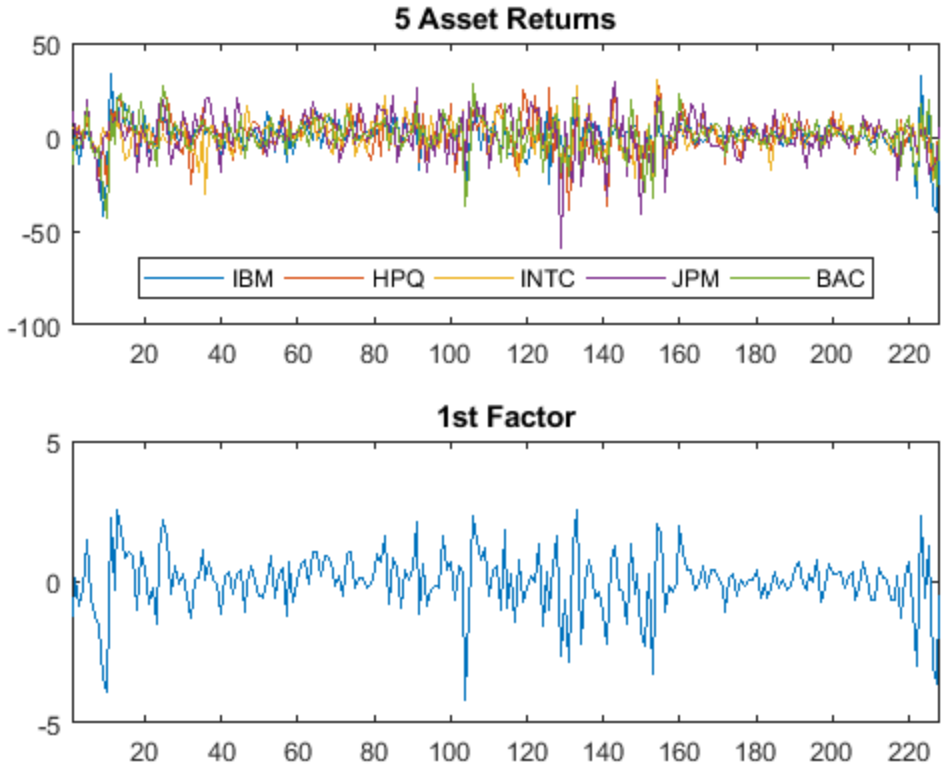
```
%  psi1 are specific variances, so var(ymat)-psi1_ret'  gives
 communalities

% overall amount of variance captured by the factor model
(trace(cov(ymat))-sum(psi1_ret))/trace(cov(ymat))

% Stats from the factor analysis
stats1_ret

% Estimated error variances, and sample variances, for each asset
[psi1_ret';var(ymat)]

% Sample mean and variance of single factor
[mean(F1_ret) var(F1_ret)]

% SER, R-squared and Standard Deviations for each asset
[sqrt(psi1_ret'); (1-psi1_ret'./var(ymat));  std(ymat)]


ans =

   228     5


ans =

    0.7261    0.4728
    0.5196    0.7300
    0.4708    0.7784
    0.4969    0.7531
    0.8426    0.2900


ans =

    6.9575   43.4187    6.5893    0.5272
    5.5045   81.9197    9.0510    0.2700
    4.0671   58.0968    7.6221    0.2216
    6.0139  110.3304   10.5038    0.2469
    8.6767   30.7511    5.5454    0.7100


ans =

    0.3891


stats1_ret =

  struct with fields:

    loglike: -0.4111
        dfe: 5
      chisq: 92.0155
```

```
          p: 2.5338e-18


ans =

   43.4187   81.9197   58.0968  110.3304   30.7511
   91.8261  112.2189   74.6379  146.4969  106.0369


ans =

    0.0000    1.2200


ans =

    6.5893    9.0510    7.6221   10.5038    5.5454
    0.5272    0.2700    0.2216    0.2469    0.7100
    9.5826   10.5933    8.6393   12.1036   10.2974
```

Q1(e) Describe the factor loadings and factor found

Plot 5 US returns series and single factor

```
figure;subplot(2,1,1);plot(ymat);xlim([1 length(Tsay_data)]);
title('5 Asset Returns');
legend('IBM','HPQ','INTC','JPM','BAC','Location','South','Orientation','horizontal
subplot(2,1,2);plot(F1_ret);xlim([1 length(Tsay_data)]);
title('1st Factor');
```



Q1(f) Assess whether 1 factor model is appropriate

```
% Correlation between first principle component and single factor
corrcoef(score_ret(:,1),F1_ret)

% Correlations of asset return and single factor
corr([ymat F1_ret])
```

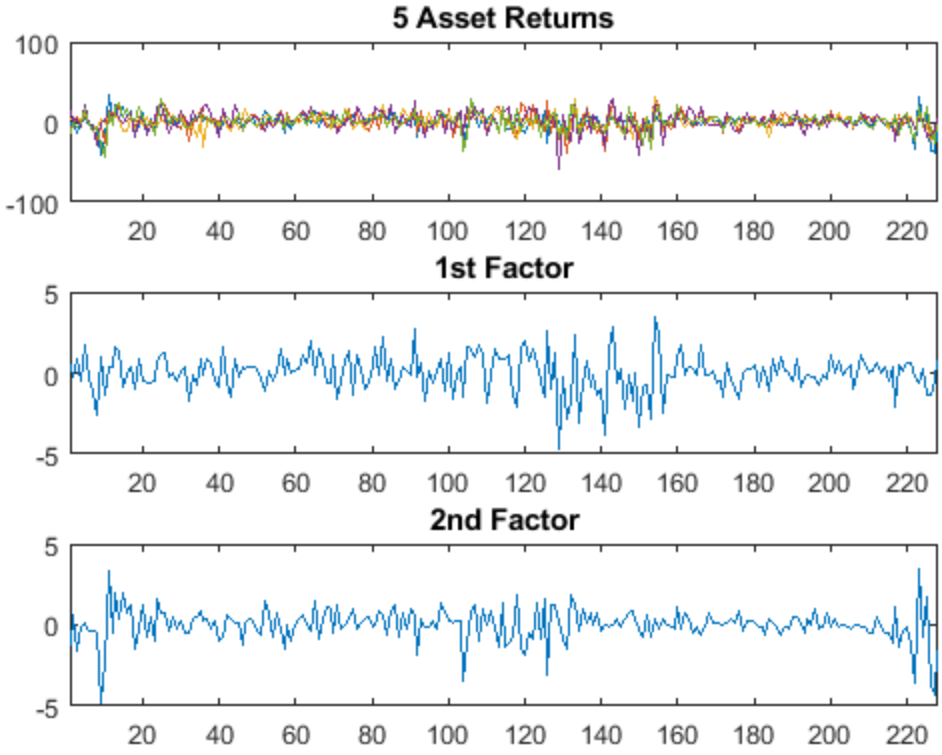
```
ans =

    1.0000    0.9036
    0.9036    1.0000


ans =

    1.0000    0.2591    0.2545    0.2521    0.6836    0.8020
    0.2591    1.0000    0.4620    0.5495    0.3889    0.5739
    0.2545    0.4620    1.0000    0.4593    0.3384    0.5200
    0.2521    0.5495    0.4593    1.0000    0.3578    0.5488
    0.6836    0.3889    0.3384    0.3578    1.0000    0.9307
    0.8020    0.5739    0.5200    0.5488    0.9307    1.0000
```

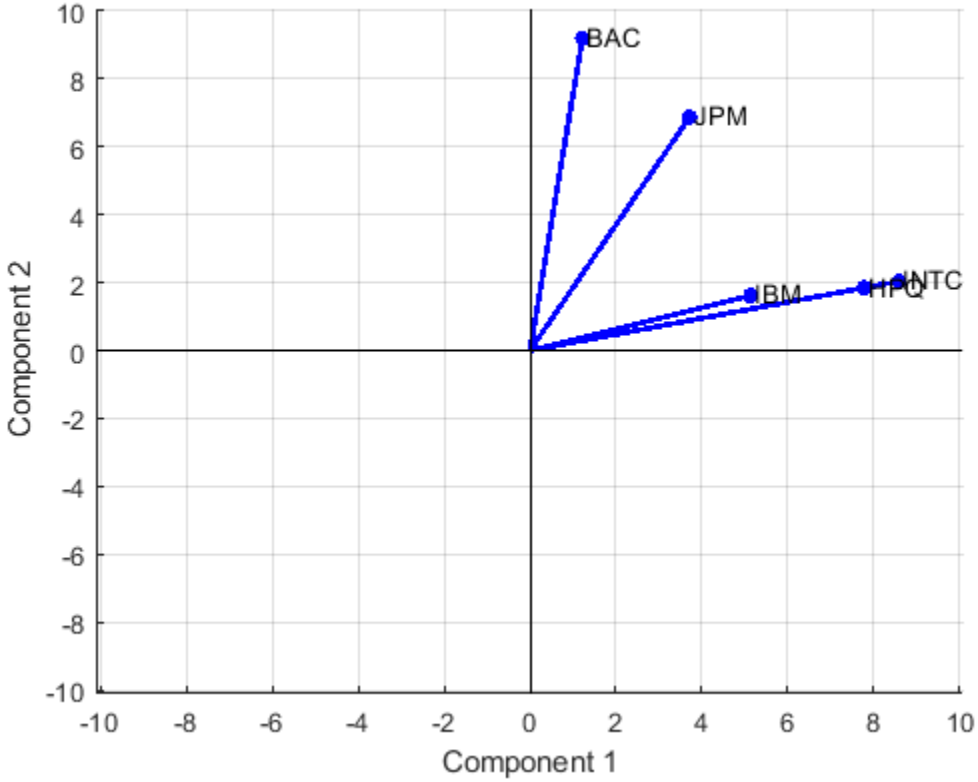
Q1(g) Perform a Factor Analysis with m=2 factors

```
% Estimate 2-factor model, m=2
[lam2_rets,psi2_rets,T2_ret,stats2_ret,F2_ret]=factoran(ymat,2,'maxit',500);
  % fit 2 factor model
% NB the maxit option specifies how many iterations to use in the
 search
% procedure for estimates. the default is 250 which is not enough for
 this
% model and data, so I set it higher.

% show standardised factor loadings and specific error variances
[lam2_rets psi2_rets]
%  Display the two columns of factor loadings, then specific error
 variances, SER and adjusted R
%  squared for each industry series from the single factor model.
lam2_ret=lam2_rets;
lam2_ret(:,1)=lam2_rets(:,1).*(std(ymat))';
lam2_ret(:,2)=lam2_rets(:,2).*(std(ymat))';
psi2_ret=psi2_rets.*(var(ymat))';

% Display the two columns of factor loadings, specific error
 variances,
% SER and adj. R-squared for each industry for the single factor
 model.
[lam2_ret psi2_ret sqrt(psi2_ret) (1-psi2_ret'./var(ymat))']

% overall amount of variance captured by the factor model
(trace(cov(ymat))-sum(psi2_ret))/trace(cov(ymat))

% Stats from the factor analysis
stats2_ret

% Estimated error variances, and sample variances, for each asset
[psi2_ret';var(ymat)]

% Sample means and variance of 2 factors
mean(F2_ret)
% Covariance matrix of 2 factors
var(F2_ret)

% SER, R-squared and Standard Deviations for each asset
[sqrt(psi2_ret'); (1-psi2_ret'./var(ymat));std(ymat)]

figure;subplot(3,1,1);plot(ymat);xlim([1 length(Tsay_data)]);
title('5 Asset Returns');
%legend('IBM','HPQ','INTC','JPM','BAC','location','South','Orientation','horizonta
subplot(3,1,2);plot(F2_ret(:,1));xlim([1 length(Tsay_data)]);
title('1st Factor');
subplot(3,1,3);plot(F2_ret(:,2));xlim([1 length(Tsay_data)]);
title('2nd Factor');
```

```
% Correlations between asset return and factors
corr([ymat F2_ret])

% create vector/cell array of labels for biplot
vbls = {'BAC','HPQ','IBM','INTC','JPM'};

% Create biplot of two factors
figure;biplot(lam2_ret,'varlabels',vbls,...  % Add variable labels to
 plot
   'LineWidth',2,...                         % Set linewidth for
 biplot
   'MarkerSize',20)                          % Set marker size for
 biplot


ans =

    0.1273    0.9577    0.0666
    0.7334    0.1739    0.4318
    0.5937    0.1868    0.6126
    0.7093    0.1680    0.4686
    0.3605    0.6659    0.4267


ans =

    1.2196    9.1773    6.1154    2.4729    0.9334
    7.7696    1.8423   48.4584    6.9612    0.5682
    5.1296    1.6141   45.7199    6.7616    0.3874
    8.5856    2.0338   68.6482    8.2854    0.5314
    3.7117    6.8567   45.2460    6.7265    0.5733


ans =

    0.5968


stats2_ret =

  struct with fields:

    loglike: -0.0012
        dfe: 1
      chisq: 0.2759
          p: 0.5994


ans =

    6.1154   48.4584   45.7199   68.6482   45.2460
   91.8261  112.2189   74.6379  146.4969  106.0369
```

```
ans =

   1.0e-15 *

    0.1553   -0.0214


ans =

    1.3581    1.0822


ans =

    2.4729    6.9612    6.7616    8.2854    6.7265
    0.9334    0.5682    0.3874    0.5314    0.5733
    9.5826   10.5933    8.6393   12.1036   10.2974


ans =

    1.0000    0.2591    0.2545    0.2521    0.6836    0.0870    0.9872
    0.2591    1.0000    0.4620    0.5495    0.3889    0.8436    0.1283
    0.2545    0.4620    1.0000    0.4593    0.3384    0.6800    0.1518
    0.2521    0.5495    0.4593    1.0000    0.3578    0.8159    0.1240
    0.6836    0.3889    0.3384    0.3578    1.0000    0.3775    0.6669
    0.0870    0.8436    0.6800    0.8159    0.3775    1.0000   -0.0615
    0.9872    0.1283    0.1518    0.1240    0.6669   -0.0615    1.0000
```


5 Asset Returns
100
0
-100
20 40 60 80 100 120 140 160 180 200 220
1st Factor
5
0
-5
20 40 60 80 100 120 140 160 180 200 220
2nd Factor
5
0
-5
20 40 60 80 100 120 140 160 180 200 220

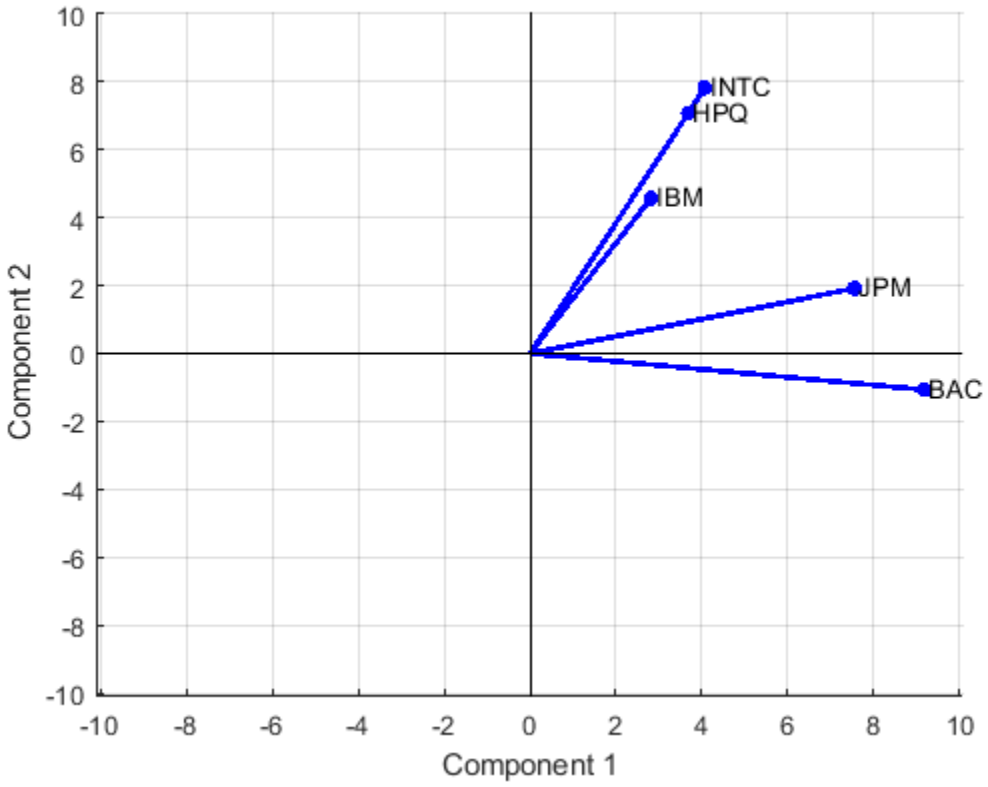

BAC
JPM
IBM
HPQ
INTC
Component 2
Component 1
10
8
6
4
2
0
-2
-4
-6
-8
-10
-10 -8 -6 -4 -2 0 2 4 6 8 10

Q1(h) Unrotated factors

Calculate and display unrotated loadings.

```
unrot_lam = lam2_ret*inv(T2_ret);   % Often makes 1st factor similar
 to single factor model :)
unrot_lam'

% Create biplot of two unrotated factors
figure;biplot(unrot_lam,'varlabels',vbls,...    % Add variable labels
 to plot
      'LineWidth',2,...                         % Set linewidth for
 biplot
      'MarkerSize',20)                          % Set marker size for
 biplot
```

```
ans =

    9.1961    3.6917    2.8229    4.0775    7.5576
   -1.0686    7.0804    4.5770    7.8245    1.9166
```



Fit 3 factor model

```
[lam3_ret,psi3_ret,T3_ret,stats3_ret,F3_ret]=factoran(ymat,3,'maxit',500);
```

```
% This code returns the following error message:
%   " Error using factoran (line 139)
%     The number of factors requested, M, is too large for the number
 of the observed variables. "
% Matlab is telling us that three factors give too many unknowns to
 estimate for this data.
```

```
Error using factoran (line 139)
The number of factors requested, M, is too large for the number of the
 observed variables.

Error in lab5code_19 (line 207)
[lam3_ret,psi3_ret,T3_ret,stats3_ret,F3_ret]=factoran(ymat,3,'maxit',500);
```

Published with MATLAB® R2017b