1. Explain the three Fama-French factors.

   The Fama-French three factors model is the regression of returns on observed factors. The three factors are market excess return, the outperformance of small versus big companies(SMB), and the outperformance of high book-to-market ratio versus low book-to-market companies(HML). If the beta coefficient of SMB is positive, it implies that small firms have higher returns than large firms. If the beta coefficient of HML is positive, it implies that value firms have higher returns than growth firms.

2. Fama-French regressions

   (a) Download the Fama-French data.

   (b) Choose two stocks(Berkshire Hathaway: "BRK.A", Taiwan Semiconductor Manufacturing: "TSM"), and download monthly price data from 2002/01 to 2022/12.

   (c) Transform the stock returns to excess returns.

   (d) Estimate market regressions of your two stock returns.

   (e) Interpret findings.(The first column of the table is Alpha, SMB, HML, and RM in order)

```
Coefficient Estimates:


        |  Coeff     SE
------------------------
Const |   0.3554   0.2572
x1    |  -0.4008   0.0969
x2    |   0.3775   0.0906
x3    |   0.6560   0.0725
```

Figure 1: BRK-A 2002 2022

From the figure above, we can observe that Alpha is not statistically significant, which implies that the excess return for BRK-A is close to zero. On the other hand, SMB, HML, and RM are statistically significant. SMB is negative, which implies that large firms outperform small ones. HML is positive, which indicates that value firms have higher returns than growth firms. RM is positive but less than one, which suggests the relationship between market excess return and theexpected return of BRK-A.

```
Coefficient Estimates:

          |  Coeff      SE
------------------------------
Const |   0.2099   0.4414
x1    |  -0.0285   0.2341
x2    |  -0.1690   0.1654
x3    |   1.2223   0.1249
```

Figure 2: TSM 2002 2022

From the figure above, we can observe that Alpha, SMB, and HML are not statistically significant. The results imply that the excess return for BRK-A is close to zero. In addition, it also implies that the size of firms and the book-to-market value do not affect the expected return of TSM so much. On the other hand, RM is statistically significant.

3. PCA analysis

   (a) Select a set of ten stock price series
       ('QCOM', 'TSM', 'INTC', 'AMD', 'NOVT', 'TXN', 'NVDA', 'ASML', 'MCHP', 'ON')

   (b) Calculate the first two PC.

```
        PCA eigenvectors (first 2)
            0.2561      0.2099
            0.3290     -0.1198
            0.3139     -0.4110
            0.2962      0.3908
            0.2315      0.6782
            0.3633     -0.1988
            0.3155      0.1636
            0.3538     -0.2025
            0.3342     -0.2274
            0.3433      0.0296
```

   (c) The percentage of the variance is explained by the first for 55.29% ,and explained by the second for 0.839%

4. MLE Factor analysis

   (a) Estimate a 2-factor model by MLE.

   (b) Report the coefficients and variance estimates.

```
Factor Analysis Beta
        0.5178      0.2636
        0.5808      0.4684
        0.2481      0.7760
        0.6822      0.2513
        0.4569      0.2374
        0.4935      0.7070
        0.5836      0.4051
        0.5008      0.6520
        0.4683      0.6021
        0.5931      0.5090


    variances
        0.6624
        0.4433
        0.3363
        0.4714
        0.7349
        0.2566
        0.4952
        0.3241
        0.4182
        0.3891
```

Matlab Code

```matlab
1  clear all;
2
3  P1 = getMarketDataViaYahoo('BRK-A','1-Jan-2002','31-Dec-2022','1
      mo');
4  P2 = getMarketDataViaYahoo('TSM','1-Jan-2002','31-Dec-2022','1mo'
      );
5  R1 = 100*(P1.Close(2:end) - P1.Close(1:end-1)) ./ P1.Close(1:end
      -1);
6  R2 = 100*(P2.Close(2:end) - P2.Close(1:end-1)) ./ P2.Close(1:end
      -1);
7  dates = P1.Date;
8  dates2 = dates(2:end,:);
9
10 %Drop the row911 data to match the date%
```

```matlab
11  T = readtable('F-F_Research_Data_Factors.CSV','Range','B912:E1162
        ','ReadVariableNames',false);
12  RM = T.Var1;
13  SMB = T.Var2;
14  HML = T.Var3;
15  Rf = T.Var4;
16
17  R1s = R1 - Rf;
18  R2s = R2 - Rf;
19
20  fprintf('---------- Fama-French Regressions ----------\n');
21  fprintf('BRK-A:\n');
22  hac([SMB HML RM],R1s,'type','HC','weights','HC3','display','full'
        );
23  fprintf('\n');
24  fprintf('TSM:\n');
25  hac([SMB HML RM],R2s,'type','HC','weights','HC3','display','full'
        );
26  fprintf('\n');
27
28
29  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
30  function data=getMarketDataViaYahoo(symbol, startdate, enddate,
        interval)
31      if(nargin() == 1)
32          startdate = posixtime(datetime('1-Jan-2018'));
33          enddate = posixtime(datetime()); % now
34          interval = '1d';
35      elseif (nargin() == 2)
36          startdate = posixtime(datetime(startdate));
37          enddate = posixtime(datetime()); % now
38          interval = '1d';
39      elseif (nargin() == 3)
40          startdate = posixtime(datetime(startdate));
41          enddate = posixtime(datetime(enddate));
42          interval = '1d';
43      elseif(nargin() == 4)
44          startdate = posixtime(datetime(startdate));
45          enddate = posixtime(datetime(enddate));
46      else
47          error('At least one parameter is required. Specify ticker
```

```matlab
                symbol.');
48            data = [];
49            return;
50        end
51
52        %% Send a request for data
53        % Construct an URL for the specific data
54        uri = matlab.net.URI(['https://query1.finance.yahoo.com/v7/
                finance/download/', upper(symbol)],...
55            'period1',   num2str(int64(startdate), '%.10g'),...
56            'period2',   num2str(int64(enddate), '%.10g'),...
57            'interval', interval,...
58            'events',    'history',...
59            'frequency', interval,...
60            'guccounter', 1,...
61            'includeAdjustedClose', 'true');
62
63        options = weboptions('ContentType','table', 'UserAgent', '
                Mozilla/5.0');
64        try
65            data = rmmissing(webread(uri.EncodedURI, options));
66        catch ME
67            data = [];
68            warning(['Identifier: ', ME.identifier, 'Message: ', ME.
                message])
69        end
70 end
```

```matlab
1 clear all;
2
3 P1 = getMarketDataViaYahoo('QCOM','1-Jan-2002','31-Dec-2022','1mo
    ');
4 P2 = getMarketDataViaYahoo('TSM','1-Jan-2002','31-Dec-2022','1mo'
    );
5 P3 = getMarketDataViaYahoo('INTC','1-Jan-2002','31-Dec-2022','1mo
    ');
6 P4 = getMarketDataViaYahoo('AMD','1-Jan-2002','31-Dec-2022','1mo'
    );
7 P5 = getMarketDataViaYahoo('NOVT','1-Jan-2002','31-Dec-2022','1mo
    ');
8 P6 = getMarketDataViaYahoo('TXN','1-Jan-2002','31-Dec-2022','1mo'
```

```matlab
   ) ;
9  P7 = getMarketDataViaYahoo ( 'NVDA' , '1-Jan-2002' , '31-Dec-2022' , '1mo
   ' ) ;
10 P8 = getMarketDataViaYahoo ( 'ASML' , '1-Jan-2002' , '31-Dec-2022' , '1mo
   ' ) ;
11 P9 = getMarketDataViaYahoo ( 'MCHP' , '1-Jan-2002' , '31-Dec-2022' , '1mo
   ' ) ;
12 P10 = getMarketDataViaYahoo ( 'ON' , '1-Jan-2002' , '31-Dec-2022' , '1mo'
   ) ;
13 R1 = 100*( P1 . Close (2: end ) - P1 . Close (1: end -1) ) ./ P1 . Close (1: end
   -1) ;
14 R2 = 100*( P2 . Close (2: end ) - P2 . Close (1: end -1) ) ./ P2 . Close (1: end
   -1) ;
15 R3 = 100*( P3 . Close (2: end ) - P3 . Close (1: end -1) ) ./ P3 . Close (1: end
   -1) ;
16 R4 = 100*( P4 . Close (2: end ) - P4 . Close (1: end -1) ) ./ P4 . Close (1: end
   -1) ;
17 R5 = 100*( P5 . Close (2: end ) - P5 . Close (1: end -1) ) ./ P5 . Close (1: end
   -1) ;
18 R6 = 100*( P6 . Close (2: end ) - P6 . Close (1: end -1) ) ./ P6 . Close (1: end
   -1) ;
19 R7 = 100*( P7 . Close (2: end ) - P7 . Close (1: end -1) ) ./ P7 . Close (1: end
   -1) ;
20 R8 = 100*( P8 . Close (2: end ) - P8 . Close (1: end -1) ) ./ P8 . Close (1: end
   -1) ;
21 R9 = 100*( P9 . Close (2: end ) - P9 . Close (1: end -1) ) ./ P9 . Close (1: end
   -1) ;
22 R10 = 100*( P10 . Close (2: end ) - P10 . Close (1: end -1) ) ./ P10 . Close (1:
   end -1) ;
23
24 R1 = ( R1 - mean ( R1 ) ) / std ( R1 ) ;
25 R2 = ( R2 - mean ( R2 ) ) / std ( R2 ) ;
26 R3 = ( R3 - mean ( R3 ) ) / std ( R3 ) ;
27 R4 = ( R4 - mean ( R4 ) ) / std ( R4 ) ;
28 R5 = ( R5 - mean ( R5 ) ) / std ( R5 ) ;
29 R6 = ( R6 - mean ( R6 ) ) / std ( R6 ) ;
30 R7 = ( R7 - mean ( R7 ) ) / std ( R7 ) ;
31 R8 = ( R8 - mean ( R8 ) ) / std ( R8 ) ;
32 R9 = ( R9 - mean ( R9 ) ) / std ( R9 ) ;
33 R10 = ( R10 - mean ( R10 ) ) / std ( R10 ) ;
34 dates = P1 . Date ;
```

```matlab
35  dates2 = dates(2:end,:);
36
37  R = [R1,R2,R3,R4,R5,R6,R7,R8,R9,R10];
38  [B,F,var] = pca(R);
39  fprintf('\n');
40  fprintf('PCA eigenvalues\n');
41  disp(var);
42  fprintf('\n');
43  fprintf('PCA eigenvectors (first 2)\n');
44  disp(B(:,1:2));
45  F1 = F(:,1);
46  F2 = F(:,2);
47  ex1=var(1,:)/10;
48  ex2=var(2,:)/10;
49
50  [B,sig,T,stats,FF] = factoran(R,2);
51  fprintf('Factor Analysis Beta\n');
52  disp(B);
53  fprintf('\n');
54  fprintf('variances\n');
55  disp(sig);
56
57  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
58  function data=getMarketDataViaYahoo(symbol, startdate, enddate,
        interval)
59      if(nargin() == 1)
60          startdate = posixtime(datetime('1-Jan-2018'));
61          enddate = posixtime(datetime()); % now
62          interval = '1d';
63      elseif (nargin() == 2)
64          startdate = posixtime(datetime(startdate));
65          enddate = posixtime(datetime()); % now
66          interval = '1d';
67      elseif (nargin() == 3)
68          startdate = posixtime(datetime(startdate));
69          enddate = posixtime(datetime(enddate));
70          interval = '1d';
71      elseif(nargin() == 4)
72          startdate = posixtime(datetime(startdate));
73          enddate = posixtime(datetime(enddate));
74      else
```

```matlab
75          error('At least one parameter is required. Specify ticker
                symbol.');
76          data = [];
77          return;
78      end

79

80      %% Send a request for data
81      % Construct an URL for the specific data
82      uri = matlab.net.URI([ 'https://query1.finance.yahoo.com/v7/
            finance/download/', upper(symbol)],...
83          'period1',   num2str(int64(startdate), '%.10g'),...
84          'period2',   num2str(int64(enddate), '%.10g'),...
85          'interval', interval,...
86          'events',    'history',...
87          'frequency', interval,...
88          'guccounter', 1,...
89          'includeAdjustedClose', 'true');

90

91      options = weboptions('ContentType','table', 'UserAgent', '
            Mozilla/5.0');
92      try
93          data = rmmissing(webread(uri.EncodedURI, options));
94      catch ME
95          data = [];
96          warning(['Identifier: ', ME.identifier, 'Message: ', ME.
                message])
97      end
98  end
```