MMA 867 Individual Assignment #4
Principal Components and Factor Analysis of Stock Returns

In class we did a preliminary factor analysis of returns from 41 stocks over 78 months, 2008 to 2014. We encountered a data issue called the 'Heywood condition' that led to a premature termination of the analysis. In this assignment you will carry out principal component and factor analyses, modify the factor analysis to eliminate the Heywood problem, and report on your findings.

You may use any statistical software you like, but the questions in this assignment relate to results from SAS. As discussed in class, it can be very helpful to cut and paste selected sections from computer reports into Excel where they can be analyzed using filters, conditional formatting, pivot tables and other tools.

a) Perform a principal components analysis on the correlation matrix for the stock returns. In SAS, you can perform this as a separate PCA procedure or as an option in the factor analysis procedure. Here is the code for a run of PROC PRINCOMP in base SAS:

```
Title 'Principal Components on 41 Stock Returns Correlation Matrix' ;
data pcdata ;
set Jefflib.StockReturns (drop=MonthNum) ;
        /* Identify input data set, exclude MonthNuUm for convenience to avoid including in analysis*/
ods graphics on ;
        /*needed for plots*/
run ;
proc princomp DATA=pcdata PLOTS=all ;
run ;
ods graphics off ;
quit ;
```

How many dimensions (components) appear to be sufficient to capture most of the variation in the data? Explain your answer.

b) Examine 'Component Pattern' plots for the first three components. Notice that, in a plot of components 1 and 2, AmerAir and DeltaAir, form a distinct group of the same industry type. Comment briefly on at least three other industry groupings that are visible in the plots. You may find it helpful to also examine the means, variances and correlations for companies of interest.

c) Now perform a factor analysis using the maximum likelihood method in which you limit the number of factors to the number of dimensions found in part a). You should find that there are problems with the procedure related to a 'Heywood case' or 'Heywood condition.' This is occurring because too many factors are being fitted to only 78 observations. Experiment with other runs in which you limit the number of factors.

What is the maximum number of factors that avoid the Heywood condition?

d) Now perform an orthogonal Varimax rotation using the number of factors from the previous question. Examine the factor loadings, eigenvectors and factor pattern plots and briefly interpret at least three of the factors in terms of how they appear to be loading. SAS base code for a run of PROC FACTOR in base SAS follows. This was obtained by copying and slightly modifying the code generated by SAS E.G.

```
TITLE "Factor Analysis: 41 Stocks Max Likelihood" ;
TITLE1 "Max 4 Factors, VARIMAX ORTHOG Rotation" ;
FOOTNOTE ;
FOOTNOTE1 "Generated by the SAS System
(&_SASSERVERNAME, &SYSSCPL) on %TRIM(%QSYSFUNC(DATE(),
NLDATE20.)) at %TRIM(%SYSFUNC(TIME(), TIMEAMPM12.))" ;
data pcdata ;
set Jefflib.StockReturns (drop=MonthNum) ;
        /* Identify input data set,
           Exclude MonthNum from analysis */
ods graphics on ;
        /*needed for plots*/
run ;
PROC FACTOR DATA=pcdata METHOD=ML
    VARDEF=DF
    /* Specify divisor for var and corr calculations */
    SINGULAR=1E-08
    CONVERGE=0.001
    MAXITER=30
    NFACTORS=4
    PRIORS=SMC
    ROTATE=VARIMAX
    NORM=KAISER
    PLOTS=LOADINGS
    /* PLOTS=INITLOADINGS */
    PLOTS=SCREE
    /* RESIDUALS */
    EIGENVECTORS
    SCORE
    REORDER
;
    VAR AMD AirCanada AmerAir Amex Apple BankAmer BMO Barrick
            BellAliant BerkHath Cisco DeltaAir Exxon Ford GE
            GrtWest Intel IBM IShSilver JCPenny Loblaw ManuLIfe
            Mcard MetroMRU MicSoft Nissan Nordstrum Oracle Pepsi
            PotashCrp Shell RyderSys Safeway SunLife Telus
            BankNova Coke GoldmanSac Toyota Verizon VISA
;
RUN;
TITLE; FOOTNOTE;
ods graphics off ;
quit ;
```

Submit a report of your findings. **Be brief --- limit yourself to a <u>one or two-page write-up</u> in PDF format. If necessary, selected and referenced sections of computer reports can be pasted in as exhibits on additional pages in the same PDF file.**