**Portfolio Management with Principal Component Analysis**

This file explains the calculation done with Excel in the file PCA\_HSI.xlsm.

(1) Download from Yahoo!Finance the daily closing price of the following constituents of HSI:

0001.HK, 0002.HK, 0003.HK, 0005.HK, 0006.HK, 0011.HK, 0012.HK, 0016.HK, 0017.HK, 0019.HK

Also download the daily closing price of HSI (^HSI).

The period is from 30 November 2018 to 29 November 2019. (In Yahoo!Finance you need to type the end date as 30/11/2019.) Copy the prices to columns A to L. In columns N to X, calculate the return of the stock on day from 30 November 2018 to 29 November 2019 using the formula

where is the stock price on day

(2) In AA3:AJ12, calculate the correlation matrix of the 10 stocks. The useful Excel command is CORREL with the following syntax:

CORREL(array1, array2),

where array1 and array2 are the price time series of stock 1 and stock 2, respectively.

To save effort in calculating the correlation functions repeatedly, array1 and array2 can be replaced by the INDEX command that returns the price time series. Its syntax is:

INDEX(area, row number, column number),

where:

area is the array containing all the price time series.

row number should be set to 0, which enables the command to return a column from area (if it is nonzero, it will only return a single element of that row number in the area).

column number is the column number containing the price time series of a stock. It should be read from the row or column label of the correlation matrix, so that the matrix can be filled up by dragging the cells.

(3) In AA16:AJ25 and AA29:AJ38, calculate the eigenvalues and eigenvectors of the correlation matrix, respectively. The macro of this calculation can be downloaded from Google by typing:

“Download worksheet for calculating eigenvectors and eigenvalues”.

The method of calculation is explained in the worksheet “Eigencalcs”. Note that for matrix operations in Excel, one should type Ctrl-Shift-Enter after marking the area covered by the matrix.

(4) Since the cells in the matrix area cannot be edited individually, copy the eigenvalues and eigenvectors into AA42:AJ52. Use the Paste-Value command. Note that in the eigenvalue matrix AA16:AJ25, all off-diagonal elements are zero, and so the most convenient way to copy the eigenvalues to a row is to sum the columns of the matrix.

(5) In AA56:AJ66, sort the eigenvalues and eigenvectors in descending magnitude of the eigenvalues. The “Sort left to right” option in Custom Sort should be useful.

(6) Plot the eigenvalues of the eigenmodes versus the eigenmode numbers. You may find that it is difficult to determine the number of principal portfolios to be included, probably due to the small number of stocks being studied. Hence, we will use a different criterion in the next part.

(7) In AA69:AJ69, calculate the cumulative variance. Let be the number of first few principal portfolios whose cumulative variance corresponds to the 80% cutoff. Determine .

**Cluster Visualization**

(8) Plot the 10 stocks in the space of the 2nd and 3rd principal components. Comment on any clusters that you observe, and comment on the nature of the clusters.

**Diversification Strategies**

Below we investigate 4 diversification strategies.

1. **Stock investment with equal weight**

(9) In this strategy, the capital allocated to each of the 10 stocks is the same. Considering the stock price, calculate the volume of stocks to be invested. Then calculate the value of the portfolio in column BB. The Excel command SUMPRODUCT is useful here (and also in many other calculations below).

**(B) Risk Parity (or Equal Risk Contribution)**

(10) In this strategy, the risk of stock per unit of capital is estimated by its standard deviation (note that the risk correlations of the stocks are neglected). The capital allocated to each of the 10 stocks is such that the risk of each stock is the same. Hence the capital allocated to each stock is proportional to Calculate the volume of stocks to be invested. Then calculate the value of the portfolio in column BA. The Excel command STDEV is useful for calculating the standard deviation.

**(C) Equal Weight Portfolio (or 1/N Strategy)**

(11) In this strategy, the first principal portfolios are selected, and equal weight is allocated to each of them. The first step is to determine the signs of the eigenvectors to be adopted. We will consider a portfolio with equal capital allocated to the 10 stocks, and require the projection of this portfolio to the principal eigenvectors to be positive. Calculate the projections.

(12) Calculate the sign-corrected eigenvectors. Then calculate the total weight of each stock contributed from the principal portfolios, and the volume of stocks to be invested.

(13) Which stocks in this strategy are in short positions? Calculate the value of the portfolio in column BB. Note that the initial value is no longer equal to 1 due to the short-positioned stocks. You are required to normalize the initial value to 1.

**(D) Diversified Risk Parity**

(14) In this strategy, the capital allocated to each of the principal portfolios are such that the risk of each portfolio is the same. Since the eigenvalue of each portfolio is the variance , the capital allocated to each portfolio is proportional to Calculate the volume of stocks to be acquired. Which stocks in this strategy are in short positions? Then calculate the value of the strategy in column BC. You are required to normalize the initial value to 1.

**Comparison of the Strategies**

(15) Plot the daily values of the portfolios of the 4 strategies. Comment on any observations you make about the performance of the strategies.

(16) The ability of the 4 strategies to reduce risks is compared by calculating the following parameters at the top of columns BB to BE:

Gain (the final value divided by the initial value)

Standard deviation

Minimum value (divided by the initial value)

Comment on any observations you make about the performance of the strategies.

Remark: In practice, the real test of the performance of the strategies should be done with a different data set (for example, data collected after November 2021).

(17) The standard deviation is not informative of the risk when the price has a trend. Another common risk measure is the beta coefficient, or systematic risk, defined as

Calculate of the 4 strategies from: the covariance of the daily returns of the strategies and the daily returns of the market (S&P 500) averaged over the one-year period, and the variance of the daily returns of the market, also averaged over the one-year period. The Excel commands COVARIANCE.P and VAR are useful.

Remark: Since S&P 500 indices exceed 1,000, the csv file contains 1000 separators (,). This misleads pd.read\_csv to recognize the numbers as strings instead of floats. You may need to remove the 1000 separators to convert the strings to floats.

Comment on any observations you make about .

**Back testing of the strategies**

(18) The performance of the strategies should be back tested by an independent set of data. Hence, download the daily adjusted closing price of the above 10 stocks and Hang Seng index from 30 November 2019 to 29 November 2020. Using the 4 strategies determined from the previous years to calculate and plot the daily values of the portfolios (the variance, eigenvalues and eigenvectors should be determined from the data of the previous year). Comment on any observations you make about the performance of the strategies.

For your further insights and interest, the names of the stocks are listed below:

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| --- | --- | --- |
| HK0001 | CK Hutchison Holdings Limited | 長和 |
| HK0002 | CLP Holdings Limited | 中電控股 |
| HK0003 | The Hong Kong and China Gas Company Limited | 香港中華煤氣 |
| HK0005 | HSBC Holdings plc | 滙豐控股 |
| HK0006 | Power Assets Holdings Limited | 電能實業 |
| HK0011 | Hang Seng Bank Limited | 恒生銀行 |
| HK0012 | Henderson Land Development Company Limited | 恒基地產 |
| HK0016 | Sun Hung Kai Properties Ltd | 新鴻基地產 |
| HK0017 | New World Development Company Limited | 新世界發展 |
| HK0019 | Swire Pacific Limited | 太古股份公司'A' |