PCA on different asset classes

Are there specific topics driving asset prices?

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High Level Roadmap

The research problem can be divided into the following **three steps:**
(1) Data Preparation & Brainstorming
(2) Statistical analysis & macro-economic interpretation
(3) Visualization & Next Steps

High Level Roadmap (Part 1)

I. **Data Preparation & Brainstorming**

1. **Data Preparation**

a. Define theoretically suitable Data

Economic and Capital Markets related time series across all asset classes, especially Factor-based Time-Series

b. Identify Data Sources

Bloomberg, Yahoo Finance, Kenneth R. French Library on Stock Return Factors, etc.

c. Data Preparation & Quality Assurance

2. **Statistical Methods Brainstorming**

Pro & Contra of e.g. Hidden Markov-Chains, Principal Component Analysis, Bayesian Nets, Neural Nets, etc.

Devise Long-List and most promising short list of suitable methods

High Level Roadmap (Part 2)

II. **Statistical Analysis & Macro-economic Interpretation**

a. Application of short-listed models to data, identify issues & solutions and come up with macro-economic interpretation of results

b. Time-Series Regression of Principal Components onto macro-economic/ Factor-Portfolios

III. **Visualization of Theme Evolution through time**

In progress

Outcome

- Fully integrated R Code (Data Input, Data Quality Checks, Statistical Analysis, Output)
- Sensitivity Assessment: Which asset classes are more heavily influenced by the identified topics, which are defensive safe havens?
- Interactive visualization dashboard / web application (e.g. R Shiny, Power BI) of "Driving Topics" through time (incl. conditional correlations)

1. Data Preparation

a) Define Theoretically Suitable Data

Chosen time series across multiple asset classes: commodity prices, bond indices, spread indices, equity indices, FX rates, as well as macro data such as CPI rates, unemployment rates, real GDP (%)

Time horizon: last 20 years

Frequency: daily

b) Identify Data Sources

Bloomberg and Kenneth R. French Library

c) Data Preparation and Quality Assurance

2. Statistical Methods Brainstorming

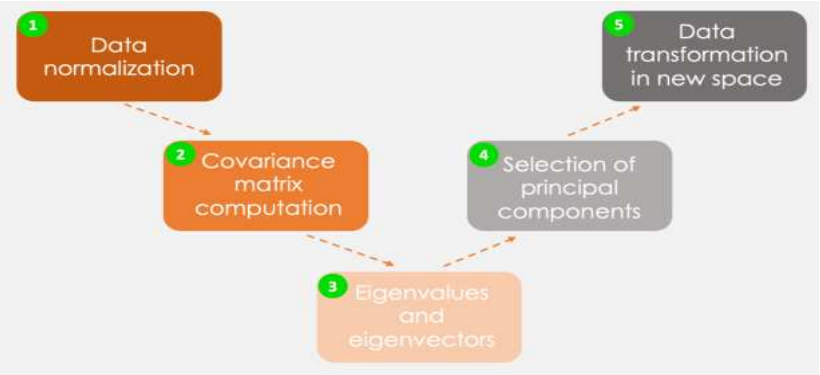
- Principal Component Analysis as a chosen statistical method for analysing high-dimensional data and capturing the most important information from it (principal components/ potential ”drivers” of asset prices)

- This is done by transforming the original data into a lower-dimensional space while collating highly correlated variables together

- Main advantages: Dimensionality Reduction, Multicollinearity Mitigation, Pattern Recognition

- Possible obstacles to be addressed: Interpretability, Sensitivity to Outliers

PCA in 5 Steps – we use a package – delete the slide?



- **Step 1 - Data normalization**
  - Created log returns and normalized them
  - Attributes them on same level, no bias
- **Step 2 - Covariance matrix**
  - symmetric matrix, each element (i, j)
  - corr. to the covariance between variables i/j.
- **Step 3 - Eigenvectors and eigenvalues**
  - **Eigenvector** represents direction. An **eigenvalue** is a number representing the amount of variance present in the data for a given direction. Each eigenvector has its corresponding eigenvalue.
- **Step 4 - Selection of principal components**
  - Data variables determine the pairs of eigenvectors and eigenvalues. In our data are 76 columns (excluding macro data), hence 76*5721 pairs. Not all the pairs are relevant. So, the eigenvector with the highest eigenvalue corresponds to the first principal component.
- **Step 5 - Data transformation in new dimensional space**
  - re-orienting the original data onto a new subspace defined by the principal components This reorientation is done by multiplying the original data by the previously computed eigenvectors.

Descriptive Data – Correlation Matrix?

- If we manage to make it look readable
- Or not
- Then delete the slide

Applying PCA – update with the new result

```
> summary(data.pca)
Importance of components:
                          Comp.1     Comp.2      Comp.3      Comp.4      Comp.5
Standard deviation     1.3718675 0.6067002 0.084690125 0.074143005 0.054761363
Proportion of Variance 0.8304466 0.1624186 0.003164849 0.002425648 0.001323232
Cumulative Proportion  0.8304466 0.9928651 0.996029989 0.998455637 0.999778868
                           Comp.6       Comp.7       Comp.8       Comp.9
Standard deviation     0.0179960562 1.310913e-02 2.331889e-03 1.220501e-08
Proportion of Variance 0.0001429032 7.582895e-05 2.399403e-06 6.573004e-17
Cumulative Proportion  0.9999217716 9.999976e-01 1.000000e+00 1.000000e+00
```

- **Nine** principal components have been generated (Comp.1 to Comp.9)
- In the **Cumulative Proportion** section, the first principal component explains almost 83% of the total variance. This implies that almost two-thirds of the data in the set of 9 variables can be represented by just the first principal component. The second one explains 16%

Loading Matrix for PC 1 & 2 – update or delete

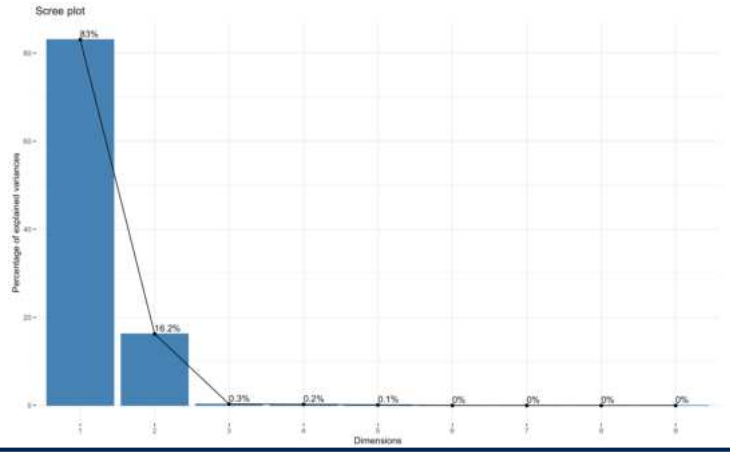
It's great to have the first two components, but what do they really mean?

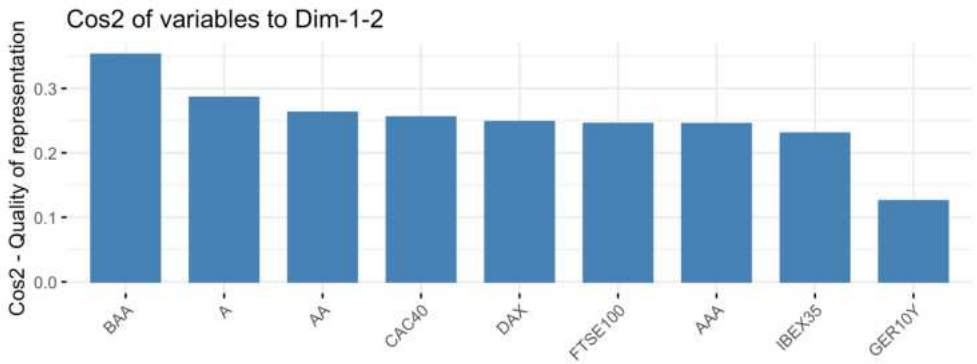
	Comp.1	Comp.2
A	0.36979515	0.2779464
AA	0.34977309	0.2964470
AAA	0.33501760	0.3027773
BAA	0.42526358	0.1820070
CAC40	-0.34155025	0.3115903
DAX	-0.34296810	0.2692544
FTSE100	-0.32849570	0.3383866
GER10Y	-0.04060333	-0.5763094
IBEX35	-0.32246346	0.3063331

- The loading matrix shows that the first principal component has high positive values for Fixed Income prices.

Visualization of the principal components

- **Scree Plot**
  - This plot shows the eigenvalues in a downward curve, from highest to lowest. The first two components can be considered to be the most significant since they contain almost 99% of the total information of the data.





- **Contribution of each variable**
  - Determines how much each variable is represented in a given component. Such a quality of representation is called the Cos2 and corresponds to the square cosine
  - A high value, on the other hand, means a good representation of the variable on that component.

Further Steps…

a) Macro-economic interpretation of the results
b) Time-series regression of PCs onto macroeconomic data/factor portfolios