

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)

Financial Data for PCA

| COMMODITIES | | BOND INDICES | | EQUITY INDICES | | CREDIT INDICES | | GVT BOND SPREADS | |
|-------------|----------------------|-----------------|-----------------|----------------|-------------------------------------|----------------|-------------------|------------------|----------------|
| Ticker | Description | Ticker | Description | Ticker | Description | Ticker | Description | Ticker | Description |
| HG1 Comdty | Copper Futures | GOBR10 Index | Germany GVT 10Y | ASE Index | Athens Stock Exchange General Index | BAMLC0R1CAAAY | ICE US High Yield | US2Y2Y10 Index | US 2Y/10Y |
| LA1 Comdty | Aluminium Futures | USGG10YR Index | US GVT 10Y | BEL20 Index | Euronext Brussels Index | | | JPYC1030 Index | Japan 10Y/30Y |
| LL1 Comdty | Lumber Futures | USGG2YR Index | US GVT 2Y | BVLX Index | PSI General Index Portugal | | | USYC1030 Index | US 10Y/30Y |
| LN1 Comdty | Lean Hog Futures | GBTP-GR10 Index | Italy GVT 10Y | NIKJ Index | Nikkei 225, Japan | | | FRYC1030 Index | France 10Y/30Y |
| LT2 Comdty | Gasoline Futures | IO0163US Index | | KOSPI Index | Korea Composite Stock Price Index | | | ATYC2YQ0 Index | Austria 2Y/10Y |
| KAG Curncy | Silver Spot Price | | | HSI Index | Hang Seng Index, Hong Kong | | | | |
| KAU Curncy | Gold Spot Price | | | | | | | | |
| XP D Curncy | Palladium Spot Price | | | | | | | | |
| XPT Curncy | Platinum Spot Price | | | | | | | | |
| NG1 Comdty | Natural Gas Futures | | | | | | | | |
| W 1 Comdty | Wheat Futures | | | | | | | | |
| SBM1 Comdty | Soybean Meal Futures | | | | | | | | |
| RR1 Comdty | Rough Rice Futures | | | | | | | | |
| QW1 Comdty | Sugar Futures | | | | | | | | |
| O 1 Comdty | Oran Futures | | | | | | | | |
| LH1 Comdty | Live Hog Futures | | | | | | | | |
| LC1 Comdty | Live Cattle Futures | | | | | | | | |
| KC1 Comdty | Coffee C Futures | | | | | | | | |
| OJ1 Comdty | Orange Juice Futures | | | | | | | | |
| CT1 Comdty | Cotton No. 2 Futures | | | | | | | | |
| CC1 Comdty | Cocoa Futures | | | | | | | | |
| CL1 Comdty | Corn Futures | | | | | | | | |

No changes in data set since last meeting

Macroeconomic Data for Regression

| CPI Index (monthly) | | UNEMPLOYMENT RATE (quarterly) | | REAL GDP % (yearly) | |
|---------------------|---------------|-------------------------------|------------------|---------------------|-----------|
| Ticker | Country | Ticker | Country | Ticker | Country |
| CPI YOY Index | US | EHUPCN Index | China | EHGDDEY Index | Germany |
| CNCPIYOY Index | China | EHUPAT Index | Austria | EHGDAUY Index | Australia |
| JNCPIYOY Index | Japan | EHUPIT Index | Italy | | |
| BZPIIPCY Index | Brazil | EHUPHK Index | Hong Kong | | |
| HKCPIY Index | Hong Kong | EHUPBR Index | Brazil | | |
| AUCPIYOY Index | Australia | EHUPSE Index | Sweden | | |
| EHPILAT Index | Latin America | EHUPCA Index | Canada | | |
| EHPIASP Index | Asian Pacific | EHUPASAY Index | South East Asian | | |
| SACPIYOY Index | South Africa | | | | |
| RUCPIYOY Index | Russia | | | | |

| CURRENCY (daily) | | Currency Indices | | |
|------------------|-------------|------------------|-----------------------------|--|
| Ticker | Factors | Ticker | Index | Measures |
| EURJPY Curncy | FF3 Mkt.Rf | DXY | USD Currency index | USD against EUR, JPY, GBP, CAD, SEK, CHF |
| EURCHF Curncy | FF3 SMB | EXY | EURO Currency index | EUR against USD, GBP, JPY, CHF |
| EURGBP Curncy | FF3 HML | MXEF0CX0 Index | MSCI EM Currency Index | 25 EM currencies against USD |
| EURSEK Curncy | FF5 Mkt. Rf | ASIADOLR | Bloomberg Asia Dollar Index | 9 Asian currencies against USD |
| EURCAD Curncy | FF5 SMB | | | |
| EURCZK Curncy | FF5 HML | | | |
| EURKRW Curncy | FF5 RMW | | | |
| | FF5 CMA | | | |

Added since last meeting

Use of **Kaiser-Meyer-Olkin (KMO)** for optimal window size estimation

➤ **Single Assets**

- For Threshold **0.9** -> Optimal window size: **423 days**
- For Threshold **0.85** -> Optimal window size: **80 days**

➤ **Avarage of Assets per Asset Class**

- For Threshold **0.7** -> Optimal window size: **770 days**

PCA Results – Rolling event window

- Variance explained by each Principal Component

- **Window size 423**

```
> print(results_table)
Window    PC1      PC2      PC3      PC4      PC5
1      423 72.5698 5.624469 4.292571 3.197415 2.235493
```

- **Window size 80**

```
> print(results_table)
Window    PC1      PC2      PC3      PC4      PC5
1       80 72.3648 4.8534 4.689563 2.71653 2.63407
```

Regression results (univariate) PCA 1

```
> results_table
```

| | Variable | Coefficients | Std.Error | t.Value | P.Value |
|----------------|----------------|---------------|-------------|-------------|--------------|
| CNCPIYOY.Index | CNCPIYOY.Index | 0.0200773079 | 0.001188966 | 16.8863573 | 6.027199e-62 |
| BZPIIPCY.Index | BZPIIPCY.Index | -0.0059108268 | 0.001207282 | -4.8959786 | 1.014937e-06 |
| HKCPIY.Index | HKCPIY.Index | 0.0093817330 | 0.001201090 | 7.8110141 | 7.116596e-15 |
| AUCPIYOY.Index | AUCPIYOY.Index | -0.0046284282 | 0.001249300 | -3.7048177 | 2.142658e-04 |
| EHPILAT.Index | EHPILAT.Index | -0.0113242864 | 0.001204368 | -9.4026813 | 8.505398e-21 |
| EHPIASP.Index | EHPIASP.Index | 0.0157129036 | 0.001186272 | 13.2456203 | 2.905203e-39 |
| SACPIYOY.Index | SACPIYOY.Index | 0.0106400311 | 0.001198276 | 8.8794466 | 9.775491e-19 |
| RUCPIYOY.Index | RUCPIYOY.Index | -0.0016497962 | 0.001211429 | -1.3618599 | 1.733152e-01 |
| EHUPCN.Index | EHUPCN.Index | -0.0026829144 | 0.001208723 | -2.2196266 | 2.649736e-02 |
| EHUPIT.Index | EHUPIT.Index | -0.0155458034 | 0.001195672 | -13.0017253 | 6.399415e-38 |
| EHUPHK.Index | EHUPHK.Index | 0.0014226021 | 0.001219623 | 1.1664275 | 2.435079e-01 |
| EHUPBR.Index | EHUPBR.Index | 0.0015277210 | 0.001209412 | 1.2631934 | 2.065898e-01 |
| EHUPSE.Index | EHUPSE.Index | -0.0007851598 | 0.001210801 | -0.6484630 | 5.167210e-01 |
| EHGDSE.Index | EHGDSE.Index | -0.0049833913 | 0.001214523 | -4.1031661 | 4.152670e-05 |
| EHGDMXY.Index | EHGDMXY.Index | -0.0077672749 | 0.001204126 | -6.4505524 | 1.240676e-10 |
| EURJPY.Curncy | EURJPY.Curncy | 0.0067846000 | 0.001242144 | 5.4620086 | 4.980165e-08 |
| EURCHF.Curncy | EURCHF.Curncy | 0.0165865361 | 0.001201444 | 13.8054956 | 1.971403e-42 |
| EURSEK.Curncy | EURSEK.Curncy | 0.0010438173 | 0.001280105 | 0.8154157 | 4.148807e-01 |
| EURCAD.Curncy | EURCAD.Curncy | 0.0048038179 | 0.001206467 | 3.9817227 | 6.957508e-05 |
| EURCZK.Curncy | EURCZK.Curncy | -0.0022951846 | 0.001226693 | -1.8710343 | 6.140984e-02 |
| EURKRW.Curncy | EURKRW.Curncy | 0.0078501312 | 0.001202300 | 6.5292607 | 7.396569e-11 |

CPI

Unemployment

GDP

Currency

Regression results (univariate) PCA 1

```
> results_table2
```

| | Variable | Coefficients | Std.Error | t.Value | P.Value |
|-----------------|-----------------|---------------|--------------|------------|--------------|
| CNCPIYOY.Index | CNCPIYOY.Index | -0.0012664295 | 0.0007292742 | -1.7365615 | 8.253796e-02 |
| BZPIIPCY.Index | BZPIIPCY.Index | -0.0017521791 | 0.0007183639 | -2.4391247 | 1.476404e-02 |
| HKCPIY.Index | HKCPIY.Index | -0.0030890071 | 0.0007167325 | -4.3098467 | 1.671107e-05 |
| AUCPIYOY.Index | AUCPIYOY.Index | 0.0010132167 | 0.0007428245 | 1.3640056 | 1.726389e-01 |
| EHPILAT.Index | EHPILAT.Index | -0.0019823742 | 0.0007219416 | -2.7458929 | 6.060358e-03 |
| EHPIASP.Index | EHPIASP.Index | -0.0058487119 | 0.0007132323 | -8.2002907 | 3.155035e-16 |
| SACPIYOY.Index | SACPIYOY.Index | -0.0015038479 | 0.0007177571 | -2.0952046 | 3.621257e-02 |
| RUCPIYOY.Index | RUCPIYOY.Index | 0.0017898786 | 0.0007189196 | 2.4896783 | 1.282429e-02 |
| EHUPCN.Index | EHUPCN.Index | 0.0034721478 | 0.0007161035 | 4.8486672 | 1.287906e-06 |
| EHUPIT.Index | EHUPIT.Index | -0.0019052829 | 0.0007234912 | -2.6334568 | 8.483056e-03 |
| EHUPHK.Index | EHUPHK.Index | 0.0025192981 | 0.0007232297 | 3.4833998 | 5.001438e-04 |
| EHUPBR.Index | EHUPBR.Index | 0.0008563777 | 0.0007181085 | 1.1925464 | 2.331145e-01 |
| EHUPSE.Index | EHUPSE.Index | -0.0023075535 | 0.0007180720 | -3.2135404 | 1.321012e-03 |
| EHGDSE.Index | EHGDSE.Index | 0.0030742996 | 0.0007210138 | 4.2638571 | 2.053453e-05 |
| EHGDMXY.Index | EHGDMXY.Index | 0.0023967606 | 0.0007175366 | 3.3402627 | 8.443000e-04 |
| EURJPY.Currency | EURJPY.Currency | 0.0006748035 | 0.0007400712 | 0.9118088 | 3.619217e-01 |
| EURCHF.Currency | EURCHF.Currency | 0.0019650003 | 0.0007287461 | 2.6964129 | 7.037046e-03 |
| EURSEK.Currency | EURSEK.Currency | -0.0024555951 | 0.0007591826 | -3.2345249 | 1.227895e-03 |
| EURCAD.Currency | EURCAD.Currency | -0.0022269048 | 0.0007168733 | -3.1064134 | 1.906360e-03 |
| EURCZK.Currency | EURCZK.Currency | 0.0013909968 | 0.0007283418 | 1.9098133 | 5.622534e-02 |
| EURKRW.Currency | EURKRW.Currency | -0.0034913333 | 0.0007154604 | -4.8798416 | 1.101098e-06 |

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Regression results (multivariate) PCA 1

```

Residuals:
    Min       1Q   Median       3Q      Max
-0.224403 -0.042143 -0.002298  0.040684  0.217935

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    0.476843   0.001031  462.512 < 2e-16 ***
CNCPIYOY.Index -0.009476   0.002536  -3.737 0.000189 ***
BZPIIPCY.Index  0.035005   0.002620  13.361 < 2e-16 ***
HKCPIY.Index   0.015727   0.001867   8.422 < 2e-16 ***
AUCPIYOY.Index -0.064047   0.003334 -19.208 < 2e-16 ***
EHPILAT.Index  0.010021   0.002644   3.790 0.000153 ***
EHPIASP.Index  0.062321   0.002661  23.418 < 2e-16 ***
SACPIYOY.Index -0.019273   0.002978  -6.471 1.09e-10 ***
RUCPIYOY.Index -0.019147   0.002013  -9.511 < 2e-16 ***
EHUPCN.Index   0.027583   0.002241  12.311 < 2e-16 ***
EHUPIT.Index   -0.025807   0.003545  -7.281 3.94e-13 ***
EHUPHK.Index   -0.037810   0.002857 -13.236 < 2e-16 ***
EHUPBR.Index   0.025086   0.003184   7.878 4.23e-15 ***
EHUPSE.Index   0.017859   0.001849   9.661 < 2e-16 ***
EHGDSE.Index   -0.017746   0.002242  -7.916 3.13e-15 ***
EHGDMXY.Index  -0.020645   0.001658 -12.451 < 2e-16 ***
EURJPY.Currency 0.034063   0.002335  14.586 < 2e-16 ***
EURCHF.Currency 0.034964   0.004575   7.643 2.62e-14 ***
EURSEK.Currency 0.034870   0.003114  11.198 < 2e-16 ***
EURCAD.Currency -0.017703   0.002114  -8.375 < 2e-16 ***
EURCZK.Currency -0.010073   0.001933  -5.210 1.97e-07 ***
EURKRW.Currency -0.012795   0.003044  -4.204 2.68e-05 ***

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.06572 on 4178 degrees of freedom
Multiple R-squared:  0.3116,    Adjusted R-squared:  0.3081
F-statistic: 90.05 on 21 and 4178 DF, p-value: < 2.2e-16
    
```

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Regression results (multivariate) PCA 2

Residuals:

| Min | 1Q | Median | 3Q | Max |
|-----------|-----------|-----------|----------|----------|
| -0.113886 | -0.031185 | -0.003424 | 0.030411 | 0.160416 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) | |
|----------------|------------|------------|---------|----------|-----|
| (Intercept) | 0.1936460 | 0.0006847 | 282.836 | < 2e-16 | *** |
| CNCPIYOY.Index | 0.0043990 | 0.0012010 | 3.663 | 0.000253 | *** |
| BZPIIPCY.Index | -0.0120739 | 0.0011946 | -10.107 | < 2e-16 | *** |
| AUCPIYOY.Index | 0.0164701 | 0.0013498 | 12.201 | < 2e-16 | *** |
| EHPIASP.Index | -0.0228207 | 0.0014429 | -15.816 | < 2e-16 | *** |
| SACPIYOY.Index | 0.0025350 | 0.0012717 | 1.993 | 0.046287 | * |
| RUCPIYOY.Index | 0.0069501 | 0.0011757 | 5.912 | 3.66e-09 | *** |
| EHUPHK.Index | 0.0060243 | 0.0010773 | 5.592 | 2.39e-08 | *** |
| EHUPSE.Index | -0.0054053 | 0.0010913 | -4.953 | 7.59e-07 | *** |
| EHGDSE.Index | 0.0054648 | 0.0012087 | 4.521 | 6.32e-06 | *** |
| EHGDMXY.Index | 0.0051259 | 0.0009747 | 5.259 | 1.52e-07 | *** |
| EURJPY.Curncy | -0.0116941 | 0.0011284 | -10.363 | < 2e-16 | *** |
| EURGBP.Curncy | -0.0034089 | 0.0011315 | -3.013 | 0.002604 | ** |
| EURSEK.Curncy | -0.0062473 | 0.0011328 | -5.515 | 3.70e-08 | *** |

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Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.04418 on 4186 degrees of freedom
Multiple R-squared: 0.1158, Adjusted R-squared: 0.1131
F-statistic: 42.18 on 13 and 4186 DF, p-value: < 2.2e-16

Regression results (multivariate) – Outliers PC1

Residuals:

| Min | 1Q | Median | 3Q | Max |
|---------|---------|--------|--------|--------|
| -1.0025 | -0.4187 | 0.1636 | 0.2762 | 1.0047 |

Coefficients:

| | Estimate | Std. Error | t value | Pr(> t) |
|----------------|-----------|------------|---------|--------------|
| (Intercept) | 0.717592 | 0.006614 | 108.494 | < 2e-16 *** |
| CPI.YOY.Index | 0.083998 | 0.020788 | 4.040 | 5.44e-05 *** |
| CNCPIYOY.Index | -0.088717 | 0.017954 | -4.941 | 8.07e-07 *** |
| JNCPIYOY.Index | -0.062213 | 0.018474 | -3.368 | 0.000765 *** |
| BZPIIPCY.Index | -0.035568 | 0.019229 | -1.849 | 0.064489 . |
| HKCPIY.Index | 0.010992 | 0.012799 | 0.859 | 0.390485 |
| AUCPIYOY.Index | -0.179394 | 0.028094 | -6.385 | 1.90e-10 *** |
| EHPILAT.Index | 0.013203 | 0.017394 | 0.759 | 0.447884 |
| EHPIASP.Index | -0.052742 | 0.022583 | -2.336 | 0.019563 * |
| SACPIYOY.Index | 0.113174 | 0.022794 | 4.965 | 7.14e-07 *** |
| RUCPIYOY.Index | -0.023788 | 0.014028 | -1.695 | 0.090128 |
| EHUPCN.Index | 0.018613 | 0.017623 | 1.056 | 0.290965 |
| EHUPAT.Index | -0.086207 | 0.023205 | -3.715 | 0.000206 *** |
| EHUPIT.Index | -0.110918 | 0.036780 | -3.016 | 0.002579 ** |
| EHUPHK.Index | -0.055436 | 0.021969 | -2.523 | 0.011662 * |
| EHUPBR.Index | -0.143754 | 0.025474 | -5.643 | 1.78e-08 *** |
| EHUPSE.Index | 0.108685 | 0.013677 | 7.946 | 2.45e-15 *** |
| EHUPCA.Index | -0.028859 | 0.024868 | -1.160 | 0.245916 |
| EHUPASAY.Index | 0.023706 | 0.025017 | 0.948 | 0.343395 |
| EHGDSE.Index | 0.056398 | 0.016727 | 3.372 | 0.000754 *** |
| EHGDMXY.Index | 0.027492 | 0.014879 | 1.848 | 0.064714 . |
| EURJPY.Curncy | 0.043476 | 0.017235 | 2.523 | 0.011662 * |
| EURCHF.Curncy | -0.135076 | 0.032179 | -4.198 | 2.75e-05 *** |
| EURGBP.Curncy | 0.113833 | 0.018794 | 6.057 | 1.51e-09 *** |
| EURSEK.Curncy | -0.005054 | 0.025216 | -0.200 | 0.841147 |
| EURCAD.Curncy | 0.129847 | 0.016125 | 8.053 | 1.05e-15 *** |
| EURCZK.Curncy | 0.073712 | 0.013579 | 5.428 | 6.01e-08 *** |
| EURKRW.Curncy | -0.165934 | 0.024889 | -6.667 | 2.96e-11 *** |
| FF3_Mkt.RF | 0.003906 | 0.007298 | 0.535 | 0.592471 |
| FF3_HML | 0.002017 | 0.007922 | 0.255 | 0.799056 |
| FF5_SMB | -0.003493 | 0.007017 | -0.498 | 0.618658 |
| FF5_RMI | -0.001389 | 0.007100 | -0.196 | 0.844898 |
| FF5_CMA | -0.001053 | 0.007979 | -0.132 | 0.895047 |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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Fama French Factors

Residual standard error: 0.4288 on 4167 degrees of freedom
Multiple R-squared: 0.1376, Adjusted R-squared: 0.131
F-statistic: 20.77 on 32 and 4167 DF, p-value: < 2.2e-16

Comparison of variables (Outliers PC1)

- Variables that became **significant** compared to multivariate regression (PC1):
 - US CPI
 - Japan CPI
 - Unemployment rate Austria
 - EUR/GBP Currency

- Variables that became **insignificant** compared to multivariate regression (PC1):
 - Brazil CPI
 - Latin America CPI
 - Hong Kong CPI
 - Russia CPI
 - unemployment rate China
 - EUR-SEK Currency

Next Steps

- Economic Interpretation of the Results