

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								
XPDCurncy	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								
JO1 Comdty	Orange Juice Futures								
CT1 Comdty	Cotton No. 2 Futures								
CC1 Comdty	Cocoa Futures								
CL1 Comdty	Corn Futures								

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		
BZPIPCY 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)	FAMA French	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			

Regression results (multivariate) PCA 1 Whole Data Set 2006-2023

```
lm(formula = PC1 ~ ., data = merged_df1)

Residuals:
    Min       1Q   Median       3Q      Max
-0.228926 -0.041365 -0.002117  0.039983  0.212111

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.4769043   0.0018312  462.471 < 2e-16 ***
CNCP1Y0Y.Index -0.0114504   0.0027635   -4.143 3.49e-05 ***
JNCP1Y0Y.Index -0.0083120   0.0028852   -2.881 0.003985 **
BZPIPCY.Index  0.0314916   0.0028323  11.119 < 2e-16 ***
HKCPIY.Index  0.0155738   0.0020649   7.542 5.64e-14 ***
AUCPIY0Y.Index -0.0706534   0.0045886  -15.398 < 2e-16 ***
EHPILAT.Index  0.0107720   0.0027190   3.962 7.57e-05 ***
EHPIASP.Index  0.0684468   0.0035292  19.394 < 2e-16 ***
SACPIY0Y.Index -0.0190010   0.0036271   -5.242 1.67e-07 ***
RUCPIY0Y.Index -0.0183799   0.0022435   -8.193 3.37e-16 ***
SPICPY0Y.Index  0.0106026   0.0032698   3.243 0.001194 **

EHUPCN.Index  0.0299034   0.0027663  10.810 < 2e-16 ***
EHUPAT.Index  0.0077510   0.0037872   2.047 0.040754 *
EHUPIT.Index  -0.0315029   0.0057505   -5.478 4.55e-08 ***
EHUPHK.Index  -0.0424801   0.0033268  -12.769 < 2e-16 ***
EHUPBR.Index  0.0163739   0.0041010   3.993 6.65e-05 ***
EHUPSE.Index  0.0212446   0.0021961   9.674 < 2e-16 ***
EHUPCA.Index  -0.0070784   0.0039009   -1.815 0.069661 .
EHUPASAY.Index -0.0014014   0.0039516   -0.355 0.722874

EHGDSE.Index  -0.0187157   0.0025991   -7.201 7.06e-13 ***
EHGDMXY.Index -0.0238192   0.0024082   -9.891 < 2e-16 ***

EURJPY.Currency  0.0332964   0.0028827  11.550 < 2e-16 ***
EURCHF.Currency  0.0338057   0.0050668   6.672 2.85e-11 ***
EURGBP.Currency -0.0002658   0.0031046   -0.086 0.931772
EURSEK.Currency  0.0378383   0.0040091   9.299 < 2e-16 ***
EURCAD.Currency -0.0132373   0.0026076   -5.076 4.01e-07 ***
EURCZK.Currency -0.0053755   0.0025245   -2.129 0.033287 *
EURKRW.Currency -0.0144196   0.0038301   -3.765 0.000169 ***

FF3_Mkt.RF -0.0007074   0.0011390   -0.621 0.534605
FF3_HML  0.0014071   0.0012354   1.139 0.254788
FF5_SMB -0.0004510   0.0010941   -0.412 0.680207
FF5_RMW  0.0003699   0.0011070   0.334 0.738278
FF5_CMA -0.0007475   0.0012439   -0.601 0.547904

MXEF0CX0.Index  0.0053032   0.0031133   1.703 0.088565 .

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

Unemployment

GDP

Currency Pairs

Fama French Factors

Currency index

Interpretation Regression Results PC1

Whole Data Set 2006-2023

- **CPI Indexes:** Negative coefficients for CPI indexes from China (CNCPIYOY Index), Japan (JNCPIYOY Index) and others suggest that higher inflation in these countries is associated with lower values on PC1, which could be linked to concerns about the impact of inflation on asset prices in these regions. Conversely, the positive coefficients for CPI indexes from Brazil (BZPIPCY Index), Hong Kong (HKCPIY Index), and other regions imply that inflation there is associated with higher PC1 values.
- **Unemployment Rate Indexes:** The negative coefficients for unemployment rates in Italy (EHUPIT Index) and Hong Kong (EHUPHK Index) indicate that higher unemployment rates in these countries may be negatively impacting financial asset prices, reflecting economic distress.
- **Currency Indices:** Positive coefficients for currency pairs suggest that stronger currencies (e.g., EURJPY, EURCHF, EUREK) relative to Euro are correlated with higher PC1 values. This could mean that currency strength is a positive driver of asset prices.
- **Fama French Factors:** most of the Fama French factors, including market risk (FF3 Mkt.Rf), size (FF3 SMB), and value (FF3 HML) have non-significant p-values, indicating that these factors may not be strong predictors of financial asset prices in the dataset.
- **MSCI EM Index:** The positive coefficient for the MSCI Emerging Markets Currency Index (MXEFOCX0 Index) suggests that the strength of emerging market currencies is positively associated with the financial asset prices represented by PC1, however the relationship is not as strong and there is no significance to it.

Regression results (multivariate) PCA 1 2006-2009

	Min	1Q	Median	3Q	Max
	-0.168243	-0.022846	0.003627	0.029019	0.094481
Coefficients:					
	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	-0.073442	0.796765	-0.092	0.926584	
CNCPIYOY.Index	-0.042600	0.007683	-5.545	4.09e-08	***
JNCPIYOY.Index	-0.070236	0.019960	-3.519	0.000460	***
BZPIIPCY.Index	0.343746	0.032117	10.703	< 2e-16	***
HKCPIY.Index	0.006245	0.005430	1.150	0.250469	
AUCPIYOY.Index	-0.040563	0.046283	-0.876	0.381085	
EHPILAT.Index	-0.499759	0.285269	-1.752	0.080207	.
EHPIASP.Index	-0.144131	0.106985	-1.347	0.178325	
SACPIYOY.Index	-0.068462	0.011953	-5.727	1.48e-08	***
RUCPIYOY.Index	0.115377	0.020096	5.521	4.65e-08	***
SPIPCYOY.Index	0.102008	0.021854	4.668	3.61e-06	***
EHUPCN.Index	-0.386620	0.102785	-3.761	0.000182	***
EHUPAT.Index	-0.483104	0.033500	-14.421	< 2e-16	***
EHUPIT.Index	-0.040644	0.280833	-0.145	0.884966	
EHUPHK.Index	0.298860	0.353505	0.845	0.398149	
EHUPBR.Index	-0.502497	0.171775	-2.925	0.003546	**
EHUPSE.Index	0.159348	0.061632	2.585	0.009915	**
EHUPCA.Index	-0.398753	0.240068	-1.661	0.097135	.
EHUPASAY.Index	0.362835	0.049654	7.307	7.06e-13	***
EHGDSE.Index	-0.074270	0.085971	-0.864	0.387926	
EHGDMXY.Index	0.136249	0.069707	1.955	0.051006	.
EURJPY.Currency	-0.019417	0.011732	-1.655	0.098342	.
EURCHF.Currency	-0.117287	0.025889	-4.530	6.86e-06	***
EURGBP.Currency	-0.052000	0.007153	-7.270	9.13e-13	***
EURSEK.Currency	0.012231	0.008609	1.411	0.158687	
EURCAD.Currency	0.002167	0.006149	0.352	0.724641	
EURCZK.Currency	0.030101	0.005948	5.061	5.27e-07	***
EURKRW.Currency	0.036533	0.007161	5.102	4.28e-07	***
FF3_Mkt.RF	0.001028	0.001382	0.744	0.457163	
FF3_HML	0.002605	0.001798	1.449	0.147762	
FF5_SMB	-0.001209	0.001430	-0.845	0.398125	
FF5_RMW	0.001320	0.002139	0.617	0.537455	
FF5_CMA	-0.003068	0.001051	-2.907	0.047835	*
MXEF0CX0.Index	0.157822	0.015732	10.032	< 2e-16	***

CPI

Unemployment

GDP

Currency Pairs

Fama French Factors

Currency index

Interpretation Regression Results PC1 2006-2009

- **CPI Index:** A significant negative coefficient suggests that rising inflation in China and Japan was inversely related to PC1. During the financial crisis, high inflation may have been a concern for Chinese asset values, as it could signal overheating in the economy amidst a global downturn. A positive and significant coefficient for Brazil contrasts with the negative coefficients for China and Japan. Same for Russia: The positive relationship indicates that as Russia's inflation (CPI) increased, PC1 also increased. This could reflect that during this period, rising CPI in Russia was associated with economic growth or the boom in global commodity prices, given Russia's status as a major exporter of oil and natural gas.
 - **Unemployment Rate:** EHUPCN Index (China Unemployment), EHUPAT Index (Austria Unemployment), and EHUPBR Index (Brazil Unemployment) have significant negative coefficients that likely indicate that higher unemployment in these countries was associated with lower values of PC1, reflecting economic stress during the crisis. A non-significant coefficient for Canadian unemployment suggests it may not have had a clear relationship with the principal component during this period. A positive coefficient for Southeast Asian unemployment is somewhat counterintuitive; this may indicate that the markets were more influenced by other factors, or there may have been expectations of recovery.
- **Comparison with the Whole Time Series Regression Results**
- **Inflation:** The negative relationship with Chinese and Japanese CPI was consistent in both regressions, indicating ongoing concerns about inflation in these economies across different time periods. Ongoing sanctions and geopolitical tensions could have altered Russia's economic landscape overall, where inflation could now be indicative of economic challenges rather than growth.
 - **Unemployment Rates:** The negative coefficients for unemployment rates during the crisis reflect the immediate impact of job losses on asset values, while over the entire dataset, this relationship may not be as strong or direct, indicating that the acute phase of the crisis had a more pronounced effect on how unemployment rates influenced asset prices.
 - **Currency Pairs:** The strong negative relationship between EUR currency pairs and PC1 during the crisis period might indicate the specific stress in the Eurozone during those years, which could include concerns about sovereign debt and the health of the banking sector. In contrast, over the entire time series, the influence of the Euro might be more balanced, reflecting a mix of positive and negative periods.

Regression results (multivariate) PCA 1 2010-2015

	Min	1Q	Median	3Q	Max
	-0.170611	-0.031601	0.008451	0.036720	0.119476
Coefficients:					
	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	0.1740739	0.0930856	1.870	0.061717	.
CNCPIYOY.Index	-0.0373651	0.0095880	-3.897	0.000103	***
JNCPIYOY.Index	-0.0093631	0.0061334	-1.527	0.127124	
BZPIIPCY.Index	-0.0487916	0.0216254	-2.256	0.024233	*
HKCPIY.Index	0.0400306	0.0047659	8.399	< 2e-16	***
AUCPIYOY.Index	0.0394486	0.0186403	2.116	0.034520	*
EHPILAT.Index	0.1208496	0.0264643	4.567	5.46e-06	***
EHPIASP.Index	0.0321436	0.0157980	2.035	0.042100	*
SACPIYOY.Index	-0.1138014	0.0136810	-8.318	2.36e-16	***
RUCPIYOY.Index	-0.1571288	0.0158151	-9.935	< 2e-16	***
SPIPCYOY.Index	0.0908994	0.0198337	4.583	5.05e-06	***
EHUPCN.Index	0.0103463	0.0269061	0.385	0.700050	
EHUPAT.Index	0.0593168	0.0145235	4.084	4.71e-05	***
EHUPIT.Index	0.0386778	0.0312469	1.238	0.216023	
EHUPHK.Index	0.0193520	0.0341021	0.567	0.570498	
EHUPBR.Index	-0.2299515	0.0677278	-3.395	0.000708	***
EHUPSE.Index	0.0294066	0.0114928	2.559	0.010626	*
EHUPCA.Index	0.0024019	0.0766629	0.031	0.975011	
EHUPASAY.Index	0.2469710	0.0392964	6.285	4.56e-10	***
EHGDSE.Index	-0.0756333	0.0125462	-6.028	2.19e-09	***
EHGDMXY.Index	0.0584290	0.0138033	4.233	2.48e-05	***
EURJPY.Currency	0.0608541	0.0103108	5.902	4.65e-09	***
EURCHF.Currency	-0.0502097	0.0150965	-3.326	0.000907	***
EURGBP.Currency	-0.0155969	0.0129141	-1.208	0.227381	
EURSEK.Currency	0.0914740	0.0125643	7.280	5.94e-13	***
EURCAD.Currency	-0.0147327	0.0082418	-1.788	0.074093	.
EURCZK.Currency	0.0377340	0.0064533	5.847	6.41e-09	***
EURKRW.Currency	0.0211813	0.0123533	1.715	0.086665	.
ff3_Mkt.RF	-0.0007167	0.0024681	-0.290	0.771568	
ff3_HML	-0.0039897	0.0037981	-1.050	0.293719	
ff5_SMB	-0.0037042	0.0021582	-1.716	0.086357	.
ff5_RMN	-0.0030459	0.0027664	-1.101	0.271108	
ff5_CMA	0.0006483	0.0020141	0.230	0.817837	
MXEFBCX0.Index	0.0828977	0.0112741	7.353	3.54e-13	***

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

Residual standard error: 0.0516 on 1223 degrees of freedom
Multiple R-squared: 0.5672, Adjusted R-squared: 0.5555
F-statistic: 48.57 on 33 and 1223 DF, p-value: < 2.2e-16

CPI

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Fama French Factors

Currency index

Interpretation Regression Results PC1 2010-2015

- **CPI Index:** A significant negative coefficient indicates that higher inflation in China was associated with a decrease in PC1, suggesting concerns over slowing growth or potential tightening measures to control inflation. A significant positive coefficient of Hong Kong CPI could suggest that inflation in Hong Kong was seen as a sign of economic strength or that the impact of inflation on financial assets was not perceived as detrimental. The strongly negative coefficient of Russia possibly reflects the economic sanctions imposed on Russia during this period, which could have led to inflationary pressures and negative economic impacts.
- **Unemployment Rate:** Brazil shows a significant negative coefficient as opposed to before, indicating that higher unemployment rates were seen as negative for the financial assets captured by PC1. Other non-significant coefficient suggests that unemployment (f.ex. in China) may not have been a decisive factor for the financial assets during this period.

▪ Economic Events of 2010-2015

- **Eurozone Debt Crisis**
- **Russian Sanctions:** Economic sanctions on Russia, which would impact the RUCPIYOY Index negatively.
- **Global Recovery Post-2008 Crisis:** A gradual recovery from the 2008 financial crisis with varying rates of recovery among countries.

▪ Comparison with Other Periods

- **Inflation Indicators:** China's inflation remained negatively associated with PC1 across all periods, which suggests consistent concerns regarding inflation's impact on financial assets in China.
- **Unemployment Indicators:** Unemployment rates seemed to have a stronger association with PC1 during the financial crisis (2006-2009) compared to the post-crisis recovery period (2010-2015), likely reflecting the immediate impact of the crisis on job markets.
- **Currency Pairs:** Compared to the whole data set regression the positive coefficient for EURSEK suggests that as the Euro strengthens against the Krona the dependent variable PC1 decreases. The opposite is true for the EURCHF.

▪

Regression results (multivariate) PC 1 2016-2020

	Min	1Q	Median	3Q	Max
	-0.138763	-0.022226	0.000666	0.023605	0.115755
Coefficients:					
	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	0.6809882	0.0787058	8.652	< 2e-16	***
CNCPIYDY.Index	0.0088293	0.0075719	1.166	0.24382	
JNCPIYDY.Index	-0.0134833	0.0062053	-2.173	0.02998	*
BZPIPCY.Index	0.0653434	0.0074916	8.722	< 2e-16	***
HKCPIY.Index	-0.0027110	0.0053010	-0.511	0.60916	
AUCPIYDY.Index	-0.1959159	0.0191857	-10.212	< 2e-16	***
EHPILAT.Index	-0.0497869	0.0180977	-2.751	0.00603	**
EHPIASP.Index	-0.0603965	0.0145112	-4.162	3.37e-05	***
SACPIYDY.Index	-0.0999599	0.0128339	-7.789	1.44e-14	***
RUCPIYDY.Index	-0.0741723	0.0109028	-6.803	1.60e-11	***
SPIPCYDY.Index	-0.0215591	0.0081500	-2.645	0.00827	**
EHUPCN.Index	0.0652821	0.0174369	3.744	0.00019	***
EHUPAT.Index	-0.0992448	0.0146463	-6.776	1.91e-11	***
EHUPIT.Index	-0.0898294	0.0301221	-2.982	0.00292	**
EHUPHK.Index	0.3398829	0.0687662	4.943	8.78e-07	***
EHUPBR.Index	-0.0311901	0.0133729	-2.332	0.01984	*
EHUPSE.Index	0.0087659	0.0063632	1.378	0.16858	
EHUPCA.Index	-0.2697439	0.0455986	-5.916	4.29e-09	***
EHUPASAY.Index	0.0184034	0.0312316	0.589	0.55580	
EHGDSE.Index	-0.1423367	0.0173188	-8.219	5.20e-16	***
EHGDMXY.Index	-0.0260864	0.0558268	-0.467	0.64039	
EURJPY.Currency	0.0045788	0.0106685	0.429	0.66786	
EURCHF.Currency	0.0861267	0.0157796	5.458	5.82e-08	***
EURGBP.Currency	-0.0046201	0.0058579	-0.789	0.43044	
EURSEK.Currency	-0.0709315	0.0081534	-8.700	< 2e-16	***
EURCAD.Currency	-0.0060174	0.0054569	-1.103	0.27037	
EURCZK.Currency	-0.0024288	0.0124249	-0.195	0.84505	
EURKRW.Currency	-0.0247511	0.0102969	-2.404	0.01638	*
ff3_Mkt.RF	-0.0034120	0.0018586	-1.836	0.06663	
ff3_HML	0.0012128	0.0021597	0.562	0.57452	
ff5_SMB	-0.0005631	0.0015062	-0.374	0.70860	
ff5_RMW	-0.0010625	0.0016593	-0.640	0.52207	
ff5_CMA	-0.0020588	0.0017424	-1.182	0.23761	
MXEF0CX0.Index	-0.0434279	0.0091340	-4.755	2.23e-06	***

CPI

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Fama French Factors

Currency index

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

Residual standard error: 0.04032 on 1223 degrees of freedom

Multiple R-squared: 0.5167, Adjusted R-squared: 0.5037

F-statistic: 39.62 on 33 and 1223 DF, p-value: < 2.2e-16

Interpretation Regression Results PC1 2016-2020

- **CNCPIYOY Index (China CPI):** It's quite unexpected to find a non-significant coefficient for Chinese inflation, considering China's substantial economic influence from 2016 to 2020. Despite the economy facing significant challenges during this period, characterized by its status as one of the world's largest economies, the absence of discernible effects of Chinese inflation on PC1 is surprising.
- **JNCPIYOY Index (Japan CPI):** Similarly, a not very significant coefficient for Japan's CPI.
- **BZPIPCY Index (Brazil CPI):** A positive and significant coefficient, possibly indicating that inflation in Brazil was associated with economic resilience or growth during the crisis. A high coefficient (0.065) suggests big impact on PC1.
- **RUCPIYOY Index (Russia CPI):** The strongly negative coefficient (-0.07) possibly reflects the economic sanctions imposed on Russia during previous time frame, which could still be a remaining impact of that.
- **SACPIYOY Index (South Africa CPI):** A negative coefficient (-0.09) suggests economic concerns, where inflation could indicate an economic imbalance during the crisis.
- **EHUPAT Index (Austria Unemployment), EHUPIT Index (Italy Unemployment) and EHUPCA Index (Canada Unemployment):** Significant negative coefficients for unemployment rates indicate that higher unemployment in these countries was associated with lower values of PC1, reflecting economic stress during the crisis.
- **EHUPCN Index (China Unemployment), EHUPHK Index (Hong Kong Unemployment):** A positive coefficient is again somewhat counterintuitive; this may indicate that the markets were more influenced by other factors, or there may have been expectations of recovery.
- **EUR Currency Pairs:** Most EUR currency pairs show insignificant coefficients for this period.

Comparison of 2016-2020 with the Whole Time Series Regression Results (PC1)

- **Inflation:** CPI indices from China and Japan lost their significance in 2016-2020 timeline
- **Unemployment Rate in Hong Kong:** The positive coefficient for unemployment rates during Covid era reflects opposite impact of job losses on asset values, while over the entire dataset, this relationship is positive, indicating that the acute phase of the crisis had maybe more unpredictability/more complicated influence on the principal component.
- **Currency Pairs:** are nonsignificant during 2016-2020 compared to the whole timeline.

Regression results (multivariate) PC 1 2021-2023

Min 1Q Median 3Q Max
-0.13108 -0.02342 -0.00065 0.02667 0.11486

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	8.838e-01	1.224e-01	7.220	1.13e-12 ***
CNKPIY0Y.Index	1.113e-01	9.889e-03	11.256	< 2e-16 ***
JNCPIY0Y.Index	-1.084e-01	8.223e-03	-13.185	< 2e-16 ***
BZPIIPCY.Index	-1.080e-01	1.132e-02	-9.534	< 2e-16 ***
HKCPIY.Index	1.331e-02	3.672e-03	3.625	0.000306 ***
AUCPIY0Y.Index	-3.458e-01	2.973e-02	-11.631	< 2e-16 ***
EHPILAT.Index	9.293e-02	1.129e-02	8.228	6.84e-16 ***
EHPIASP.Index	8.937e-03	5.246e-02	0.170	0.864779
SACPIY0Y.Index	-1.398e-02	1.185e-02	-1.180	0.238305
RUCPIY0Y.Index	1.682e-01	2.156e-02	7.802	1.73e-14 ***
SPIPCY0Y.Index	-1.547e-05	1.134e-02	-0.001	0.998912
EHUPCN.Index	1.689e-01	1.299e-02	12.994	< 2e-16 ***
EHUPAT.Index	1.855e-01	2.093e-02	8.866	< 2e-16 ***
EHUPIT.Index	-3.257e-01	1.626e-01	-2.004	0.045418 *
EHUPHK.Index	-8.679e-02	5.546e-02	-1.565	0.118000
EHUPBR.Index	-5.470e-01	6.574e-02	-8.321	3.31e-16 ***
EHUPSE.Index	1.312e-01	3.279e-02	4.001	6.84e-05 ***
EHUPCA.Index	-1.353e-01	2.783e-02	-4.859	1.39e-06 ***
EHUPASAY.Index	-1.533e-01	5.297e-02	-2.894	0.003900 **
EHG0SE.Index	1.548e-01	3.089e-02	5.012	6.50e-07 ***
EHGDMXY.Index	-1.358e-01	1.710e-02	-7.938	6.26e-15 ***
EURJPY.Currency	1.019e-01	1.421e-02	7.172	1.57e-12 ***
EURCHF.Currency	-6.317e-02	4.312e-02	-1.465	0.143294
EURGBP.Currency	-4.985e-03	1.200e-02	-0.415	0.678034
EURSEK.Currency	2.911e-02	1.265e-02	2.302	0.021588 *
EURCAD.Currency	-3.196e-02	9.815e-03	-3.256	0.001173 **
EURCZK.Currency	2.874e-02	7.955e-03	3.613	0.000320 ***
EURKRW.Currency	2.637e-02	1.740e-02	1.515	0.130036
FF3_MKT_RF	1.832e-03	1.356e-03	1.351	0.177067
FF3_HML	-6.308e-04	1.570e-03	-0.402	0.687826
FF3_SMB	1.034e-03	1.392e-03	0.743	0.457645
FF3_RMW	2.700e-03	1.239e-03	2.179	0.029573 *
FF3_CMA	-8.784e-04	1.351e-03	-0.650	0.515245
MXEF0CX0.Index	9.688e-02	1.647e-02	5.889	5.52e-09 ***

CPI

Unemployment

GDP

Currency Pairs

Fama French Factors

Currency index

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

Residual standard error: 0.04385 on 876 degrees of freedom
Multiple R-squared: 0.6254, Adjusted R-squared: 0.6113
F-statistic: 44.32 on 33 and 876 DF, p-value: < 2.2e-16

Interpretation Regression Results PC1 2021-2023

Economic Context of 2021-2023

- **Global Economic Recovery after Covid:** Following the challenges posed by the COVID-19 pandemic, the global economy embarked on a path of recovery during 2021-2023. Many countries implemented vaccination campaigns and economic stimulus measures to mitigate the impact of the pandemic, leading to improved economic conditions worldwide.
- **War in Ukraine:** significant global economic implications, leading to increased geopolitical tensions, disruptions in commodity markets, and heightened uncertainty among investors. Additionally, it poses risks to regional stability, impacting trade flows, energy supplies, and financial markets worldwide.
- **Inflationary Pressures:** Inflation became a significant concern during this period, with many countries experiencing higher inflation rates. Factors contributing to inflationary pressures included supply chain disruptions, increased demand as economies reopened after Covid, and higher commodity prices.

Interpretation of 2021-2023 Regression Results (PC1)

- **China, Hong Kong, Austria and Russia show** positive and significant coefficients, possibly indicating that inflation in these countries was associated with economic resilience or growth during the crisis. Also coefficients are quite high, suggesting big impact on PC1. (surprising for Russia though, many sanctions were imposed, financial market was unstable)
- **EHUPAT Index (Austria Unemployment) and EHUPCN Index (China Unemployment):** Significant positive coefficients for unemployment rates indicate that higher unemployment in these countries was associated with higher values of PC1; could be due to awaited recovery (especially in case of China post-Covid)
- **EUR Currency Pairs:** Most EUR currency pairs show insignificant coefficients for this period.

Comparison of 2021-2023 with the Whole Time Series Regression Results (PC1)

- **Inflation:** CPI indices from China and Russia turned positive in 2021-2023 timeline
- **Unemployment Rate in Hong Kong:** The positive coefficient for unemployment rates during Covid era reflects opposite impact of job losses on asset values, while over the entire dataset, this relationship is positive, indicating that the acute phase of the crisis had maybe more unpredictability/more complicated influence on the principal component.
- **Currency Pairs:** are mostly nonsignificant during 2021-2023 compared to the whole timeline.
- **Fama French RMW Profitability factor became slightly significant in this time frame, positive coefficient.**

Dummy Regression (data within 1 SD)

```
lm(formula = within_range ~ ., data = merged_dtl)
```

Residuals:

Min	1Q	Median	3Q	Max
-8.9985	-0.4207	0.1574	0.2745	1.0811

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.7183547	0.0066838	108.779	< 2e-16 ***
CNCPIY0Y.Index	-0.0818192	0.0176972	-4.623	3.89e-06 ***
JNCPIY0Y.Index	-0.0663428	0.0184765	-3.591	0.000334 ***
BZPIIPCY.Index	-0.0289286	0.0181376	-1.595	0.110799
HKCPIY.Index	0.0188744	0.0132232	1.427	0.153548
AUCPIY0Y.Index	-0.1848435	0.0293851	-6.290	3.49e-10 ***
EHPILAT.Index	0.0131867	0.0174125	0.757	0.448984
EHPIASP.Index	-0.0499435	0.0226810	-2.210	0.027174 *
SACPIY0Y.Index	0.1274297	0.0232280	5.486	4.35e-08 ***
RUCPIY0Y.Index	-0.0421902	0.0143672	-2.937	0.003337 **
SPIPC0Y0Y.Index	0.1800928	0.0209397	4.780	1.81e-06 ***
EHUPCN.Index	0.0239424	0.0177155	1.351	0.176618
EHUPAT.Index	-0.0614959	0.0242527	-2.536	0.011261 *
EHUPIT.Index	-0.1211941	0.0368260	-3.291	0.001007 **
EHUPHK.Index	-0.0618120	0.0213047	-2.901	0.003735 **
EHUPBR.Index	-0.1621126	0.0262629	-6.173	7.35e-10 ***
EHUPSE.Index	0.1126224	0.0140635	8.008	1.50e-15 ***
EHUPCA.Index	-0.0291781	0.0249810	-1.168	0.242998
EHUPASAY.Index	0.0168321	0.0253061	0.665	0.505998
EHG0SE.Index	0.0595374	0.0166444	3.577	0.000351 ***
EHG0MX.Index	0.0191325	0.0154221	1.241	0.214825
EURJPY.Currency	0.0306363	0.0184609	1.660	0.097086
EURCHF.Currency	-0.1220053	0.0324475	-3.760	0.000172 ***
EURGBP.Currency	0.0942473	0.0198815	4.740	2.20e-06 ***
EURSEK.Currency	0.0328059	0.0260581	1.259	0.208117
EURCAD.Currency	0.1440751	0.0166989	8.628	< 2e-16 ***
EURCZK.Currency	0.0936173	0.0161670	5.791	7.53e-09 ***
EURKRW.Currency	-0.1700384	0.0245279	-6.932	4.78e-12 ***
ff3_Mkt.RF	0.0051130	0.0072941	0.701	0.483358
ff3_HML	0.0025797	0.0079117	0.326	0.744395
ff5_SMB	-0.0031256	0.0070068	-0.446	0.655557
ff5_RMW	-0.0007883	0.0070889	-0.111	0.911462
ff5_CMA	-0.0011312	0.0079660	-0.142	0.887087
MXEF0CX0.Index	0.0357027	0.0199371	1.791	0.073483

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

Residual standard error: 0.4281 on 4166 degrees of freedom
Multiple R-squared: 0.1404, Adjusted R-squared: 0.1336
F-statistic: 28.62 on 33 and 4166 DF, p-value: < 2.2e-16

CPI

Unemployment

GDP

Currency Pairs

Fama French Factors

Currency index

Interpretation Regression Results PC1 Dummy Variables

- The regression is trying to predict when the stock market's behavior is "normal" (within 1 SD) or "abnormal"
- **R-Squared:** From the R-squared of around 0.14 a lot about the market's movements is not captured
- **More Typical Market Behavior**
 - SPICPYOY Index (Spain CPI)
 - EURGBP
 - EURCAD
 - EURCZK
- **Less Typical Market Behavior**
 - CNCPIYOY Index (China CPI)
 - JNCPIYOY Index (Japan CPI)
 - AUCPIYOY Index (Australia CPI)
 - EHUPBR (Unemployment Brazil)
 - EURCHF
 - EURKRW

Regression results (multivariate) PC2 Whole Data Set 2006-2023

```
lm(formula = PC2 ~ ., data = merged_df2)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.114224	-0.030852	-0.002126	0.029132	0.156215

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.1934058	0.0006822	283.481	< 2e-16 ***
CNKPIYOY.Index	0.0138854	0.0018283	7.595	3.79e-14 ***
JMKPIYOY.Index	0.0081708	0.0019088	4.281	1.91e-05 ***
BZPIIPCY.Index	-0.0144083	0.0018738	-7.689	1.83e-14 ***
HKCPIY.Index	-0.0013144	0.0013661	-0.962	0.33603
AUCPIYOY.Index	0.0345371	0.0030358	11.377	< 2e-16 ***
EHPILAT.Index	-0.0056027	0.0017989	-3.114	0.00186 **
EHPIASP.Index	-0.0379810	0.0023349	-16.266	< 2e-16 ***
SACPIYOY.Index	0.0100796	0.0023997	4.200	2.72e-05 ***
RUCPIYOY.Index	0.0094074	0.0014843	6.338	2.58e-10 ***
SPIPCYOY.Index	-0.0111822	0.0021633	-5.169	2.46e-07 ***
EHUPCN.Index	-0.0052150	0.0018302	-2.849	0.00448 **
EHUPAT.Index	-0.0102930	0.0025056	-4.108	4.07e-05 ***
EHUPIT.Index	0.0119568	0.0030046	3.143	0.00169 **
EHUPHK.Index	0.0215548	0.0022010	9.793	< 2e-16 ***
EHUPBR.Index	0.0039146	0.0027133	1.443	0.14916
EHUPSE.Index	-0.0088810	0.0014529	-5.562	2.84e-08 ***
EHUPCA.Index	0.0040330	0.0025008	1.563	0.11820
EHUPASAY.Index	-0.0018398	0.0026144	-0.704	0.48165
EHGUSE.Index	0.0072809	0.0017196	4.234	2.34e-05 ***
EHGDMCY.Index	0.0092073	0.0015933	5.779	8.07e-09 ***
EURJPY.Currency	-0.0194836	0.0019072	-10.216	< 2e-16 ***
EURCHF.Currency	-0.0062065	0.0033522	-1.869	0.06164
EURGBP.Currency	-0.0037716	0.0020540	-1.836	0.06639
EURSEK.Currency	-0.0125742	0.0026021	-4.671	3.10e-06 ***
EURCAD.Currency	0.0019616	0.0017252	1.137	0.25559
EURCZK.Currency	-0.0005354	0.0016702	-0.321	0.74858
EURKRW.Currency	-0.0012917	0.0025340	-0.510	0.61026
FF3_Mkt.RF	0.0002016	0.0007536	0.268	0.78910
FF3_HML	-0.0006772	0.0008174	-0.829	0.40742
FF5_SMB	0.0002292	0.0007239	0.317	0.75157
FF5_RMN	-0.0005132	0.0007324	-0.701	0.48353
FF5_CMA	0.0002497	0.0008230	0.303	0.76160
MXEF0CXB.Index	-0.0039799	0.0020597	-1.932	0.05340

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

Residual standard error: 0.0434 on 4166 degrees of freedom
Multiple R-squared: 0.1507, Adjusted R-squared: 0.1439
F-statistic: 22.39 on 33 and 4166 DF, p-value: < 2.2e-16

CPI

Unemployment

GDP

Currency Pairs

Fama French Factors

Currency index

Interpretation PC2 Whole Dataset

- **CPI Indexes:** Negative coefficients for CPI indexes from Asia Pacific region (EHPIASP), Brazil (BZPIPCY Index), Hong Kong (HKCPIY Index), and other regions imply that inflation there is associated with lower PC2 values (which is completely opposite from PC1 results!)
- Conversely, positive coefficients for CPI indexes from China (CNCPIYOY Index), Japan (JNCPIYOY Index) and Australia (AUCPIYOY) (which also has the strongest impact on PC2 with 0.035) suggest that higher inflation in these countries is associated with higher values on PC2 (again, completely opposite of PC1)
- **Unemployment Rate Indexes:** The positive coefficients for unemployment rates in Italy (EHUPIT Index), Canada (EHUPCA) and Hong Kong (EHUPHK) indicate that higher unemployment rates in these countries may be positively impacting financial asset prices. (opposite of PC1)
- **Currency Indices:** Negative coefficients for most currency pairs suggest that stronger currencies (e.g., EURJPY, EURCHF, EUREK) relative to Euro are correlated with lower PC2 values. This could mean that currencies' strength against Euro or Euro going weaker is a negative driver of asset prices. (opposite of PC1)
- **Fama French Factors:** non-significant as for PC1.
- **MSCI EM and Bloomberg Asia Dollar Index:** The negative coefficient for the MSCI Emerging Markets Currency Index (MXEF0CX0 Index) suggests that the strength of emerging market currencies is negatively associated with the financial asset prices represented by PC2, even though relationship is not as strong (opposite of PC1)

Summary of regression Results

CPI Index (monthly)

Ticker	Country	2006-2023	Coeff	2006-2009	Coeff	2010-2015	Coeff	2015-2020	Coeff	2020-2023	Coeff
CNCPIYOY Index	China	---	-0,011	---	-0,043	---	-0,037		0,009	+++	0,113
JNCPIYOY Index	Japan	-	-0,008	---	-0,070		-0,009	-	-0,013	---	-0,108
BZPIPCY Index	Brazil	+++	0,030	+++	0,344	-	-0,049	+++	0,065	---	-0,108
HKCPIY Index	Hong Kong	+++	0,016		0,006	+++	0,040		-0,003	+++	0,013
AUCPIYOY Index	Australia	---	-0,071		-0,040	+	0,039	---	-0,196	---	-0,346
EHPILAT Index	Latin America	+++	0,011		-0,500	+++	0,121	---	-0,050	+++	0,093
EHPIASP Index	Asian Pacific	+++	0,068		-0,144	+	0,032	---	-0,060		0,009
SACPIYOY Index	South Africa	---	-0,019	---	-0,070	---	-0,114	---	-0,100		-0,014
RUCPIYOY Index	Russia	---	-0,018	+++	0,120	---	-0,157	---	-0,074	+++	0,168
SPICPYDY	Spain	++	0,011		0,102		0,091	---	-0,022		0,000

Summary of regression Results

UNEMPLOYMENT RATE (quarterly)

Ticker	Country	2006-2023	Coeff	2006-2009	Coeff	2010-2015	Coeff	2015-2020	Coeff	2020-2023	Coeff
EHUPCN Index	China	+++	0,03	---	-0,387		0,01	+++	0,065	+++	0,169
EHUPAT Index	Austria	+	0,008	---	-0,483	+++	0,059	---	-0,992	+++	0,186
EHUPIT Index	Italy	---	-0,032		-0,041		0,039	--	-0,09	-	-0,326
EHUPHK Index	Hong Kong	---	-0,042		0,299		0,019	+++	0,34		-0,0868
EHUPBR Index	Brazil	+++	0,016	--	-0,502	---	-0,23	-	-0,031	---	-0,547
EHUPSE Index	Sweden	+++	0,02	++	0,154	+	0,029		0,0088	+++	0,131
EHUPCA Index	Canada		-0,007		-0,399		0,002	---	-0,27	---	-0,135
EHUPASAY Index	South East Asian		-0,001	+++	0,363	+++	0,247		0,018	--	-0,153

Summary of regression Results

REAL GDP % (yearly)

Ticker	Country	2006-2023	Coeff	2006-2009	Coeff	2010-2015	Coeff	2015-2020	Coeff	2020-2023	Coeff
EHGDDEY Index	Germany	---	-0,019		-0,074	---	-0,076	---	-0,142	+++	0,155
EHGDAUY Index	Australia	---	-0,024		0,136	+++	0,058		-0,026	---	-0,136

Summary of regression Results

CURRENCY (daily)

Ticker	2006-2023	Coeff	2006-2009	Coeff	2010-2015	Coeff	2015-2020	Coeff	2020-2023	Coeff
EURJPY Curncy	+++	0,033		-0,015	+++	0,061	+++	0,005	+++	0,102
EURCHF Curncy	+++	0,034	---	-0,117	---	-0,05		0,086		-0,063
EURGBP Curncy		0	---	-0,052		-0,016	---	-0,005		0,005
EURSEK Curncy	---	0,038		0,012	+++	0,091		-0,071	+	-0,029
EURCAD Curncy	---	-0,013		0,002		-0,015		-0,006	-	-0,032
EURCZK Curncy	-	-0,001	+++	0,03	+++	0,038	-	-0,002	+++	0,029
EURKRW Curncy	---	-0,014	+++	0,037		0,021		-0,025		0,0264

Summary of regression Results

FAMA French

Factors	2006-2023	Coeff	2006-2009	Coeff	2010-201	Coeff	2015-2020	Coeff	2020-2023	Coeff
FF3 Mkt.Rf		0		0,001		-0,001		-0,003		0,002
FF3 HML		0,001		0,002		-0,004		0,001		0
FF5 SMB		0		0,001		-0,004		-0,001		0,001
FF5 RMW		0		0,002		-0,003		-0,001	+	0,003
FF5 CMA		-0,001	-	0,002		0,001		-0,002		0

Summary of regression Results

Currency Indices

Measures	2006-2023	Coeff	2006-2009	Coeff	2010-2015	Coeff	2015-2020	Coeff	2020-2023	Coeff
25 EM currencies against USD		0,005	+++	0,016	+++	0,083	---	-0,043	+++	0,097