

Research Project Attempt: Hedge Fund Index Replication

# **QF603-Quantitative Analysis of Financial Markets**



Prepared By:

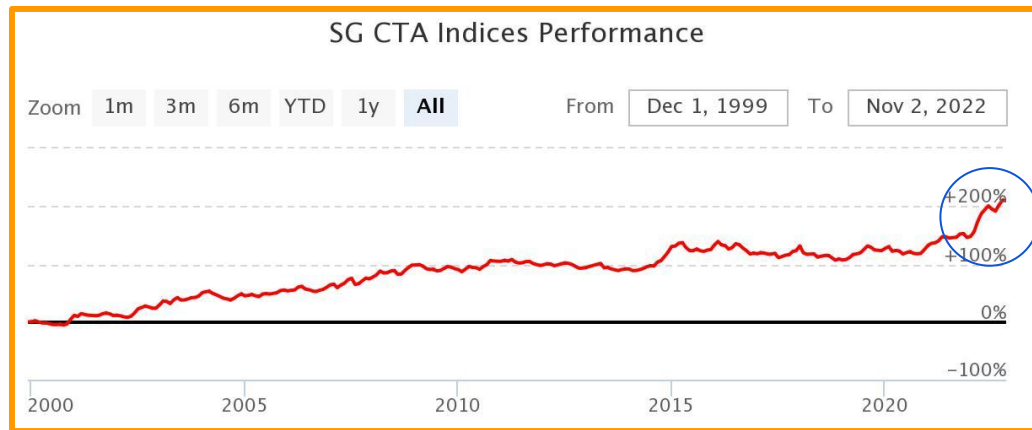
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# What is the SocGen Commodity Trading Advisors (“CTA”) Index?

- The SocGen CTA Index is a daily performance benchmark for Commodity Trading Advisors (“CTA”). It is an equally weighted index of the largest 20 CTA hedge funds.
- It is not directly investible (i.e. there are no publicly available funds that a retail investor can invest in).

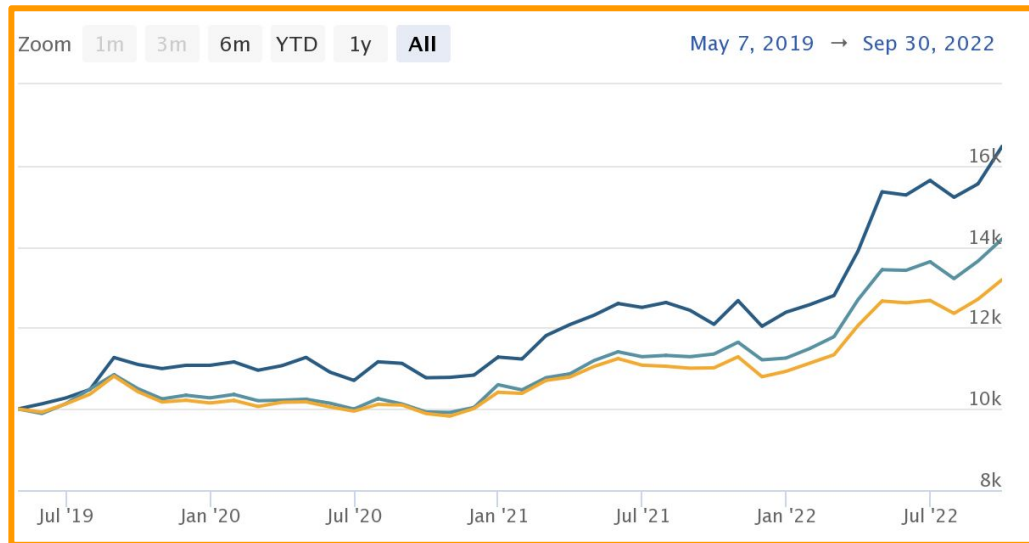


# Motivations

- Since we are unable to invest directly in the SG-CTA index, retail investors are not able to benefit from the diversification benefits during market dislocations.
- Our objective was to find out if we would be able to replicate the returns of the SG-CTA index using publicly investable assets. To this end, we note (and borrow from) the work done by Dynamic Beta LLC, who has successfully accomplished the same task in their ETF DBMF.
- This research methodology can (hopefully) also be applicable to other non-investable indexes

# Data Set

- Returns data for NEIXCTA from Bloomberg going back to 1/1/2000
- Returns data for the following asset class futures from Bloomberg going back to 1/1/2000 - based on DBMF
  - EUR
  - GOLD
  - MXEA
  - MXEF
  - SPX
  - WTI OIL
  - YEN JPY
  - LUATTRUU



# Methodology


- Linear Regression (rolling windows)
- Tangency
- PCA

# Rolling Regression

- Fit a model to the underlying returns data using linear regression, and use the coefficients as portfolio weights.
- Slicing the dataset to remove “stale” data, and rolling the window period over the full dataset.
- Backtesting the model returns to and compare correlation to the CTA returns data.

# Linear Regression

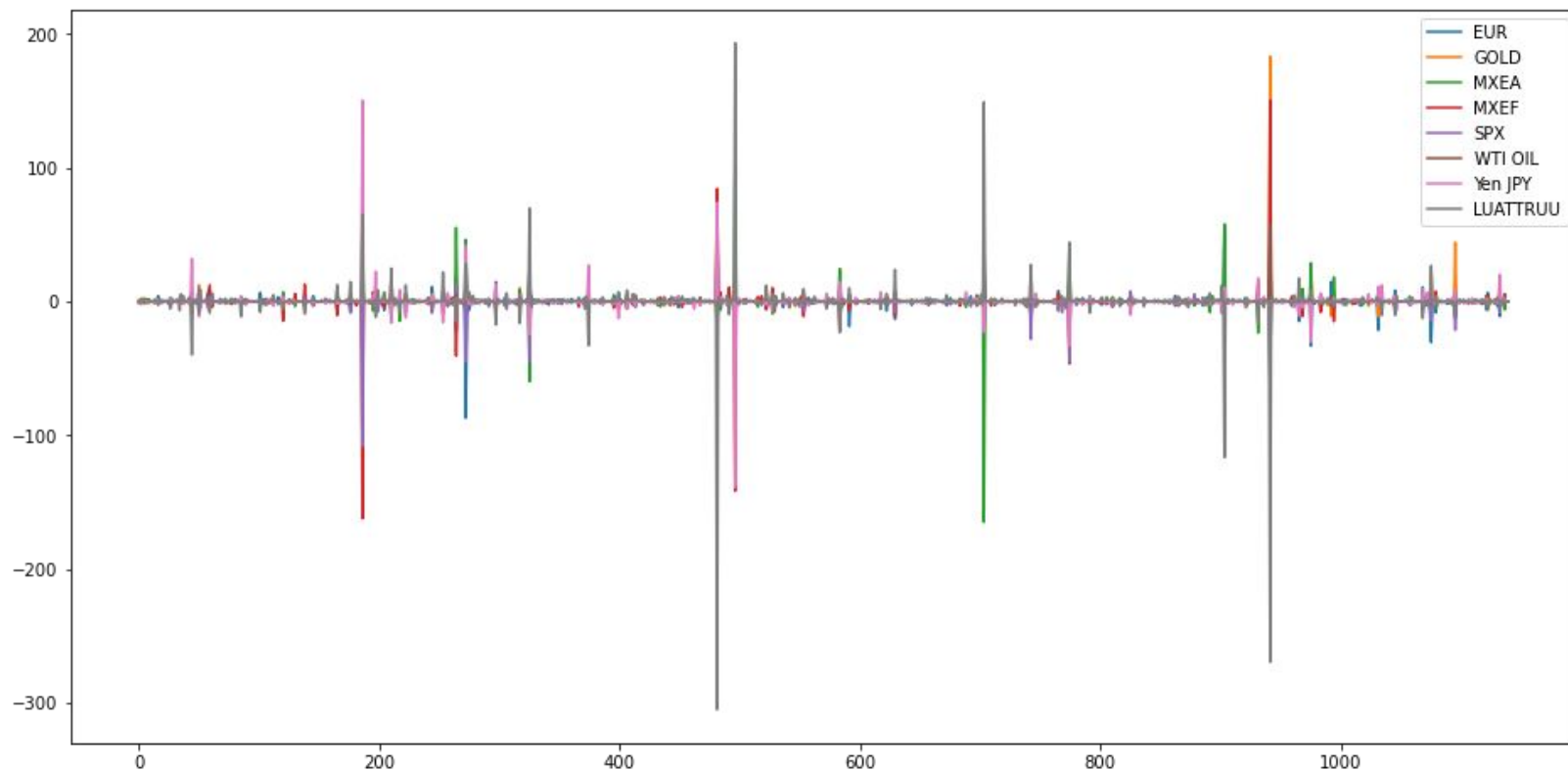
Comparing R-squared values for the various windows



10 days		20 days		60 days		120 days		250 days	
count	1140.000000	count	1138.000000	count	1128.000000	count	1116.000000	count	1090.000000
mean	0.798443	mean	0.426675	mean	0.177808	mean	0.109493	mean	0.062773
std	0.161113	std	0.155390	std	0.086430	std	0.064023	std	0.041854
min	0.204727	min	0.038080	min	0.018731	min	0.005274	min	0.006581
25%	0.703845	25%	0.311563	25%	0.115252	25%	0.063179	25%	0.030354
50%	0.836504	50%	0.422062	50%	0.167348	50%	0.097823	50%	0.051000
75%	0.926512	75%	0.535683	75%	0.222400	75%	0.142745	75%	0.085805
max	0.999903	max	0.894975	max	0.575743	max	0.354308	max	0.208431

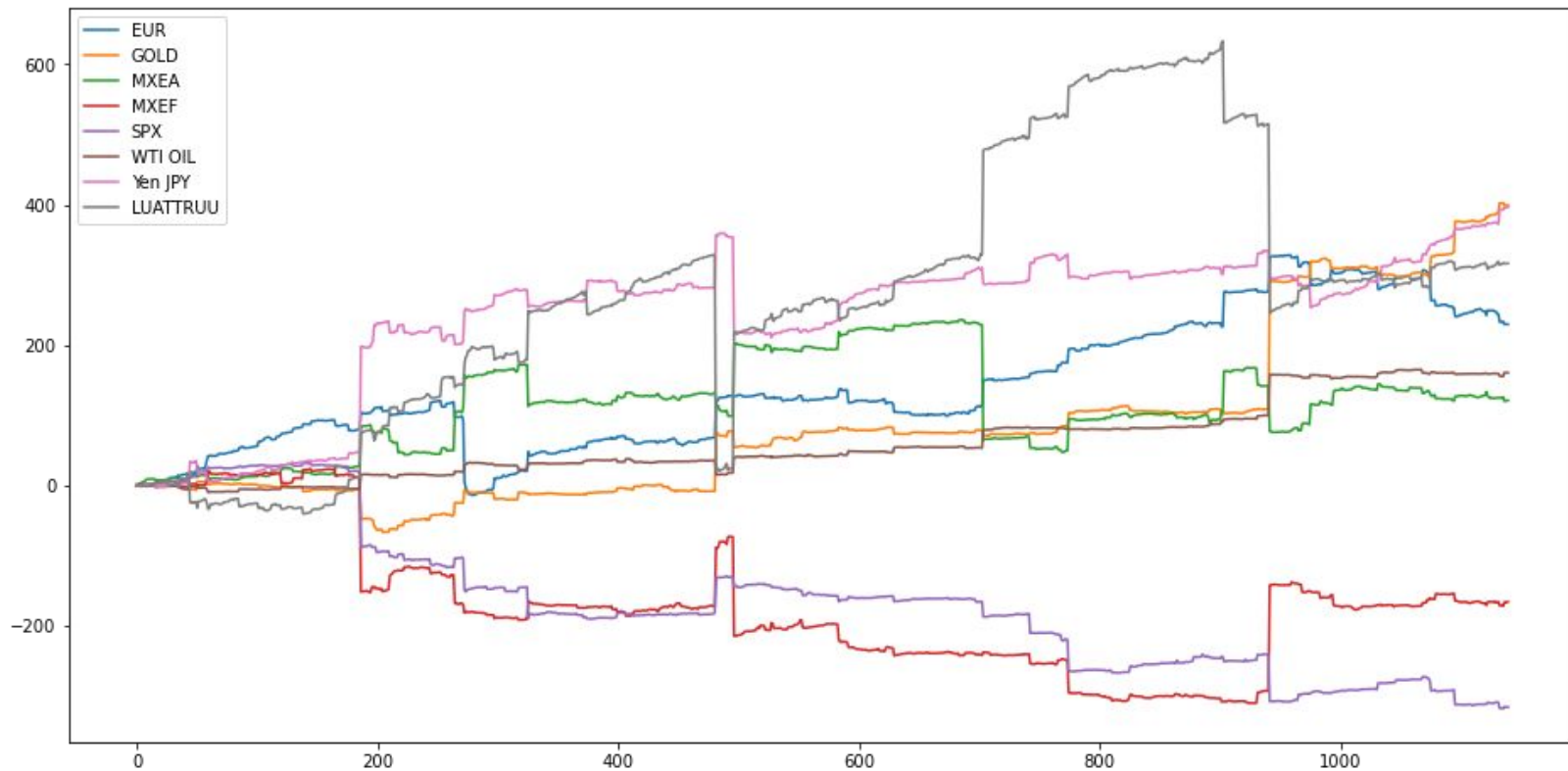
\*Note: DBMF uses 30-60 day rolling windows

## Portfolio Weights (scaled by sum of coefficients)

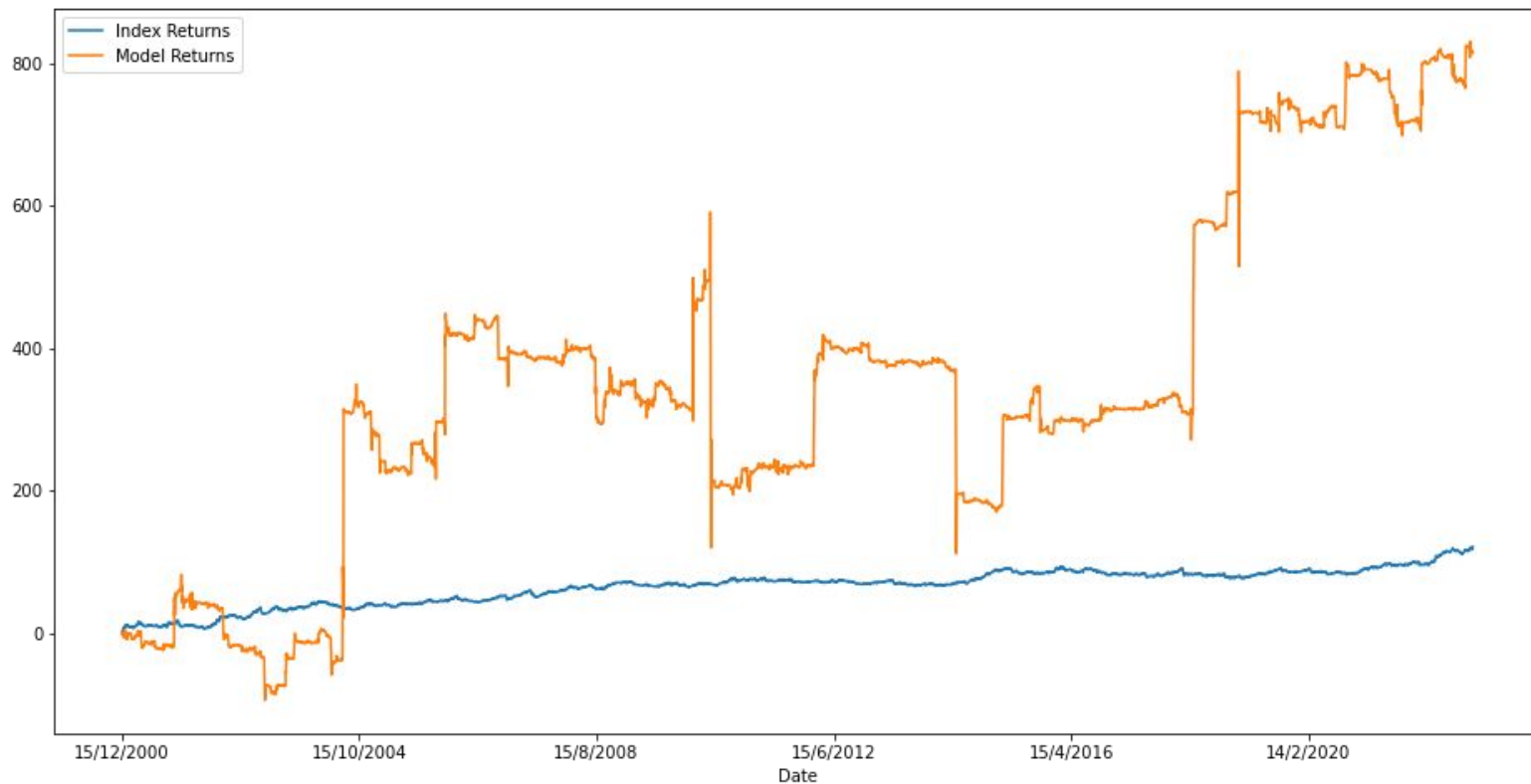




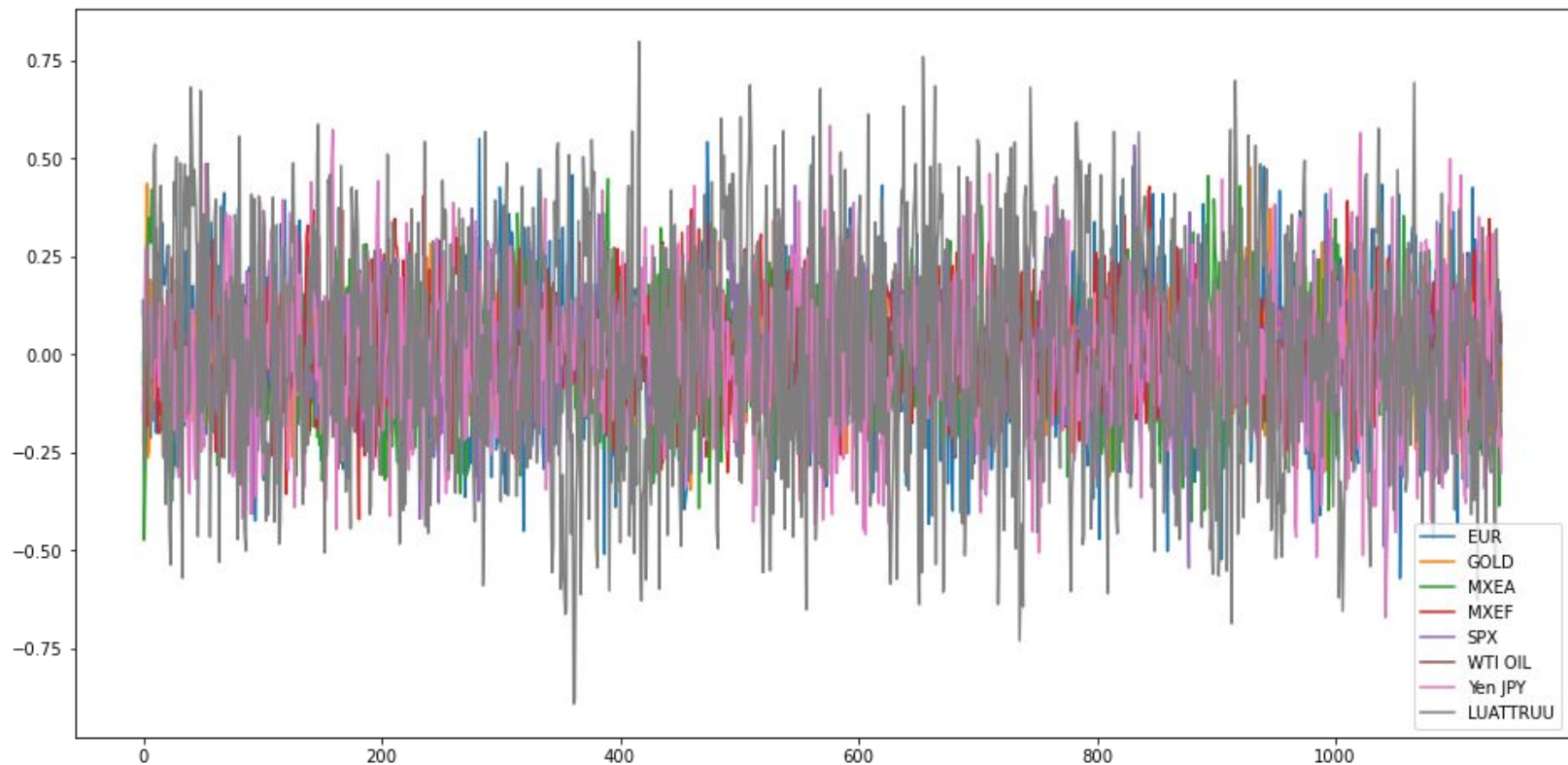
# Cumulative exposure



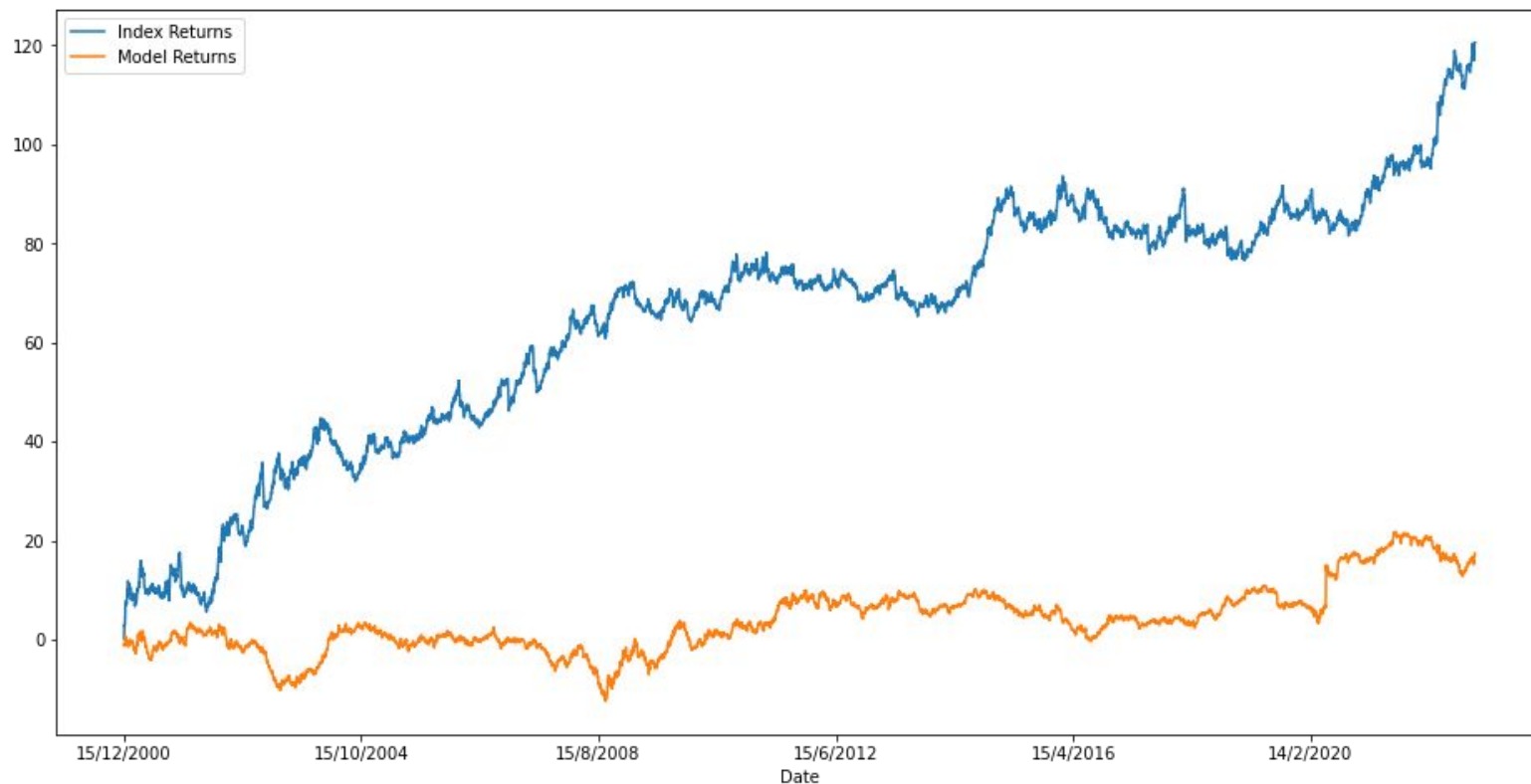
# Rolling regression results



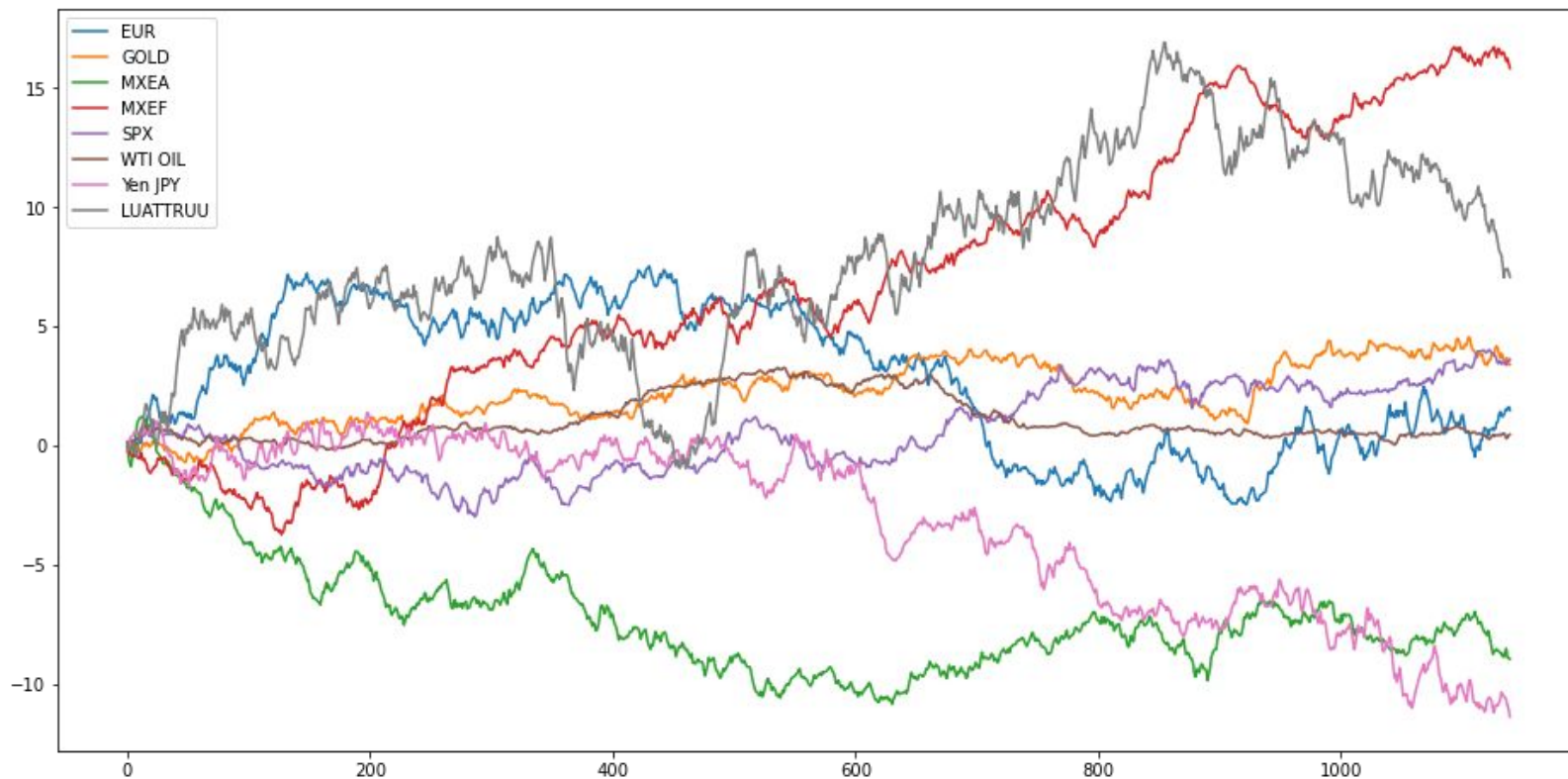
# Portfolio weights (scaled by sum of absolute coefficients)



# Rolling regression results

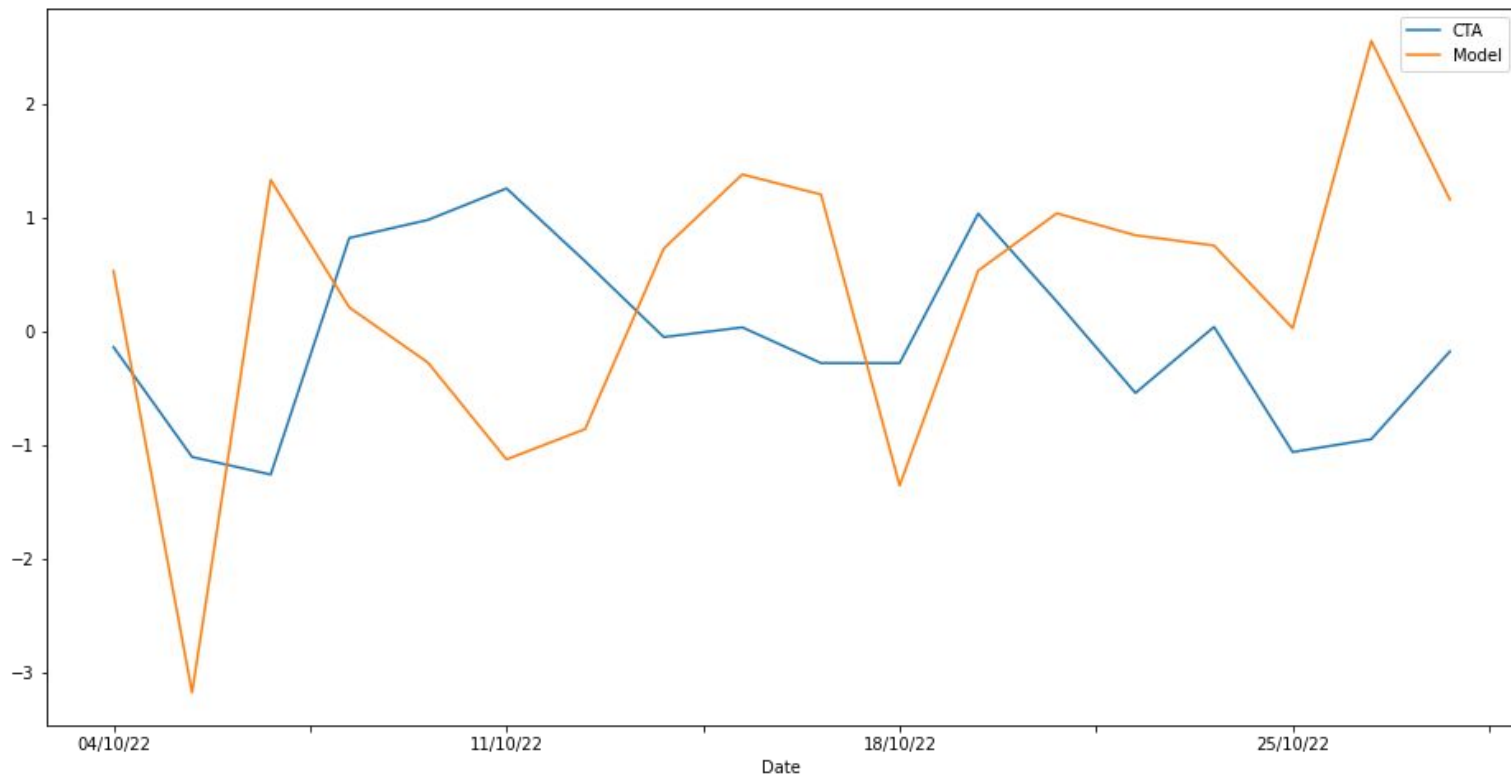


# Cumulative exposure



# Test data (October 2022)

	CTA	Model
CTA	1.000000	-0.131975
Model	-0.131975	1.000000



# Tangency

Based on the 8 asset classes we are using in our data, we calculated the tangency weight for each asset class since it has the highest possible sharpe ratio.

Tangency Weights	
<b>EUR</b>	-0.037625
<b>GOLD</b>	0.180118
<b>MXEA</b>	-0.098034
<b>MXEF</b>	0.147430
<b>SPX</b>	0.080253
<b>WTI OIL</b>	-0.002816
<b>Yen JPY</b>	0.043556
<b>LUATTRUU</b>	0.687118

# Tangency

- The expected return based on the tangency weights

	EUR	GOLD	MXEA	MXEF	SPX	WTI OIL	Yen JPY	LUATTRUU	Expected Return	Cumulative Expected Return
Date										
1/12/2000	0.801925	0.263306	-0.400033	-1.882028	0.363392	2.818409	0.824425	0.428959	0.130883	-0.869117
4/12/2000	0.659166	-0.262615	-0.434765	0.903910	-2.096935	-1.283831	-0.152754	-0.455324	-0.380401	-1.249517
5/12/2000	-0.654849	0.188076	1.397322	-0.370472	0.203299	-1.511424	0.035997	0.316828	0.106748	-1.142770
6/12/2000	1.375156	1.370377	0.299401	3.044896	0.871261	2.676660	-0.872616	0.260400	0.817950	-0.324820
7/12/2000	-0.392377	-0.148148	1.183807	1.644581	-1.025641	2.294056	0.308558	-0.165848	-0.074802	-0.399622
...	...	...	...	...	...	...	...	...	...	...
10/10/2022	-0.431034	-1.546477	-1.442073	-1.409008	-2.800359	-1.629965	0.323580	-0.389549	-0.802407	123.706840
11/10/2022	0.061843	-0.136041	-1.266548	-1.440283	-0.749246	-1.953254	0.096075	-0.242687	-0.332205	123.374635
12/10/2022	-0.051504	0.411081	-0.855197	-2.277325	-0.651923	-2.327924	0.719868	0.247448	-0.020310	123.354325
13/10/2022	0.752345	-0.407605	-0.596563	0.078644	-0.329076	2.108399	0.142945	-0.497834	-0.399837	122.954488
14/10/2022	-0.552373	-1.314234	0.218455	-1.249220	2.596568	-3.927730	1.053562	-0.280126	-0.348671	122.605817



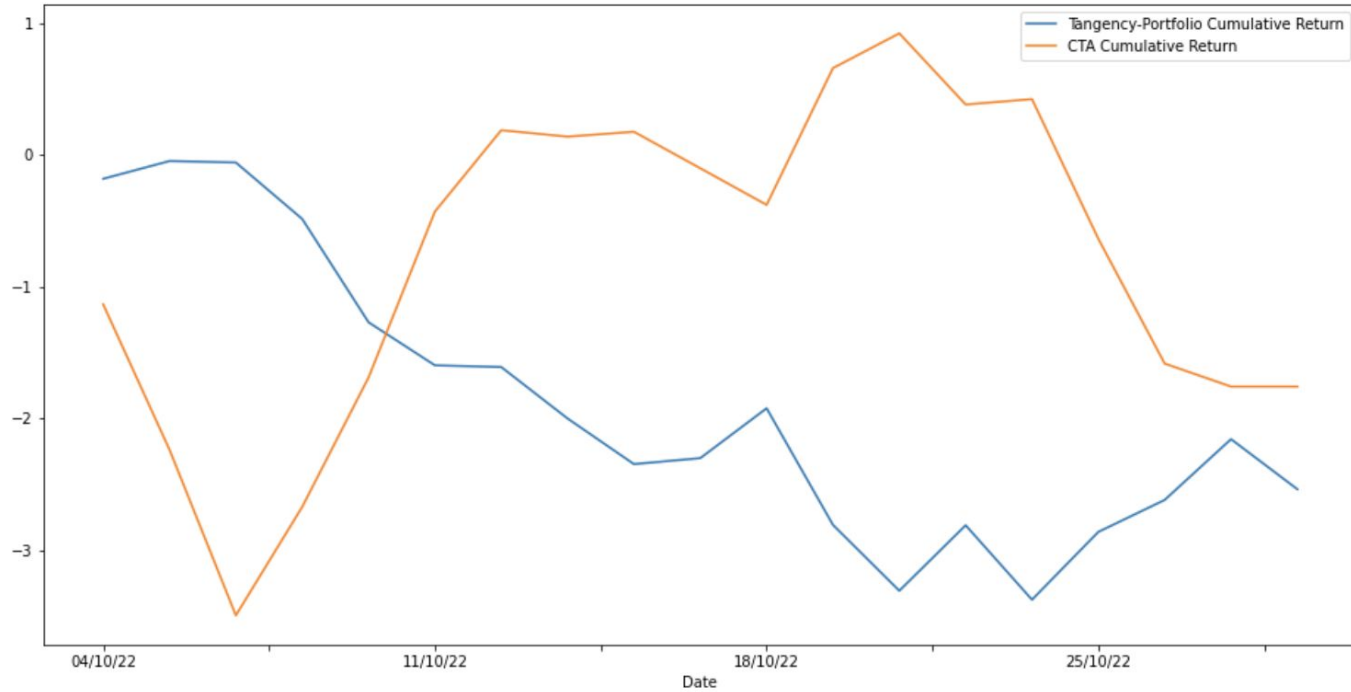
# Tangency

- Tangency cumulative return compare with actual cumulative return



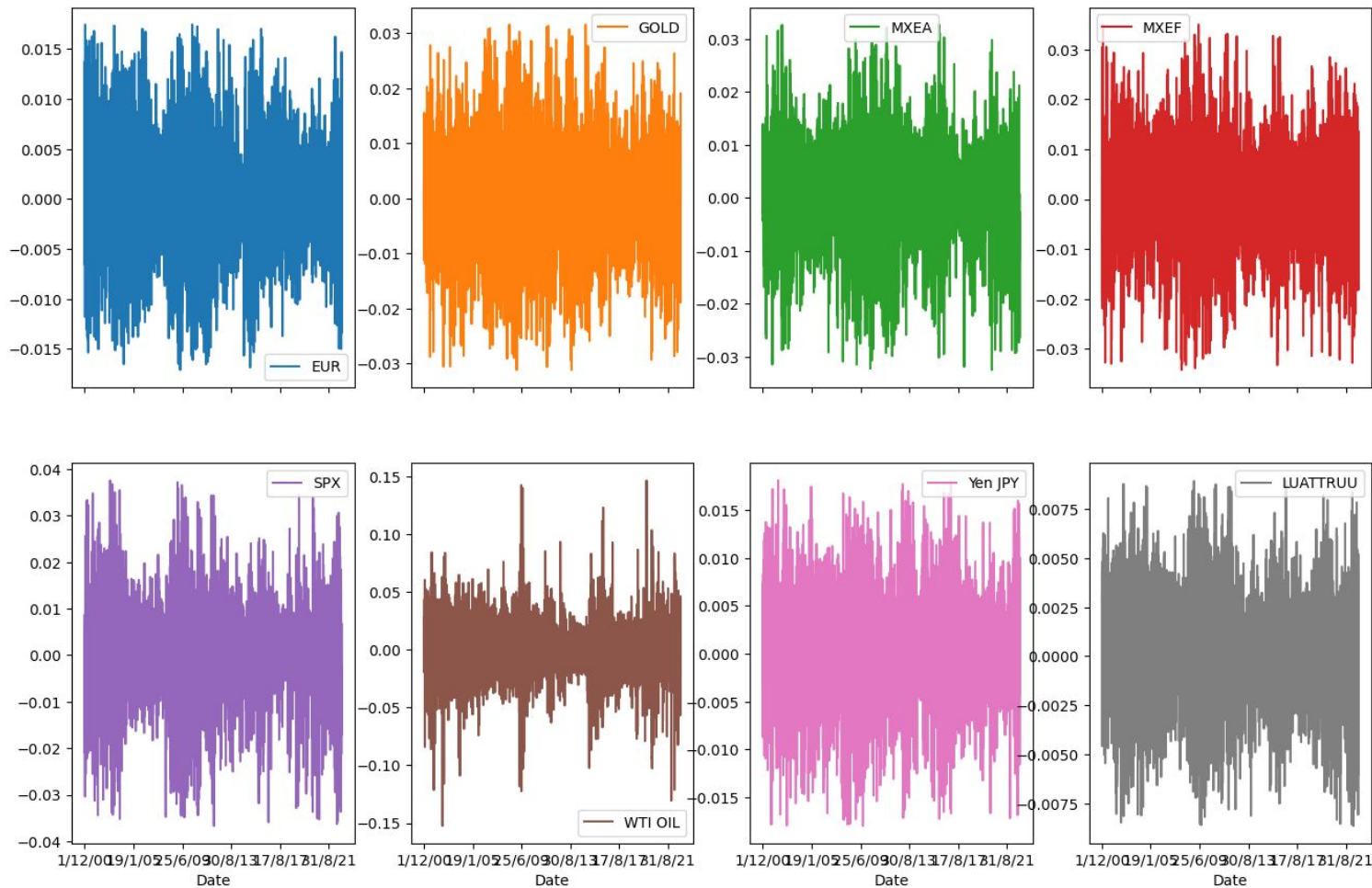
# Tangency

- Expected return based on tangency model for 3rd Oct - 28th Oct compare with actual return



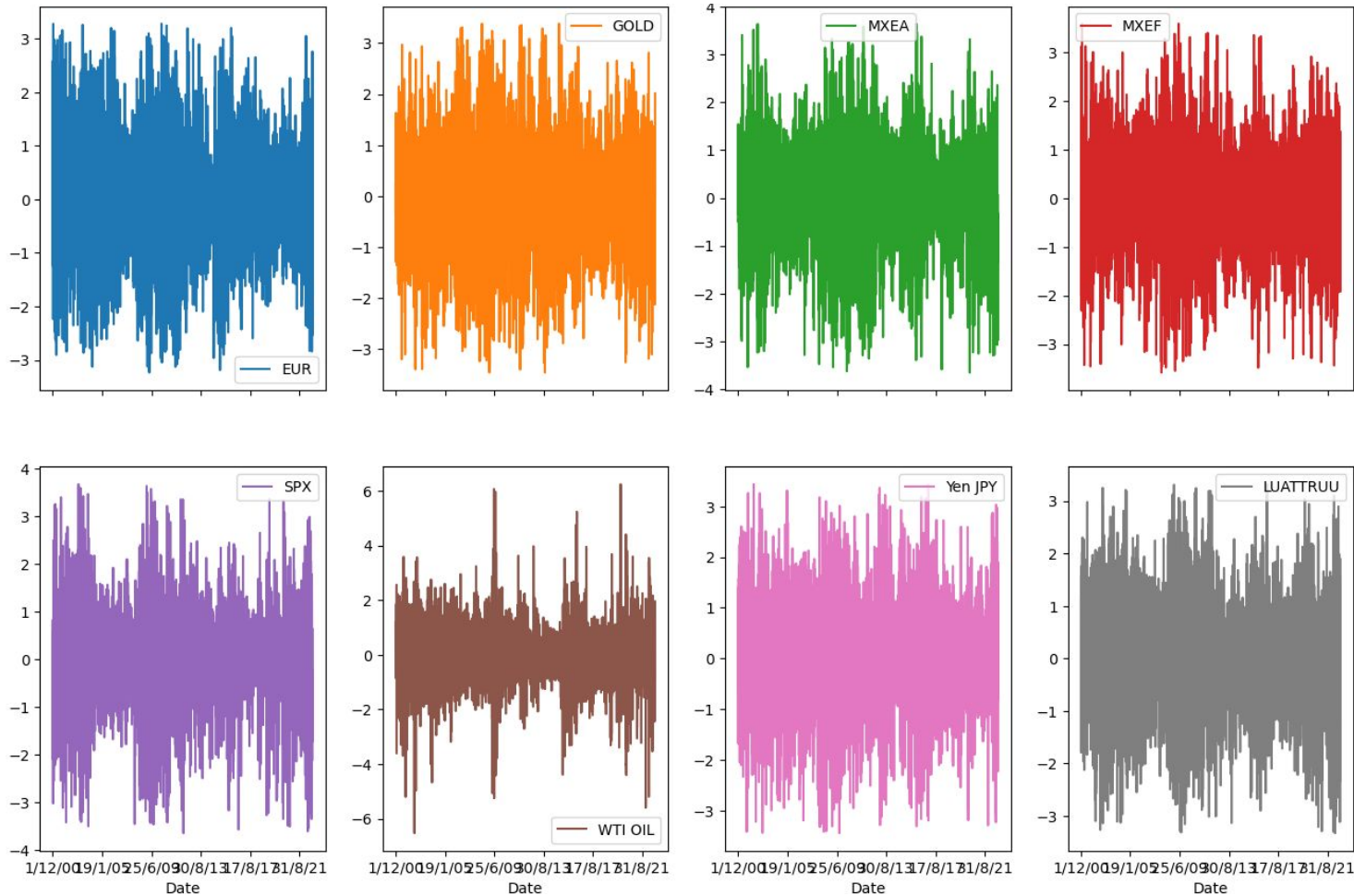
# PCA

## Raw Returns



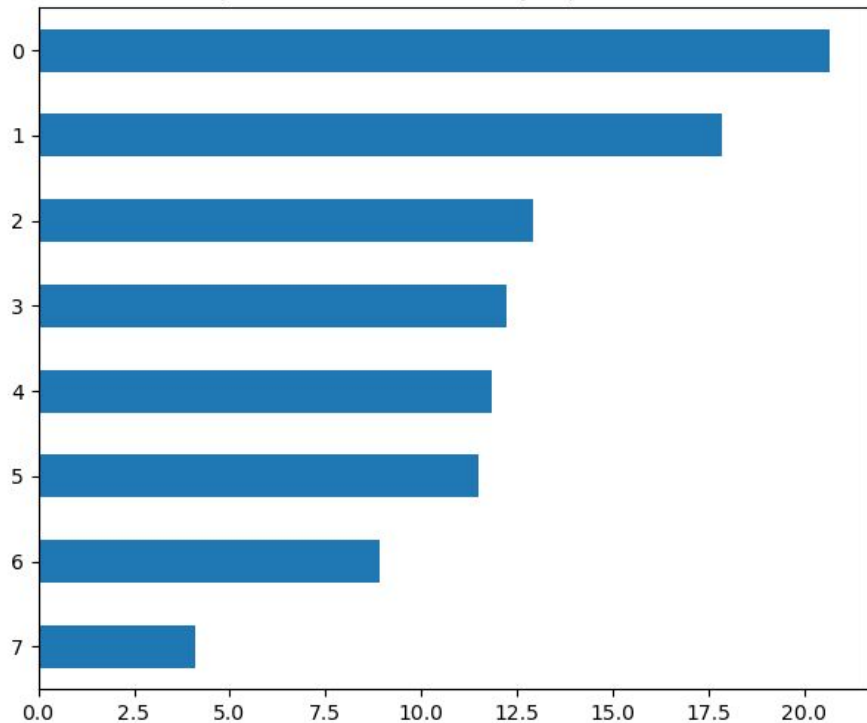
# PCA

Scaled Returns

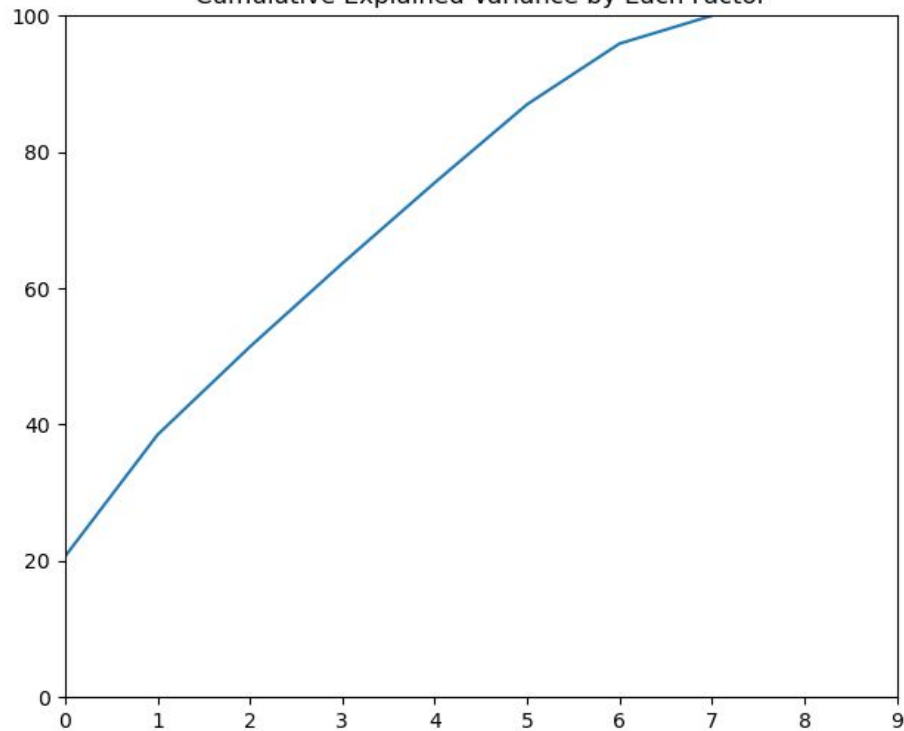


# PCA-Compute all eigenvalues & Vectors from the covariance matrix of the assets

Explained Variance Ratio by Top 10 Factors



Cumulative Explained Variance by Each Factor



## PCA-Optimal Eigen-Portfolio based on Sharpe Ratio

	Annual Return	Annual Vol	Sharpe
0	0.082869	0.086021	0.963350
5	0.107783	0.148574	0.725448
1	0.326191	0.647476	0.503789
2	0.066088	0.189274	0.349165
4	0.062194	0.207628	0.299545
6	0.029581	0.103656	0.285377
3	-0.007854	0.245232	-0.032029
7	-0.973931	3.182749	-0.306003

# PCA-Eigen-Portfolio Weights

	Eigen 0 Weights	Eigen 1 Weights	Eigen 2 Weights	Eigen 3 Weights	Eigen 4 Weights	Eigen 5 Weights	Eigen 6 Weights	Eigen 7 Weights
<b>MXEA</b>	49.305533	36.330146	-4.512397	-5.755196	-0.732559	1.184190	-0.554000	2023.632595
<b>MXEF</b>	48.564009	18.815264	-1.079009	2.528875	-1.096439	-1.302678	2.737167	-2064.033661
<b>EUR</b>	2.748237	-367.675070	-0.054810	-11.211277	8.190093	6.884933	54.264893	92.361357
<b>GOLD</b>	2.693347	-19.242662	117.351213	42.653967	1.422956	-2.085677	-0.699108	89.582277
<b>LUATTRUU</b>	0.862808	14.664325	-26.682613	100.160386	53.813032	-13.212100	1.081178	66.134735
<b>WTI OIL</b>	0.345147	-15.330975	-9.759607	52.645192	-11.607963	74.909854	-6.264232	-25.391769
<b>SPX</b>	0.014375	68.240260	21.440074	-86.858747	54.382879	28.483521	-6.052519	-100.042503
<b>Yen JPY</b>	-4.533455	364.198713	3.297149	5.836801	-4.371999	5.137957	55.486621	17.756966

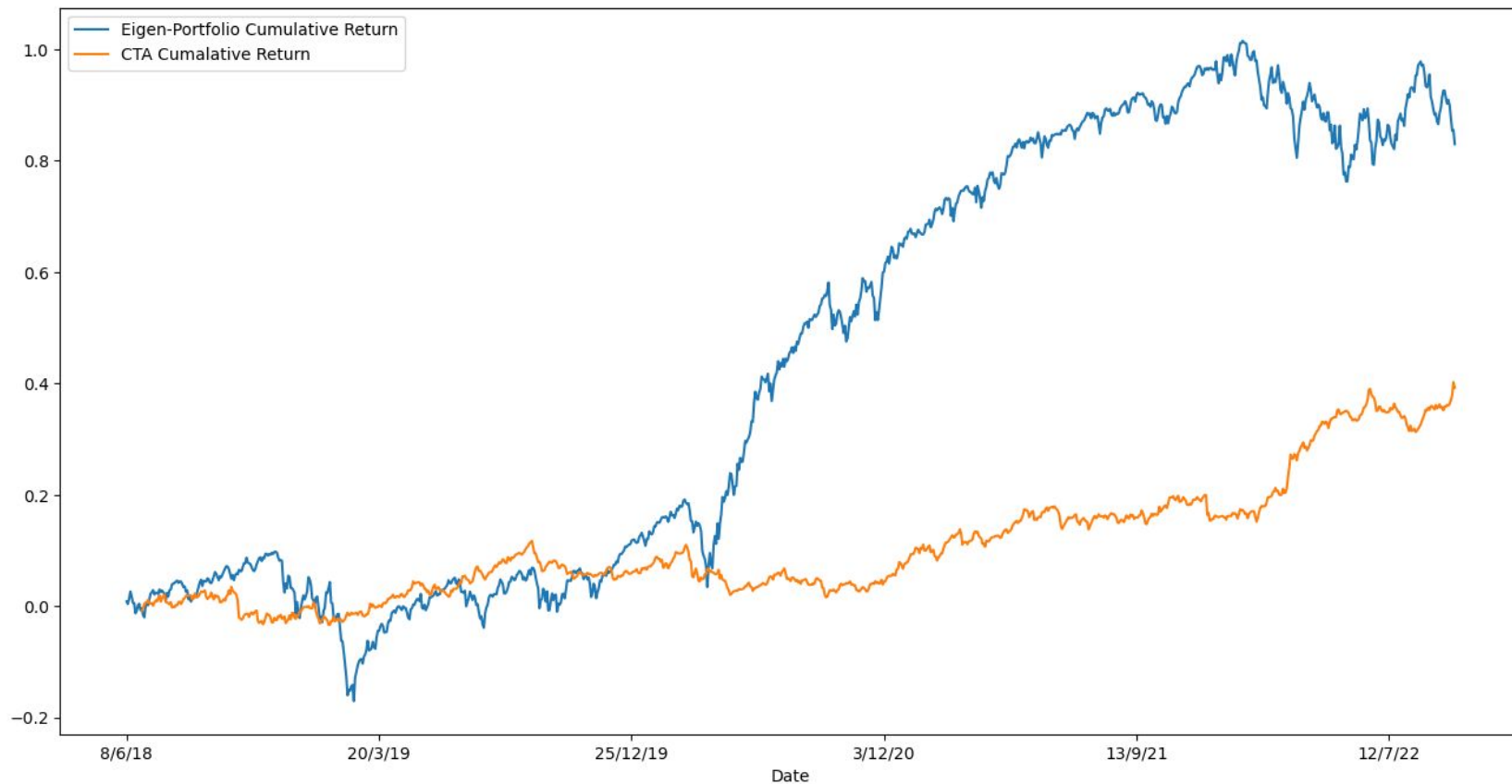
<https://medium.datadriveninvestor.com/practical-applications-of-dimensionality-reduction-portfolio-optimization-cb14aefdbc18>

# PCA-Optimal Eigen-Portfolio [0] Cumulative Return Graph

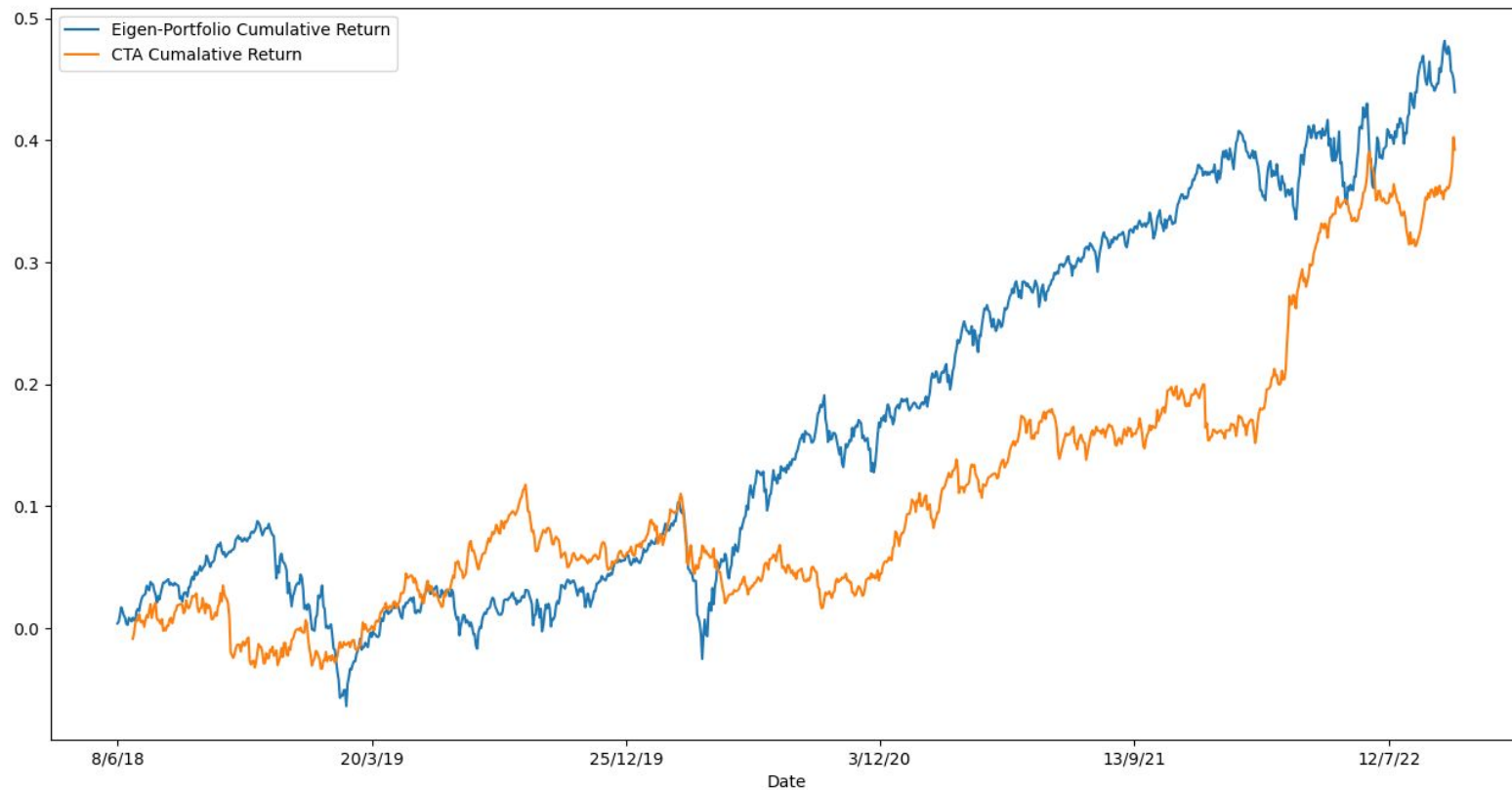




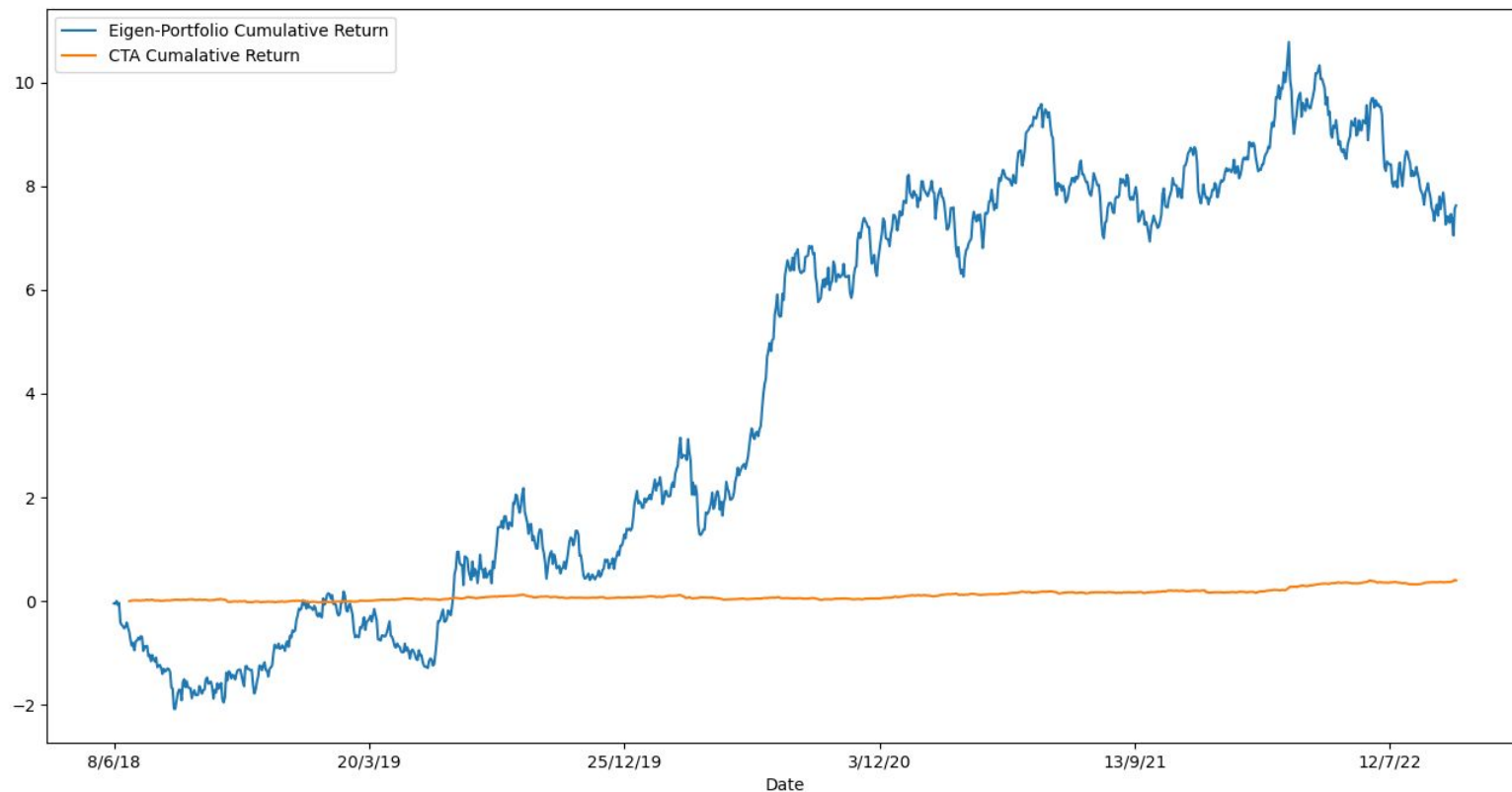
# PCA-Other interesting Eigen-Portfolios[2]



# PCA-Other interesting Eigen-Portfolios[6]



# PCA-Other interesting Eigen-Portfolios[7]: The one with insane weights



# Key Takeaway

- Beta Coefficients of a Linear Regression cannot be directly taken as portfolio weights.
- Tangency portfolio may not be a good model for replication. However, it provide the most efficient portfolio.
- Surprisingly, PCA portfolios give a model that replicated quite close to the index.

# Potential improvements?

- Unsupervised Machine learning models? Currently we are using pre-specified factors (8 factors for the dataset). PCA can be used to determine factors from larger dataset.
- Non-linear relationships between the index and the underlying cannot be replicated using linear models. Explore Generalised Additive Models instead?

**Thank you**

