

Computational Finance

Euro area corporate bond

**Department of Economics and Management "Marco Fanno" University of Padova
A.A. 2015-2016**

**MEF Computational Finance Course.
Prof.Caporin**

**GROUP 5: CLEMENTE CORTILE
ANDREA FRANCO
IOANA STETCO**

Objective and main points:

- “Market” index: Euro area corporate bond index
- Assets: the 5 components of the market by maturity and the total indexes for US, Japan and UK
- Structure an investment process for a new managed portfolio.
- Deal with the steps associated with an investment process: strategic and tactical asset allocation, portfolio risk management etc.
- Use Matlab to implement a quantitative and qualitative analysis.

Presentation outline

Preliminary Analysis

Strategic Asset Allocation

Monthly Tactical Choices

Resampled Efficient Frontier

Chow-Kritzman's Approach

Risk Management (VaR)

Preliminary Analysis



Corporate Bonds



Market



Market VS Market by Maturity



Market VS US, JP, UK



TSS - Daily returns



TSS - Monthly Returns



TSS – 2010-2015 Monthly returns

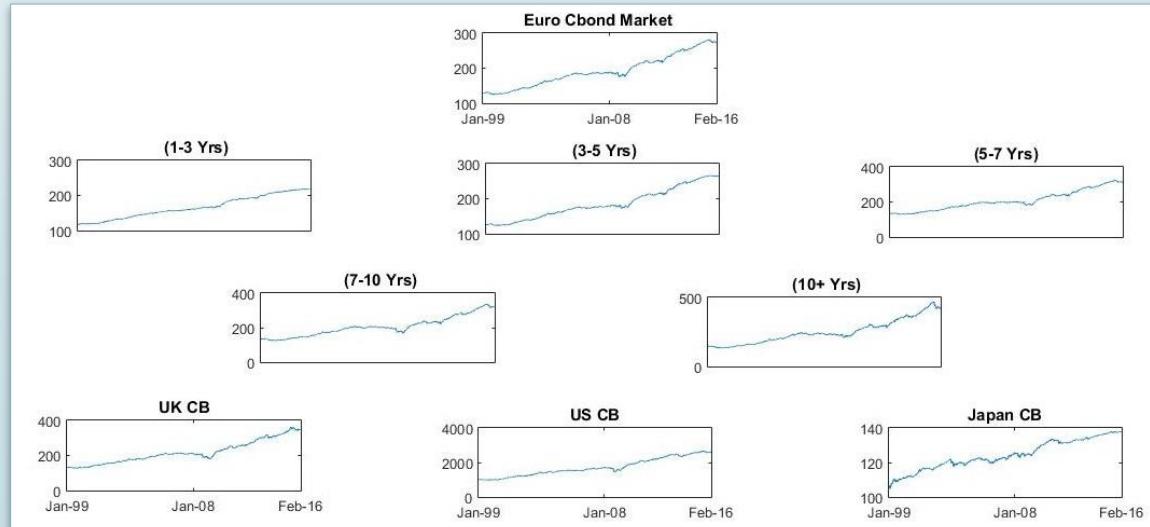


TSS – Market/Benchmark

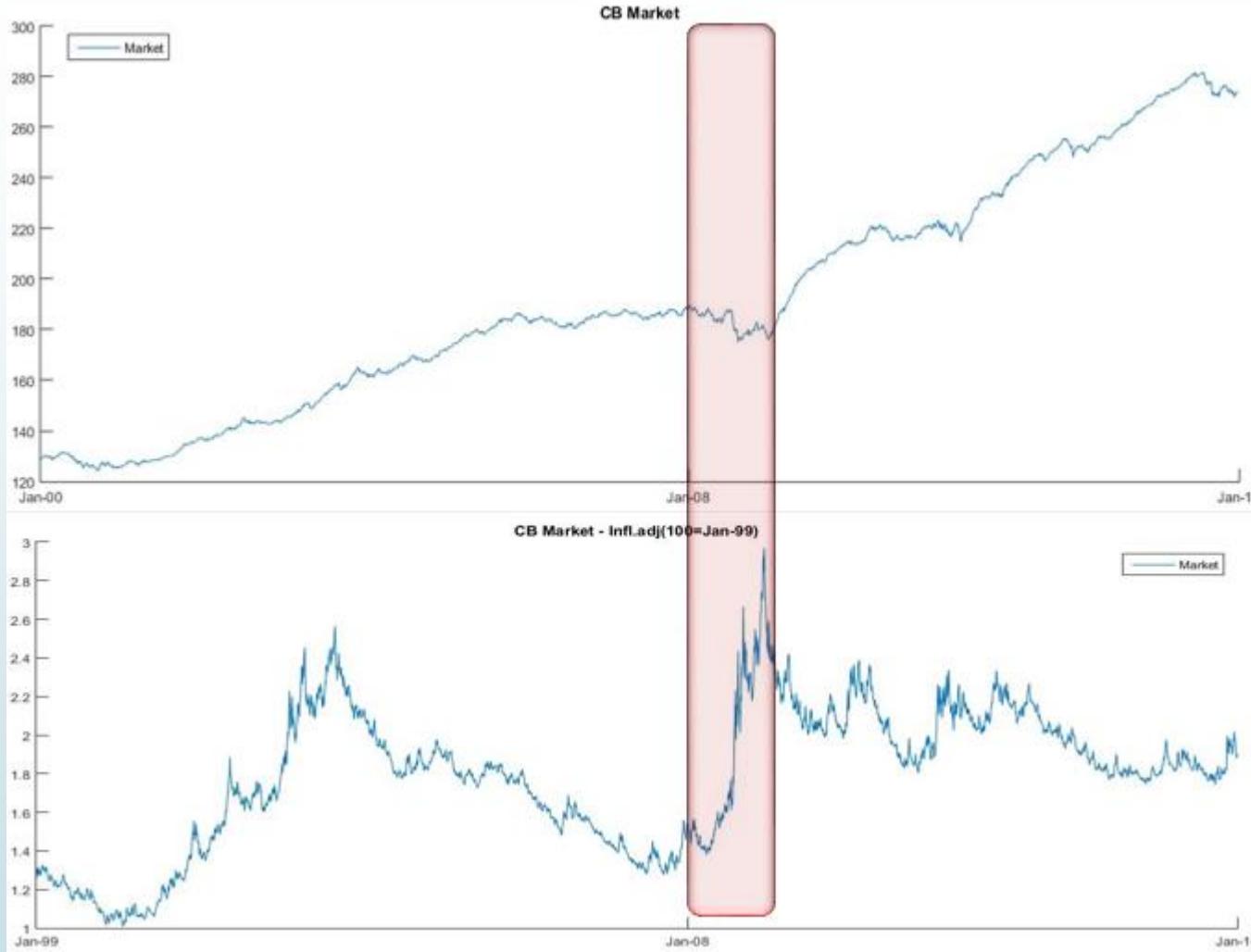
Preliminary Analysis – Corporate Bonds

- Corporate bonds are defined as debt instruments, issued by corporations to finance its own operations.
- Their maturity, which is at least of one year, defines them as long-term debt instruments.
- Mainly traded in dealer-based OTC markets, they're referred to as «Listed Bonds» when traded in official exchanges.

- Benchmark: EU Corporate Bond (less than 1yr maturity - ML EU00)
- Assets#1: Components of benchmark by maturity
- Assets#2: UK US JP Corporate bond indexes



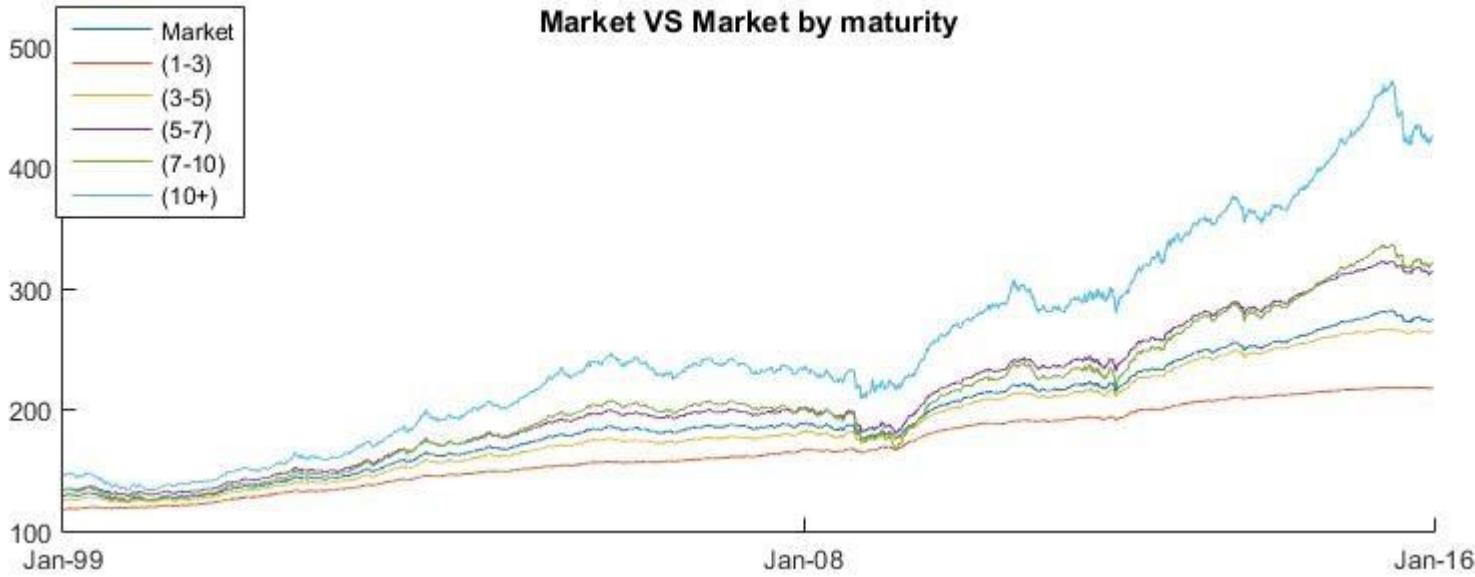
Preliminary Analysis– Market



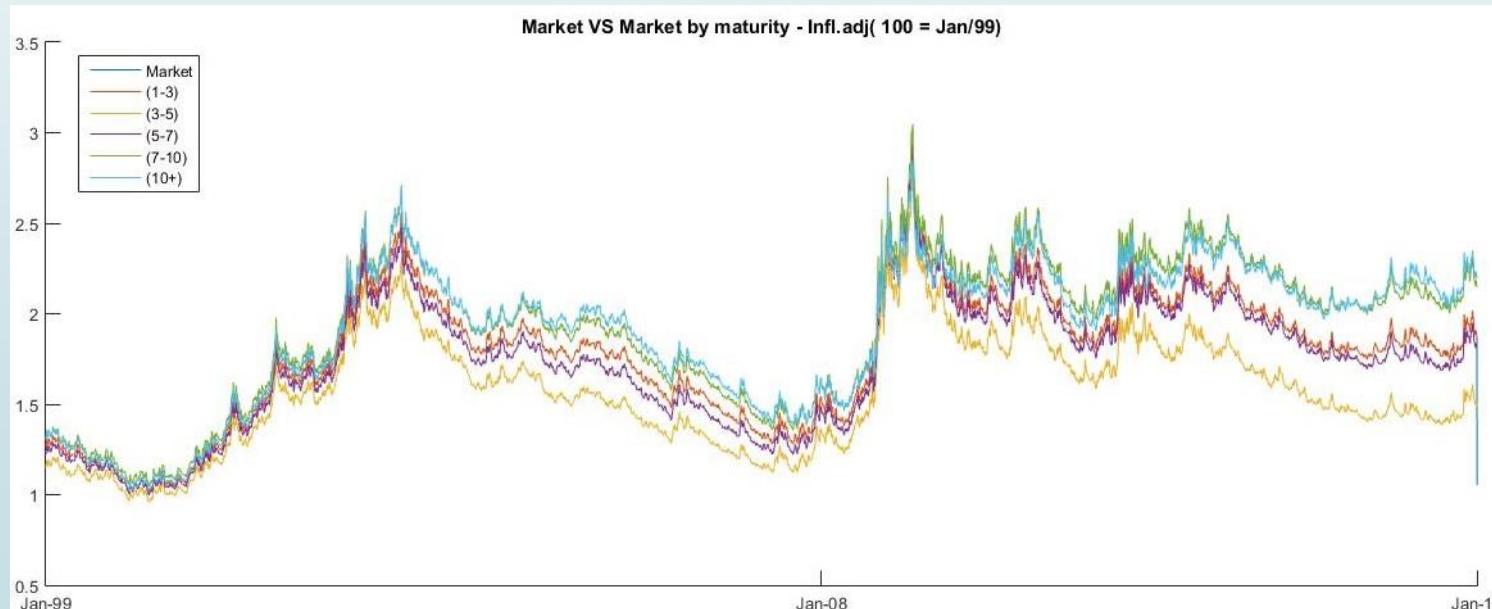
- Market index shows a steady upward trend
- Trend is broken around 2008

- Controlling for inflation (MSCI Index, Jan-99=100)
- Upward trend is caused mainly by inflation
- Average index raises after 2008
- Adj.Index has higher volatility

Preliminary Analysis– Market vs Market-by Maturity

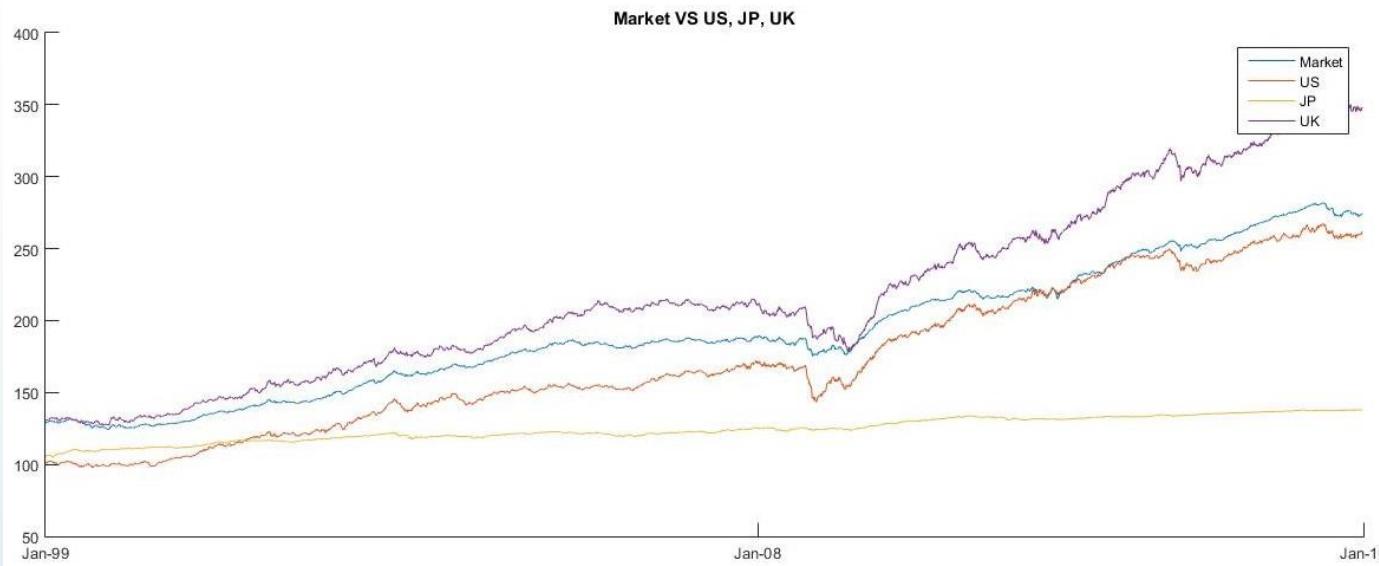


- All indexes show similar upward shifted trends, except for the 10+

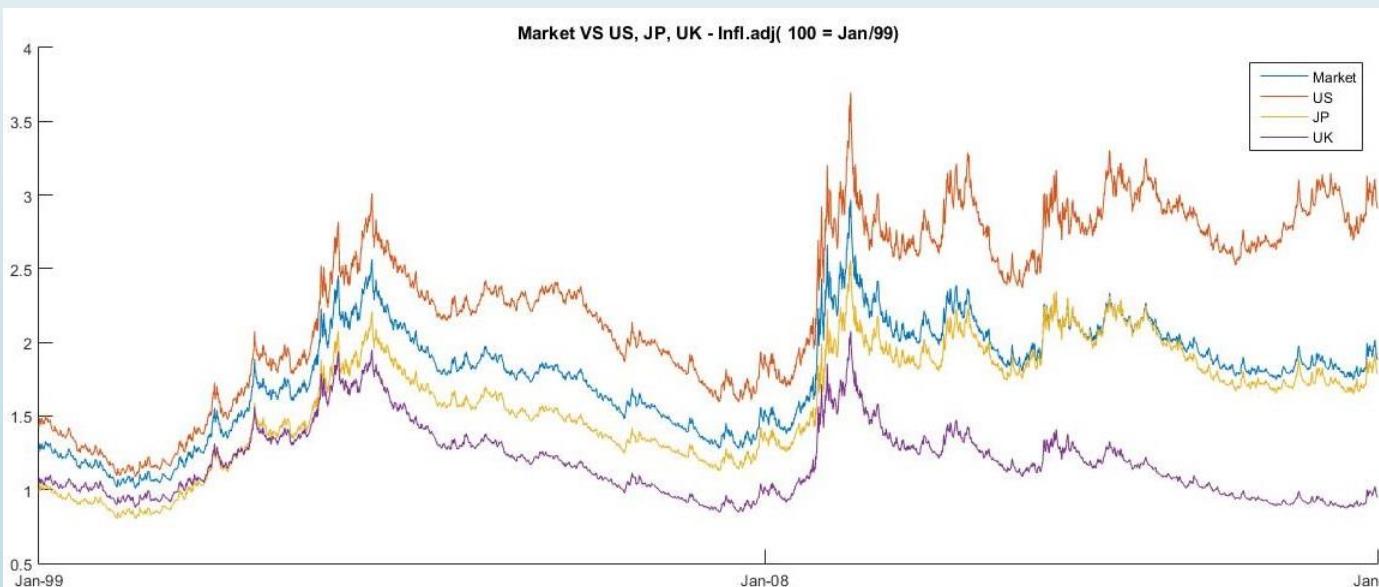


- Adj.Indexes show an even more similar pattern

Preliminary Analysis– Market vs US, JP, UK

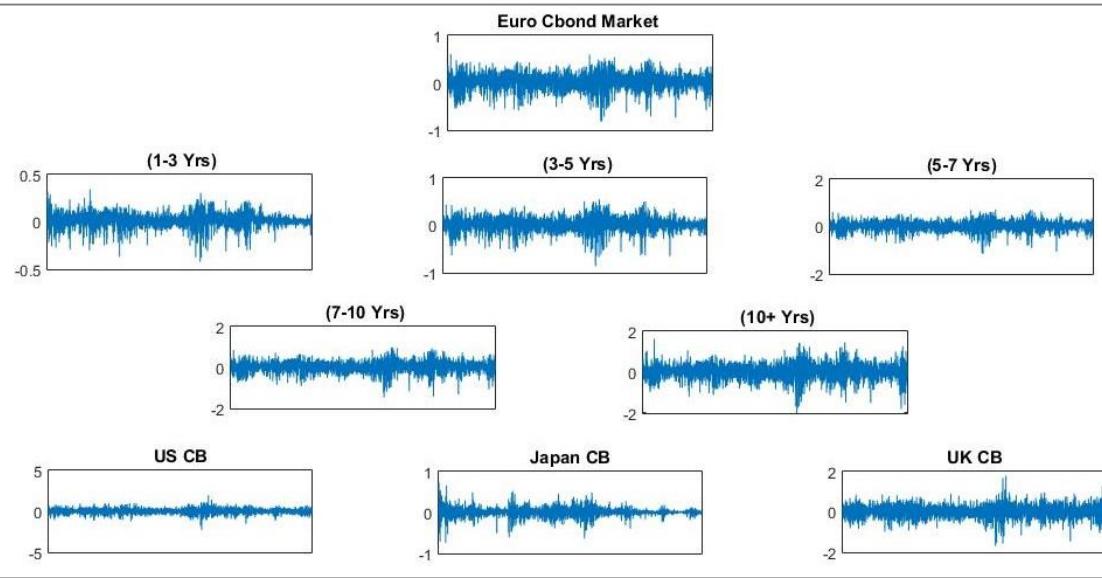


- US and UK present similar, more erratic trends
- EU Market appears more stable than US, UK
- JP index has less similarities with other markets and has lower variability



- Adjusting the indexes for inflation uniforms their behaviour

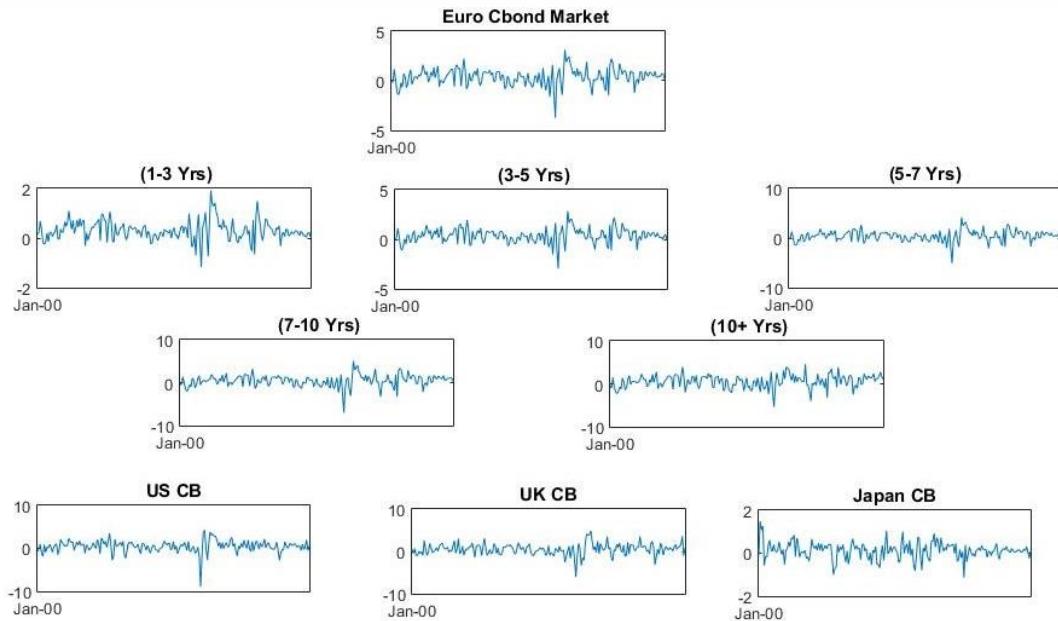
Time Series Statistics – Daily Returns



- Volatility increases with maturity
- US and Jé index presents same volatility as riskier security (7-10 / 10+)
- All indexes have non-central distributional behaviour

	Mean	Median	StDev	Min	Max	Skew	Kurt
Euro Cbond Market	0.02	0.02	0.16	-0.82	0.61	-0.55	4.95
(1-3 Yrs)	0.01	0.01	0.07	-0.42	0.34	-0.61	6.76
(3-5 Yrs)	0.02	0.02	0.14	-0.86	0.55	-0.60	5.93
(5-7 Yrs)	0.02	0.03	0.20	-1.15	0.72	-0.57	5.42
(7-10 Yrs)	0.02	0.03	0.26	-1.46	0.98	-0.51	5.27
(10+ Yrs)	0.03	0.04	0.35	-2.01	1.63	-0.38	5.21
US CB	0.02	0.03	0.31	-2.28	1.99	-0.34	5.35
Japan CB	0.01	0.01	0.10	-0.74	0.74	-0.24	9.36
UK CB	0.02	0.03	0.29	-1.69	1.79	-0.28	5.04

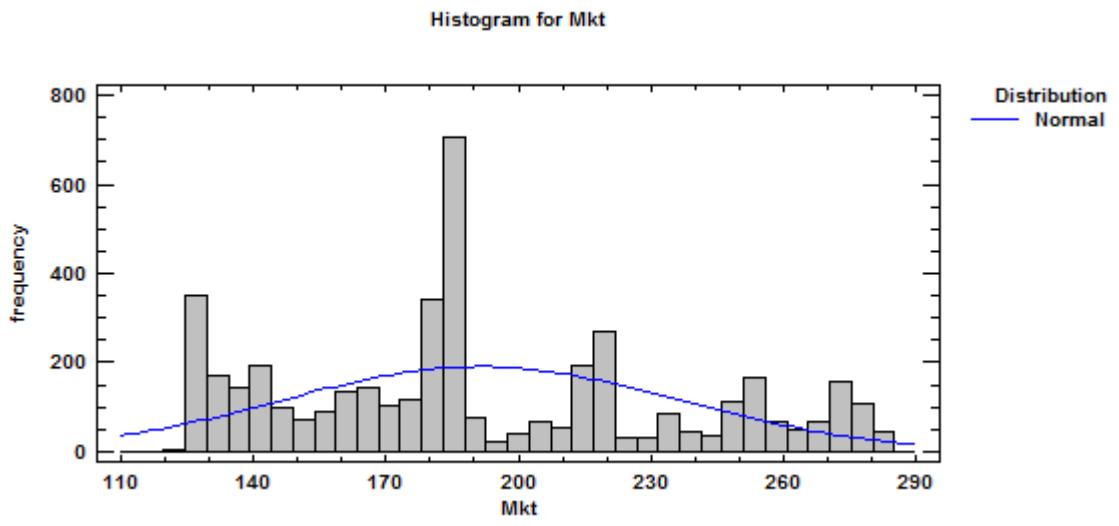
Time Series Statistics – Summary Statistics Monthly Returns



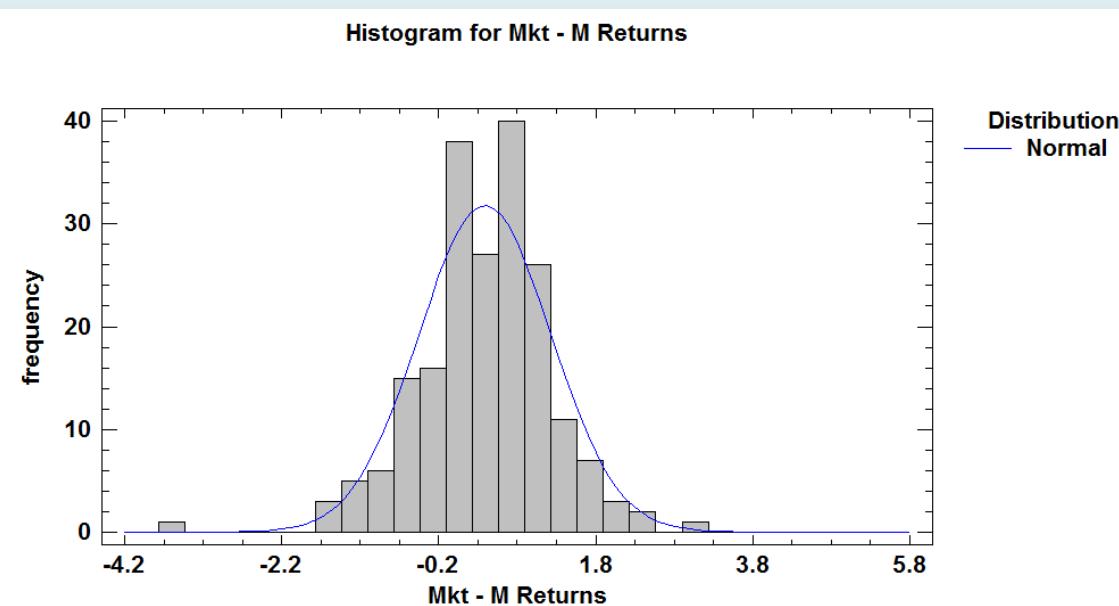
- Converted daily into monthly returns
- StdDev. Increased in comparison to daily
- Skewdness is reduced

	Mean	Median	StDev	Min	Max	Skew	Kurt	StDev	Skew
	—	—	—	—	—	—	—	—	—
Euro Cbond Market	0.39	0.44	0.84	-3.73	3.13	-0.52	5.62	0.16	-0.55
(1-3 Yrs)	0.31	0.28	0.40	-1.18	1.91	0.30	5.19	0.07	-0.61
(3-5 Yrs)	0.38	0.38	0.73	-2.96	2.85	-0.30	5.21	0.14	-0.60
(5-7 Yrs)	0.44	0.52	1.07	-5.04	4.16	-0.50	6.45	0.20	-0.57
(7-10 Yrs)	0.47	0.55	1.39	-7.05	5.02	-0.80	7.22	0.26	-0.51
(10+ Yrs)	0.59	0.76	1.50	-5.41	4.58	-0.43	3.91	0.35	-0.38
US CB	0.49	0.57	1.35	-8.99	4.21	-1.63	14.25	0.31	-0.34
Japan CB	0.13	0.13	0.38	-1.14	1.50	-0.06	4.46	0.10	-0.24
UK CB	0.51	0.57	1.36	-6.06	4.86	-0.35	5.92	0.29	-0.28

Time Series Statistics – Market/Benchmark



- Kolmogorov-Smirnov test on benchmark index rejects the hypothesis that the index is distributed like a normal (95% conf.int., P-value = 0.00)



- Kolmogorov-Smirnov test on benchmark monthly returns fails to rejects the hypothesis that the index is distributed like a normal (95% conf.int., P-value = 0.48)

Time Series Statistics – 2010-2015 Monthly Returns

Full sample Monthly Returns

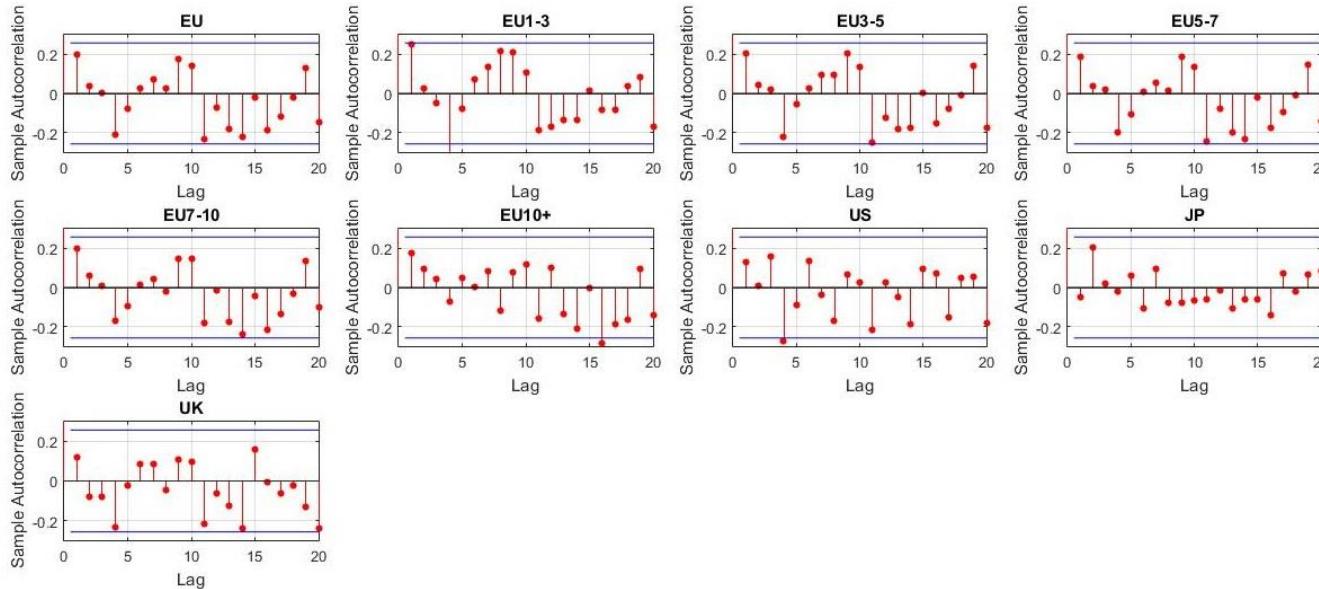
	Mean	Median	StDev	Min	Max	Skew	Kurt
Euro Cbond Market	0.45	0.46	0.75	-1.49	2.23	-0.38	3.81
(1-3 Yrs)	0.24	0.20	0.35	-0.66	1.49	0.55	5.31
(3-5 Yrs)	0.41	0.31	0.67	-1.12	2.19	0.00	3.52
(5-7 Yrs)	0.55	0.54	1.00	-2.08	2.83	-0.33	3.67
(7-10 Yrs)	0.67	0.81	1.33	-3.31	3.36	-0.77	4.45
(10+ Yrs)	0.83	1.22	1.56	-4.02	4.58	-0.58	4.23
US CB	0.50	0.57	0.98	-2.81	2.55	-0.54	4.14
Japan CB	0.07	0.10	0.25	-1.14	0.46	-1.97	10.20
UK CB	0.69	0.89	1.27	-3.17	3.60	-0.31	4.05

- Last 5 years' volatility appears higher than the full sample's average
- Assets's compared risk doesn't change between the two periods
- Skewdness is slightly increased

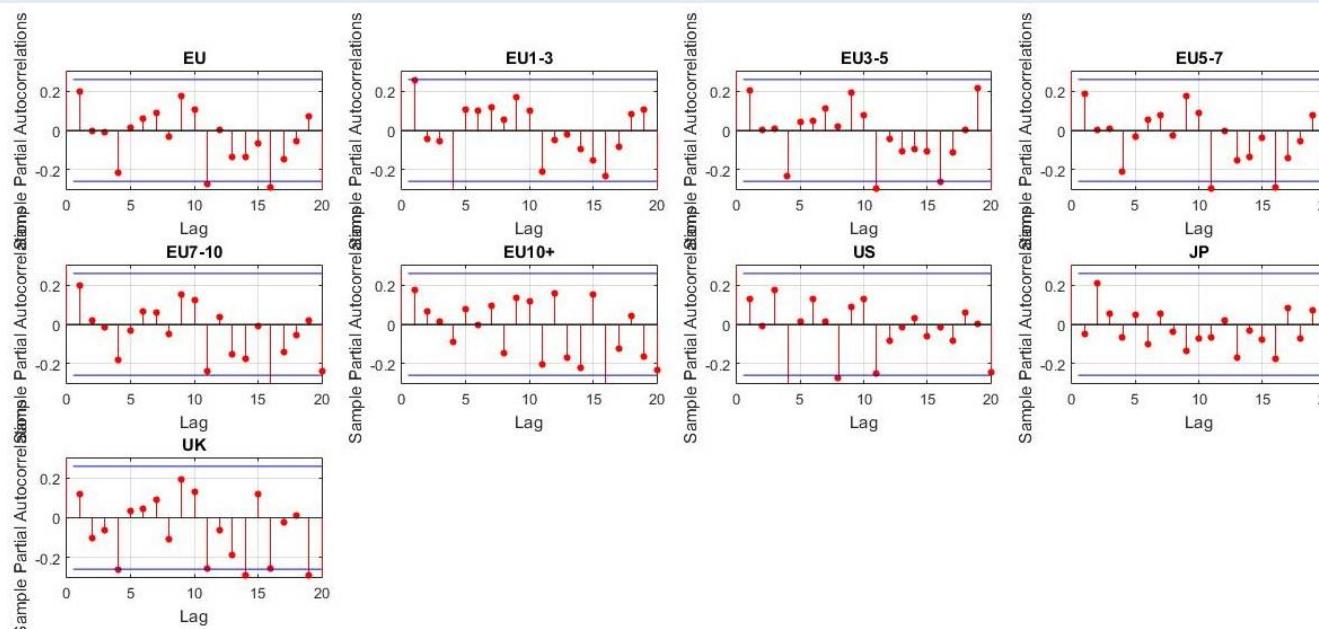
2010-2016 Monthly Returns

	Mean	Median	StDev	Min	Max	Skew	Kurt
Euro Cbond Market	0.39	0.44	0.84	-3.73	3.13	-0.52	5.62
(1-3 Yrs)	0.31	0.28	0.40	-1.18	1.91	0.30	5.19
(3-5 Yrs)	0.38	0.38	0.73	-2.96	2.85	-0.30	5.21
(5-7 Yrs)	0.44	0.52	1.07	-5.04	4.16	-0.50	6.45
(7-10 Yrs)	0.47	0.55	1.39	-7.05	5.02	-0.80	7.22
(10+ Yrs)	0.59	0.76	1.50	-5.41	4.58	-0.43	3.91
US CB	0.49	0.57	1.35	-8.99	4.21	-1.63	14.25
Japan CB	0.13	0.13	0.38	-1.14	1.50	-0.06	4.46
UK CB	0.51	0.57	1.36	-6.06	4.86	-0.35	5.92

Time Series Statistics – Monthly Returns



- All returns appear to have a stationary behaviour
- PACF significant lag correlations appear above four lags



Time Series Statistics – Monthly Returns

ARMAX model. $Y = \text{mkt return}$, $X = \text{mkt by maturity}$

ARIMA Model Summary

Parameter	Estimate	Stnd. Error	t	P-value
AR(1)	1.09201	0.0496798	21.9809	0.000000
MA(1)	0.945206	0.0715782	13.2052	0.000000
1-3	0.106991	0.0542097	1.97365	0.053645
3-5	0.328791	0.0629718	5.22124	0.000003
5-7	0.182741	0.0497562	3.67274	0.000559
7-10	0.237121	0.0220492	10.7541	0.000000
Mean	0.0142032	0.0129641	1.09558	0.278214
Constant	-0.00130677			

- Mkt by maturity X-set is statistically significant in an ARMA model of the mkt returns
- US,JP,UK are not statistically significant, even in a 4 lag model

ARMAX model. $Y = \text{mkt return}$, $X = 10+\text{CB}, \text{US}, \text{JP}, \text{UK}$

ARIMA Model Summary

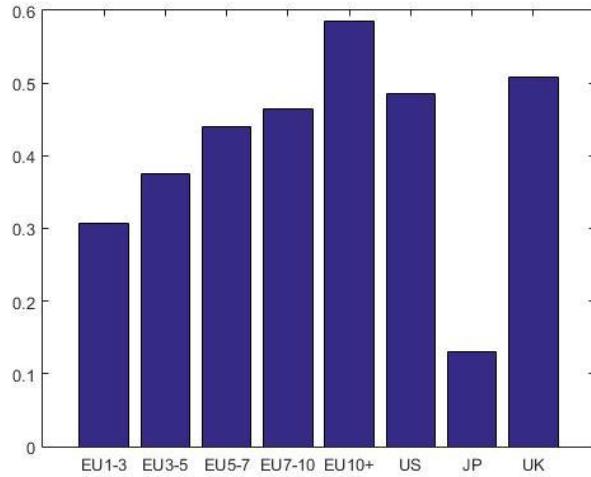
Parameter	Estimate	Stnd. Error	t	P-value
AR(1)	-0.134429	0.117054	-1.14843	0.256602
AR(2)	-0.210892	0.101144	-2.08508	0.042520
AR(3)	-0.0851647	0.100081	-0.85096	0.399107
AR(4)	-0.832324	0.0986221	-8.43953	0.000000
MA(1)	-0.31769	0.129154	-2.45977	0.017637
MA(2)	-0.39319	0.0998777	-3.93672	0.000272
MA(3)	-0.543504	0.115538	-4.70412	0.000023
MA(4)	-0.801192	0.152455	-5.25526	0.000004
10+	0.417796	0.0388982	10.7408	0.000000
US	0.0131485	0.0874492	0.150356	0.881127
JP	-0.240368	0.128187	-1.87514	0.066995
UK	0.00929165	0.0672212	0.138225	0.890653
Mean	0.110751	0.0520014	2.12978	0.038456
Constant	0.250609			

Strategic Asset Allocation (Sample moments)

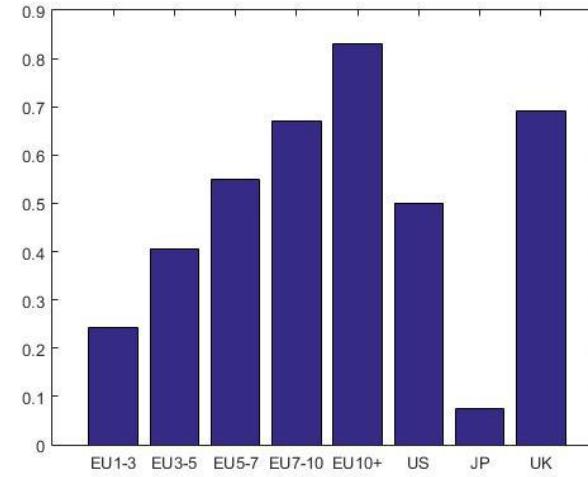
- Full vs 5 years Monthly Returns
- Full vs 5 years, GMV & Max TO
- Matlab code for MaxSh and EQW prfs
- Efficient Frontier (last 5 years sample, no weight restriction, $rf = 0, 1$)
- Efficient Frontier (last 5 years sample, no weight restriction, $rf = 0,025$)
- Efficient Frontier (last 5 years sample, non negative weight restriction, $rf < 0,02$)
- Efficient Frontier (last 5 years sample, Unconstrained vs Constrained Comparison)
- Efficient Frontier – Weights/Risk Area Plot
- Matlab code for weight search on EF

Strategic Assets Allocation – full vs 5 yrs, monthly returns

Full sample
Mean

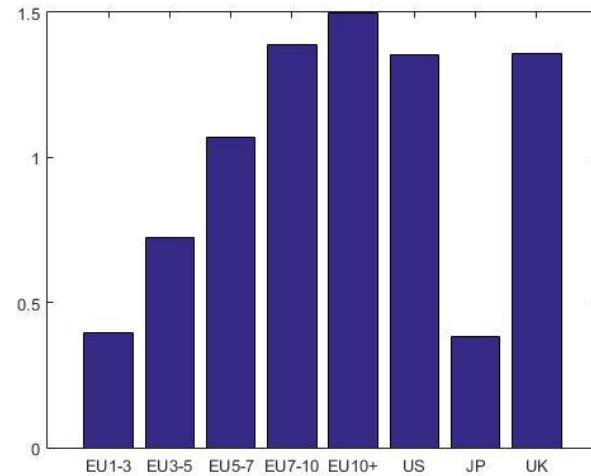


Last 5 years
Mean

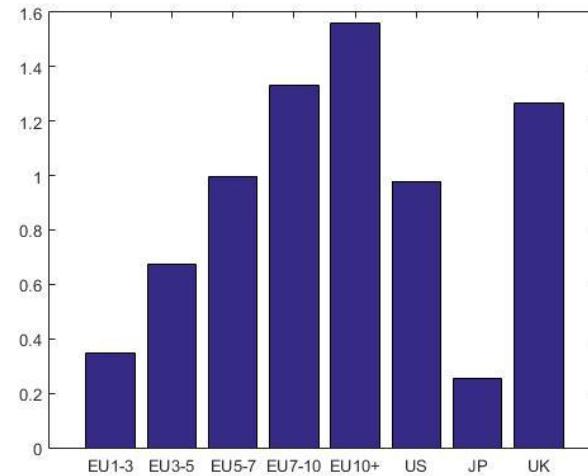


- Last 5 years sample has overall higher mean and cov

Cov



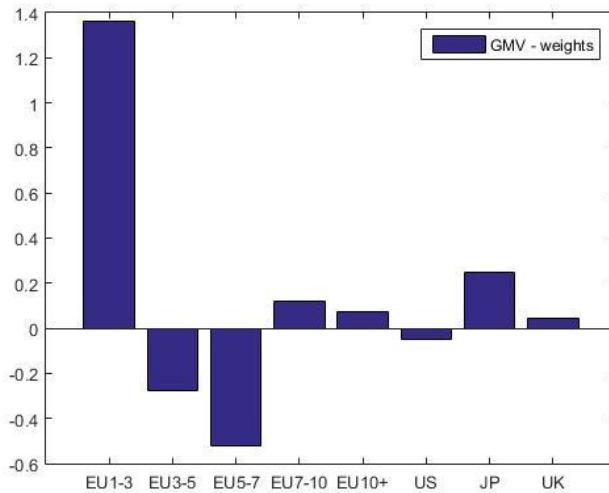
Cov



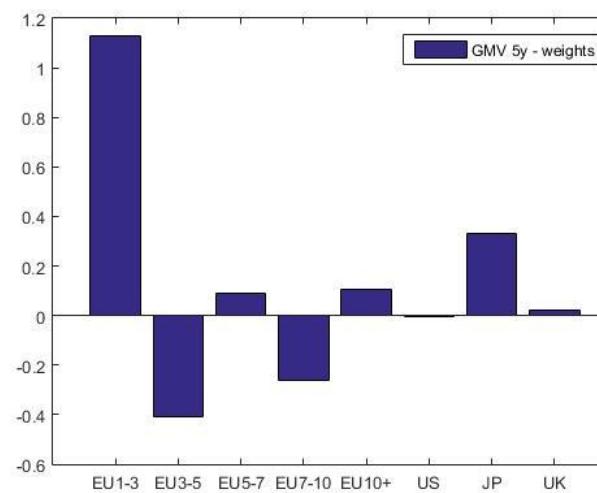
- Correlation between EU returns do not change over the two samples
- US cov and returns drops in the last five years sample

Strategic Assets Allocation – full vs 5 yrs, GMV & MaxTO

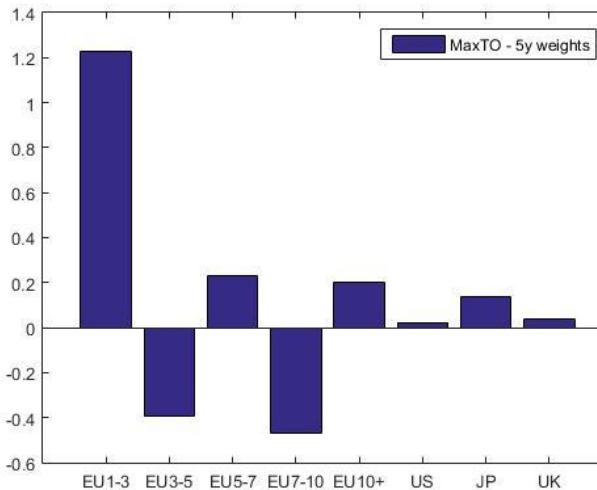
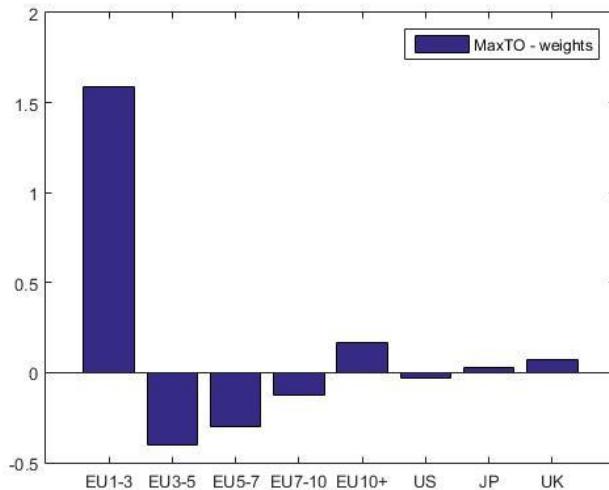
Full sample



Last 5 years



- Scale differs across samples
- GMV Mv cov approach minimizes long positions on high risk assets (EU10 and US)



- MaxTO for the full sample is mostly focused on long position for EU1-3 (the closest asset to the benchmark)

Strategic Assets Allocation

Matlab code for MaxSh and EQW prfs

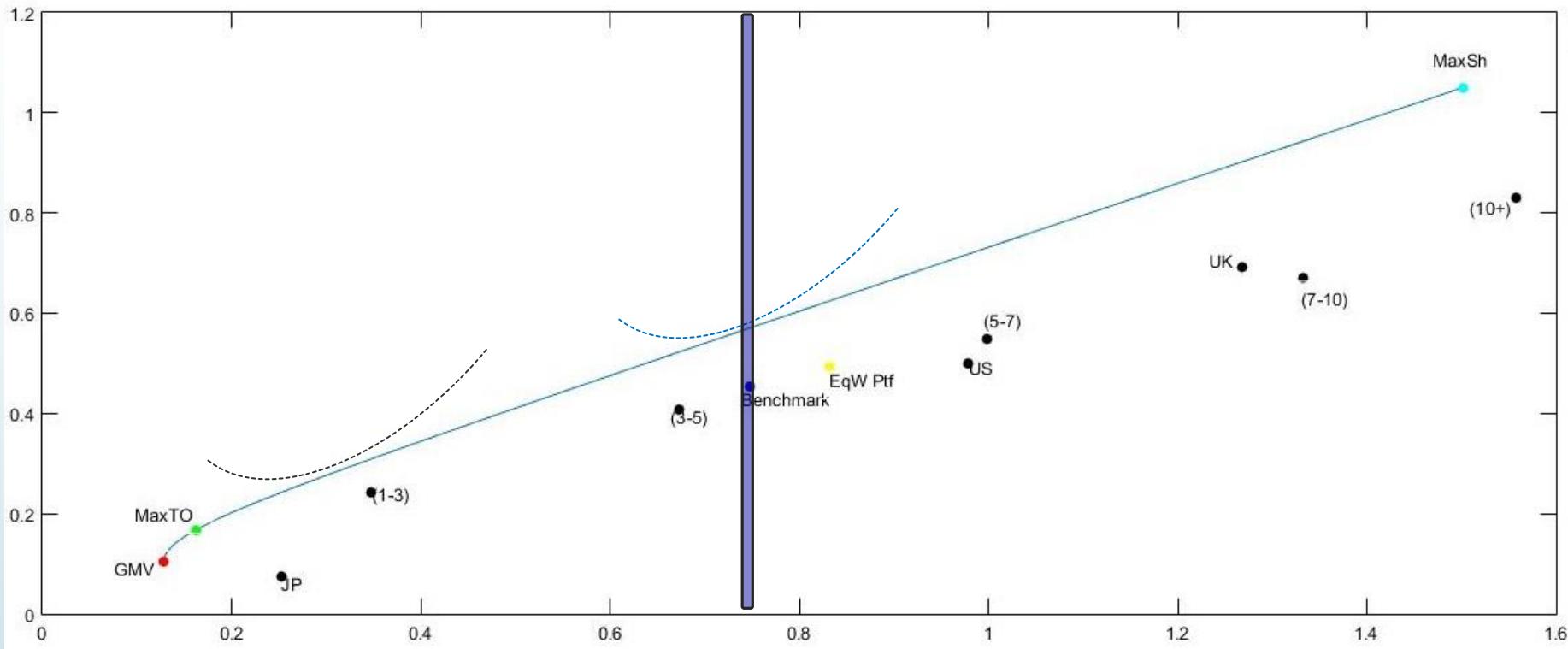
```
153 %Sharpe Ratio computation for all EF ( SRef array )
154 %and MAX Sharpe Ratio computation ( with pointer rr,rs )
155 -
156 SRef = 0;
157 SRmax = 0;
158 SRmaxP = 0;
159 flag = 0;
160 for SRindex = 1:size(rr, 1);
161     SRef(SRindex) = (rr(SRindex)- rf)/rs(SRindex);
162     if SRindex == 1
163         SRmax = SRef(SRindex);
164     end;
165     if SRmax < SRef(SRindex)
166         SRmax = SRef(SRindex);
167         flag = 1;
168         if flag == 1
169             SRmaxP = SRindex;
170         end;
171     end;
172 end;
173 end;
174 SRmax_s = rs(SRmaxP);
175 SRmax_r = rr(SRmaxP);
```

```
181 %Equally weighted portfolio
182 EQWsum = 0;
183 rEQW = 0;
184 for EQWrowi = 1:size(rM5,1)
185     for EQWcolumni = 2:size(rM5,2)
186         EQWsum = (rM5(EQWrowi,EQWcolumni))+EQWsum;
187         EQWcolumni = EQWcolumni+1;
188     end;
189     rEQW(EQWrowi,1) = (EQWsum/((size(rM5,2)-1)));
190     EQWsum = 0;
191 end;
192 retEQW = (mean(rEQW));
193 sEQW = std(rEQW);
```

Strategic Assets Allocation

Efficient Frontier with Sample Moments

Last 5 years sample ($R_f = 0.1$), No weight restriction



- EF portfolios outperform the benchmark
- Benchmark is composed only by CB with less than one-year maturity

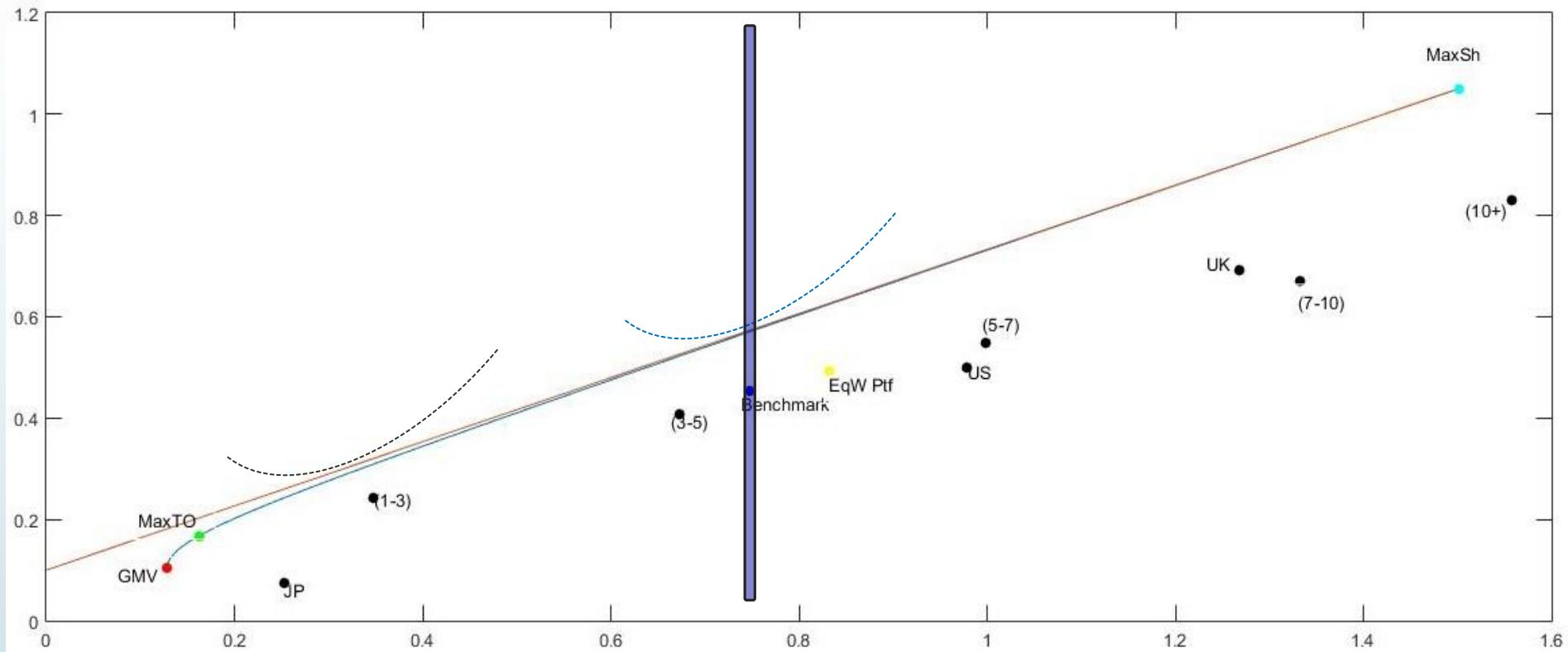
- Alternative Equally-weighted portfolio benchmark is outperformed as well
- UK prtf Sharpe ratio > US prtf Sharpe ratio

- Potential overestimation of risk (or underestimation of return) by sample moment method due to highrisk/lowreturn ratio.
- Ex benchmark (rs/rr) = (70%/40%)

Strategic Assets Allocation

Efficient Frontier with Sample Moments

Last 5 years sample ($R_f = 0.1$), No weight restriction

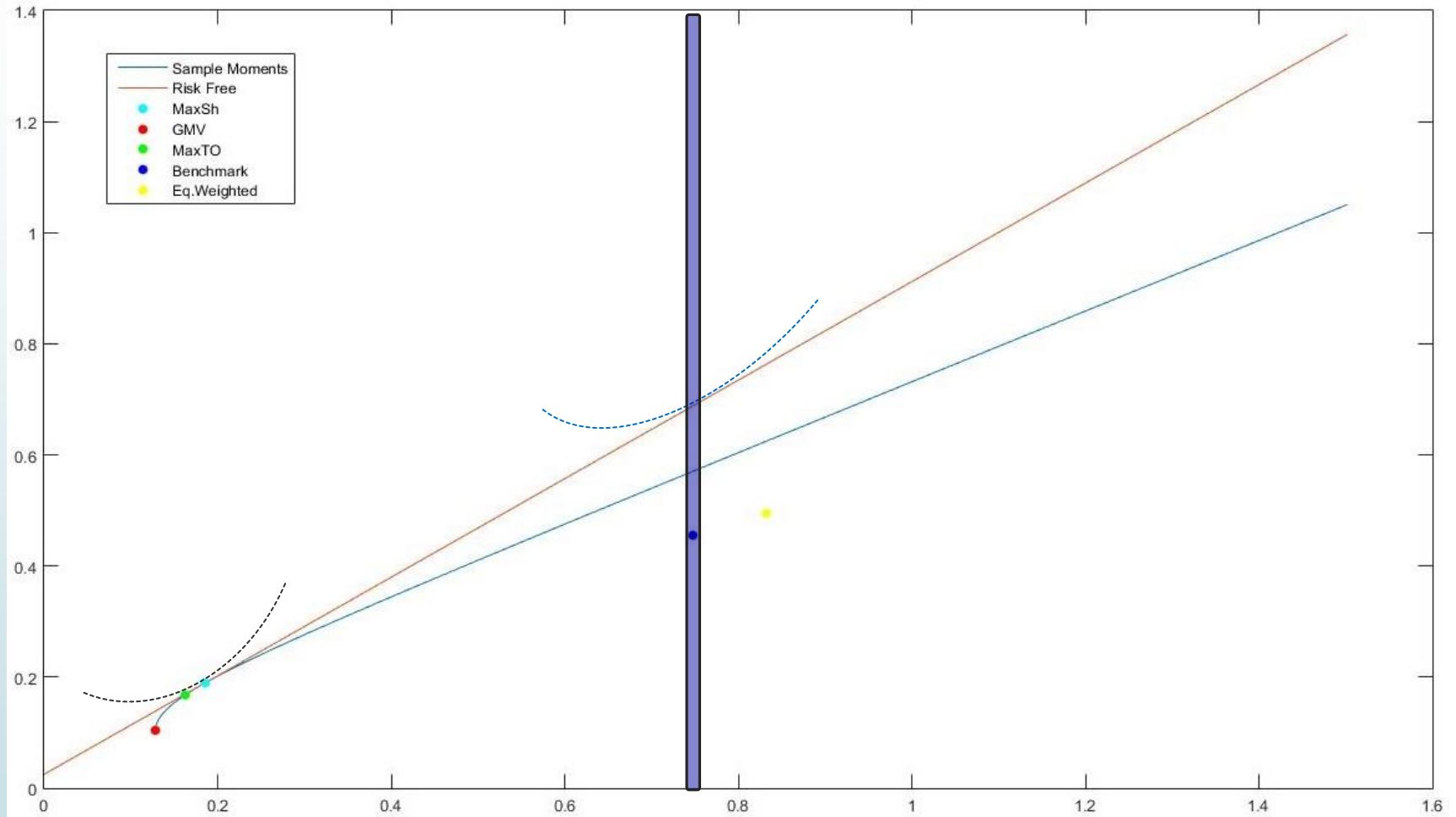


- R_f added
- R_f and EF are almost overlapped.

Strategic Assets Allocation

Efficient Frontier with Sample Moments

Last 5 years sample ($R_f = 0.025$), No weight restriction

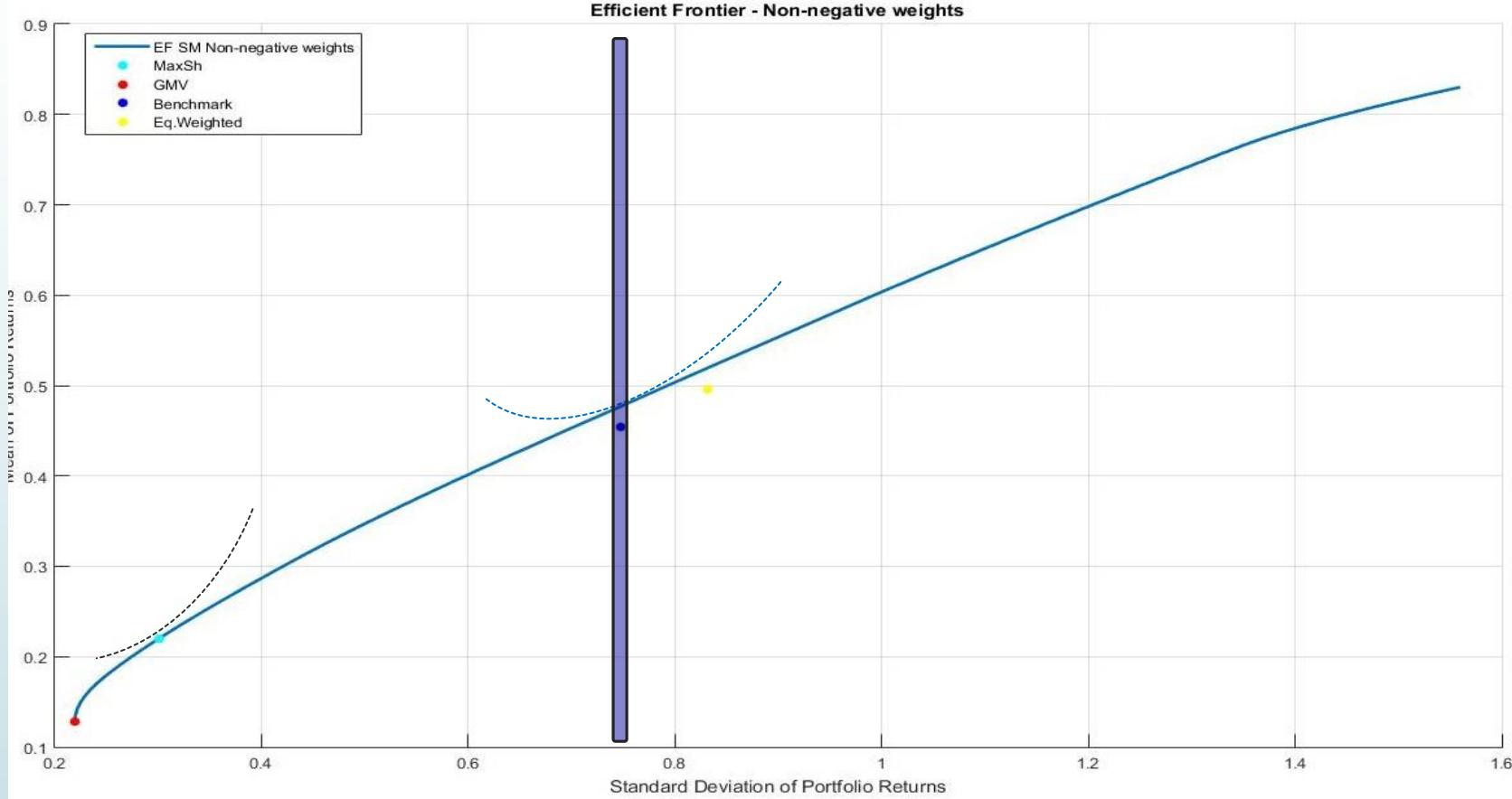


- Lowering R_f (3-month USTreasury Bill rate) sets the MaxSh Portfolio to a lower risk-return point
- Benchmark returns are well below R_f returns. Overall SM Mkv seems to estimate Corporate bonds as risky (Ex: $r_s/r_r = 70\%/40\%$)

Strategic Assets Allocation

Efficient Frontier with Sample Moments

Last 5 years sample ($R_f < 0.02$), non-negative weight restriction

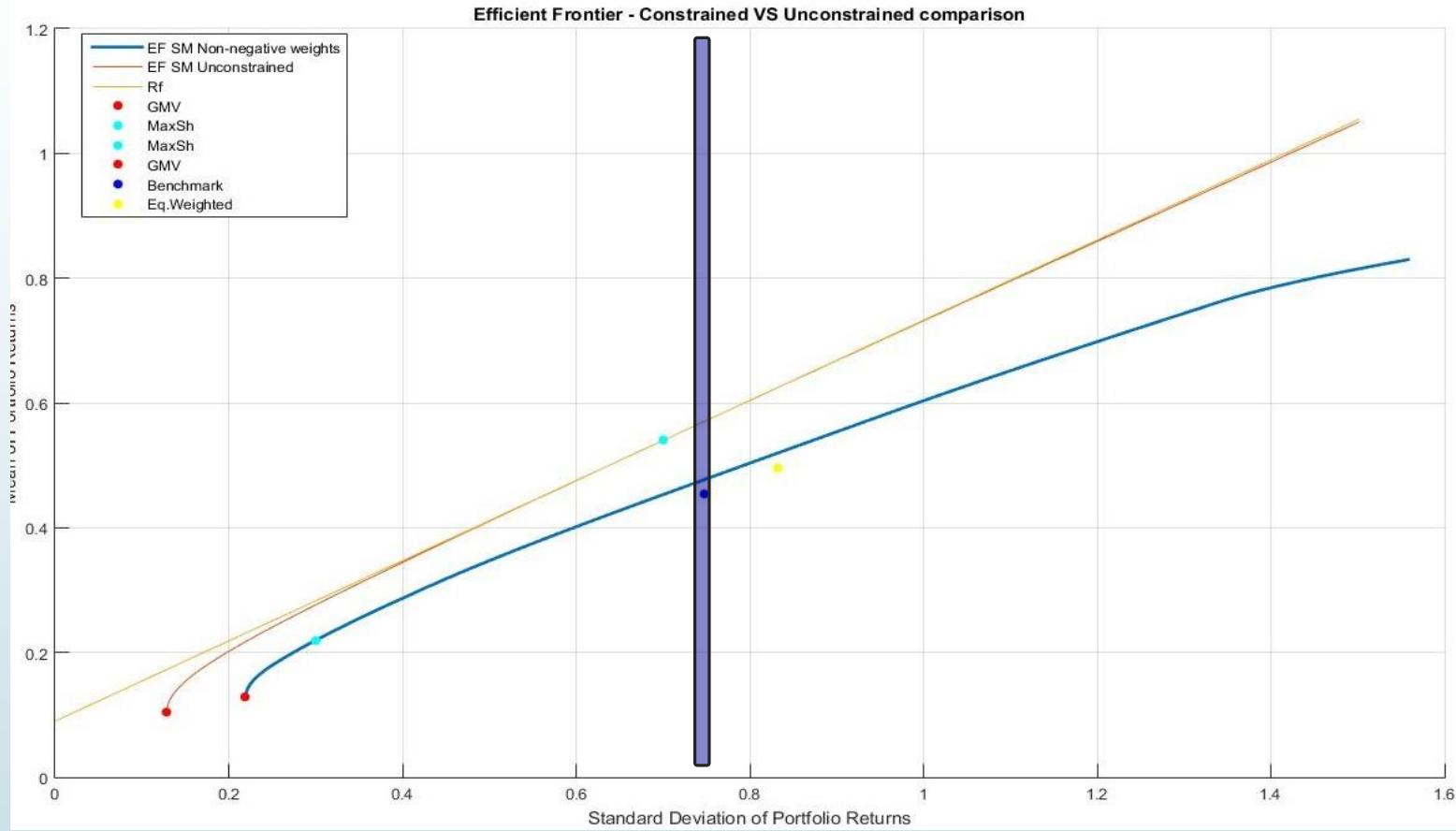


- EF with non-negative weights restriction is right-shifted, closer to the benchmark

Strategic Assets Allocation

Efficient Frontier with Sample Moments

Last 5 years sample Unconstrained vs Constrained comparison

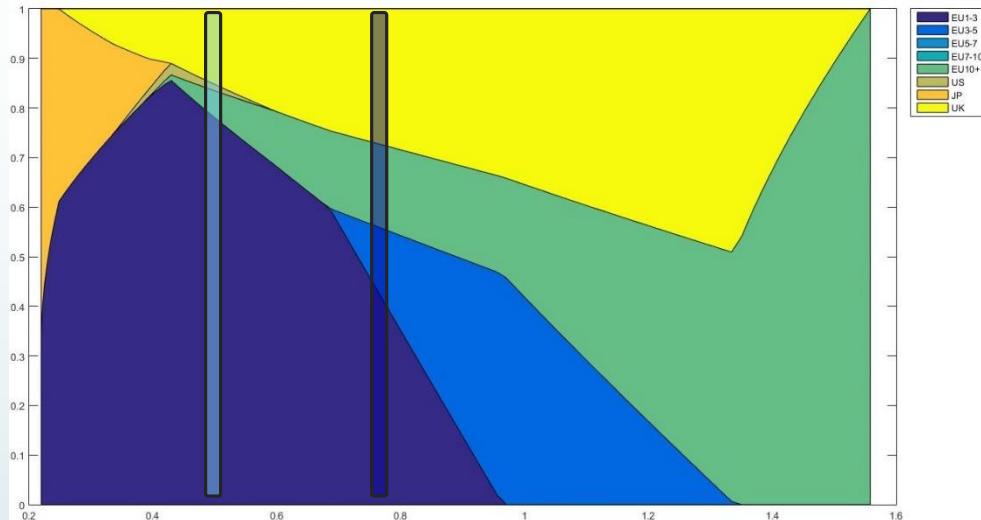


- EF with non-negative weights restriction is right-shifted, closer to the benchmark
- $R_f = 0.09$ for unconstrained EF, $R_f < 0.02$ for constrained EF

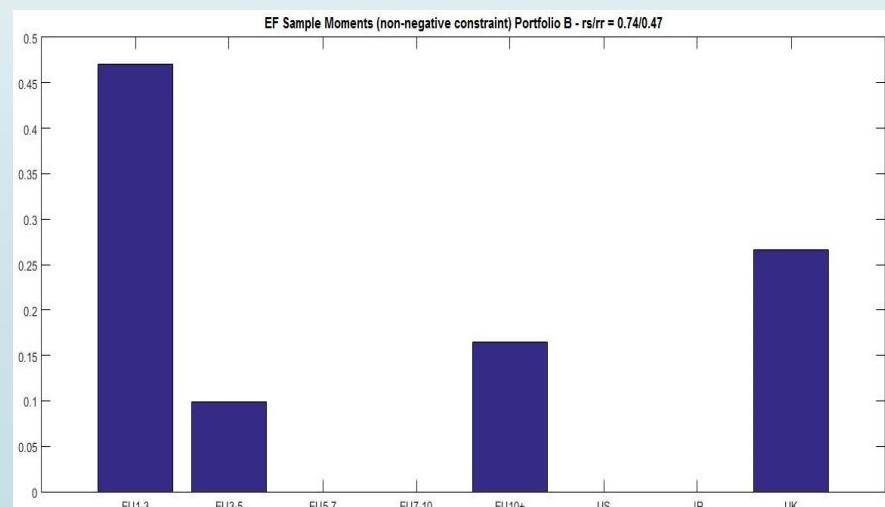
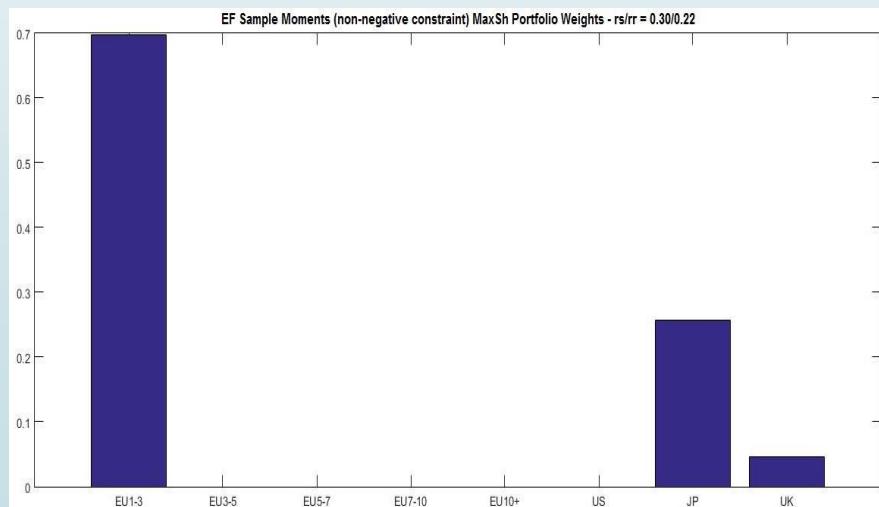
Strategic Assets Allocation

EF SM – Weights/risk area plot

Last 5 years sample



- Portfolio B from constrained EF has an higher degree of diversification, but it's riskier
- MaxSh Portfolio is made up by EU1-3 assets for 70%, also low on diversification
- Both heavily invest on EU1-3



Strategic Assets Allocation

Matlab code for weight search on EF

```
311 %search for specific portfolio weight in constrained EF ( given stdev)
312 - target = prskMS;           %Target std
313 - stop1 = size(prisk(:,1));
314 - dist= size(prisk(:,1));    %looking for min distance
315 - fnd = [];
316 - wtgindex = [];           %weight index searcher
317 - for i=1:stop1
318 -     dist(i,1)=abs(target - prisk(i,1));
319 -     if (i<1)
320 -         fnd = dist(i,1);
321 -     end;
322 -     if (i>1)
323 -         if (dist(i,1)<dist(i-1))
324 -             fnd = dist(i,1);
325 -             wtgindex = i;
326 -         end;
327 -     end;
328 - end;
329 - tgtprt = pwgt(:,wtgindex); %storing closest weight from frontier
330 - porttgt2rs = prisk(wtgindex);
331 - porttgt2rr = pret(wtgindex);
332 - approx1 = fnd;
```

Strategic Asset Allocation (Equilibrium Moments)

Unconstrained Equilibrium
Moments Comparison

Constrained Equilibrium
Moments Comparison

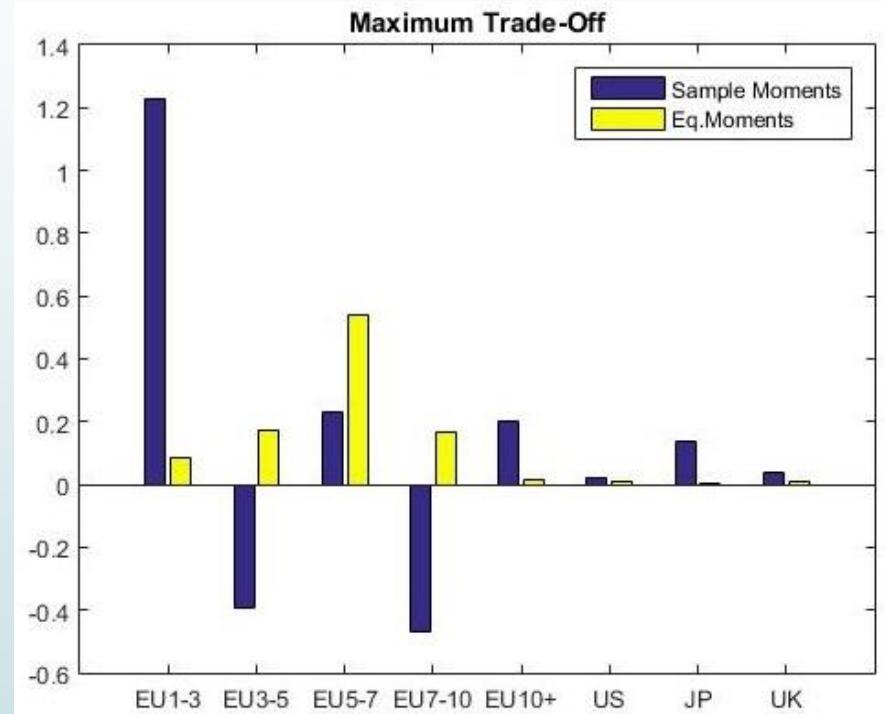
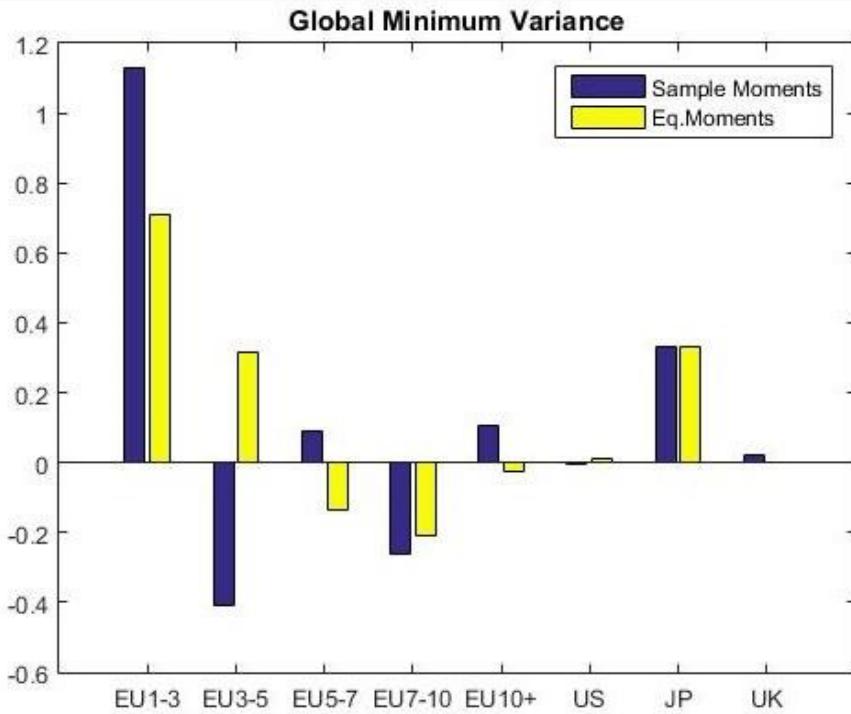
*EF Constrained Eqilibrium
Moments – Weights/risk
area plot*

Strategic Assets Allocation

Uncon.Equilibrium moment comparison

```
% compute optimal portfolios by means of equilibrium returns  
MMeb=eqret';  
MVebe=beta'*beta'+vmeq+diag(diag(cov(resid)));
```

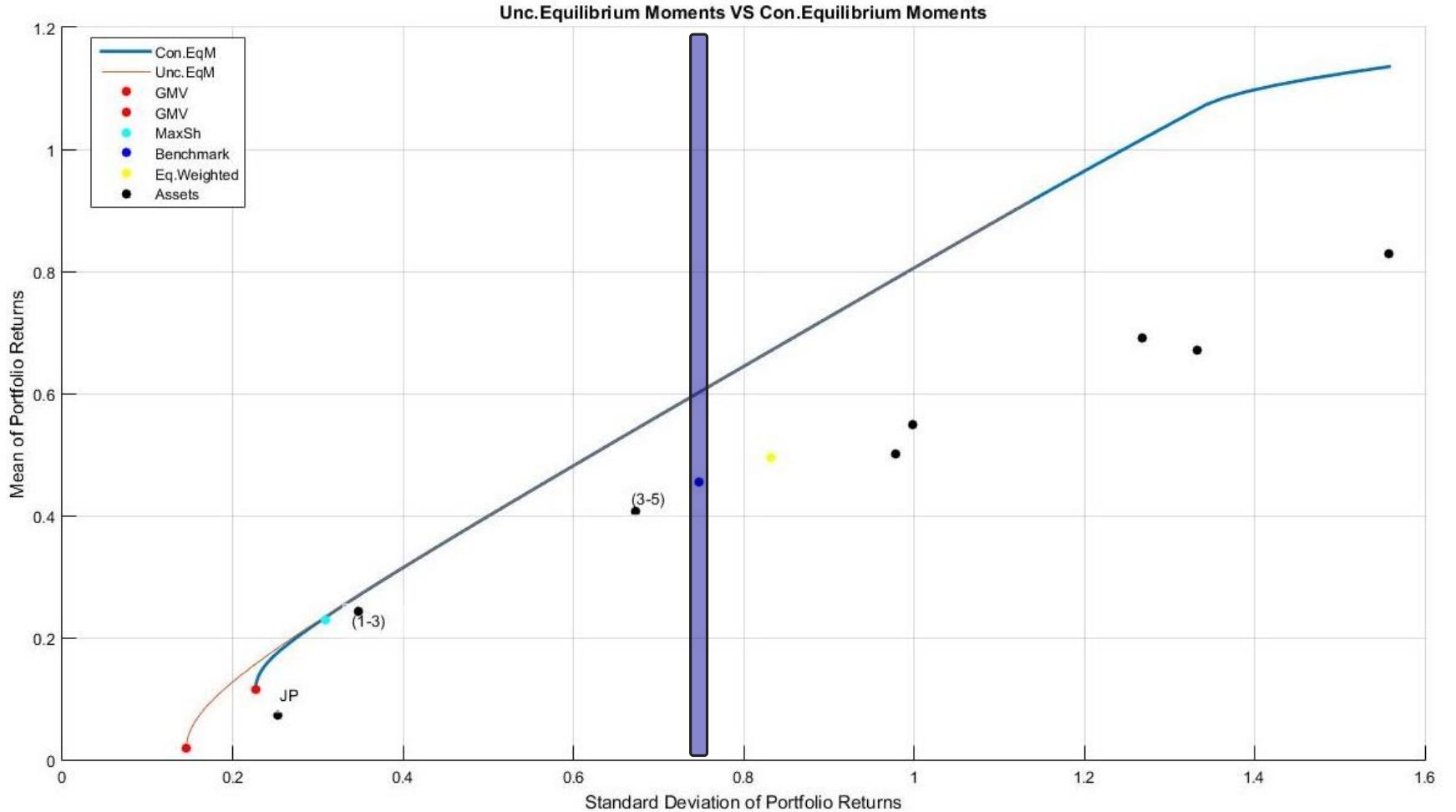
Average of the Eq.mkt returns times the elasticity of returns w.r.t. market premium ($r_m - r_f$) [Beta]



- EF EqM weights for GMV portfolio show an higher degree of diversification, less investment on (EU1-3)
- MaxTO portfolio is composed by non-negative weights only

Strategic Assets Allocation

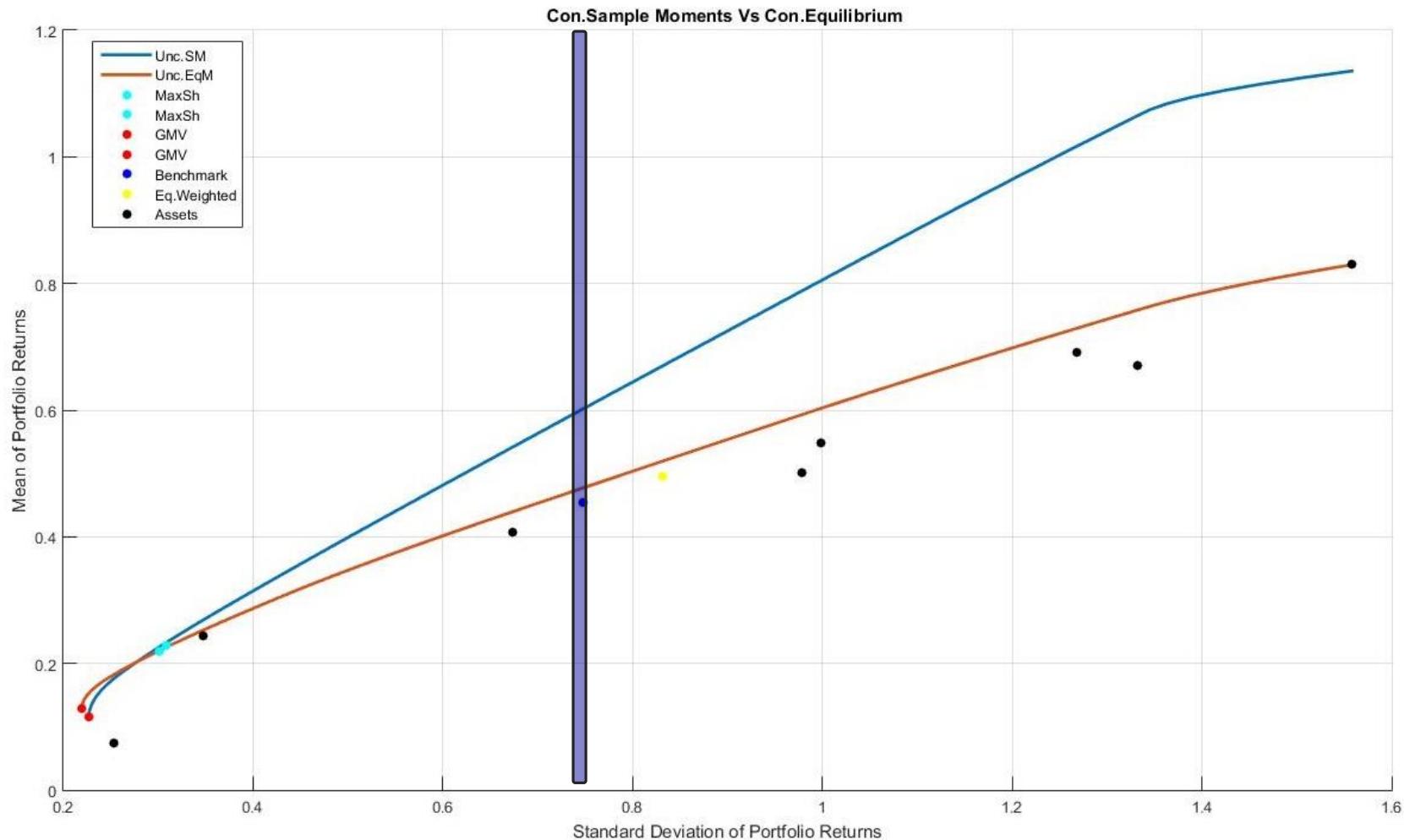
Con.Equilibrium moment comparison



- Constrained Equilibrium moments EF and its unconstrained counterpart overlap for level of risk greater than 0.25
- Unconstrained minimizes the risk with short selling positions

Strategic Assets Allocation

Con.Equilibrium moment comparison

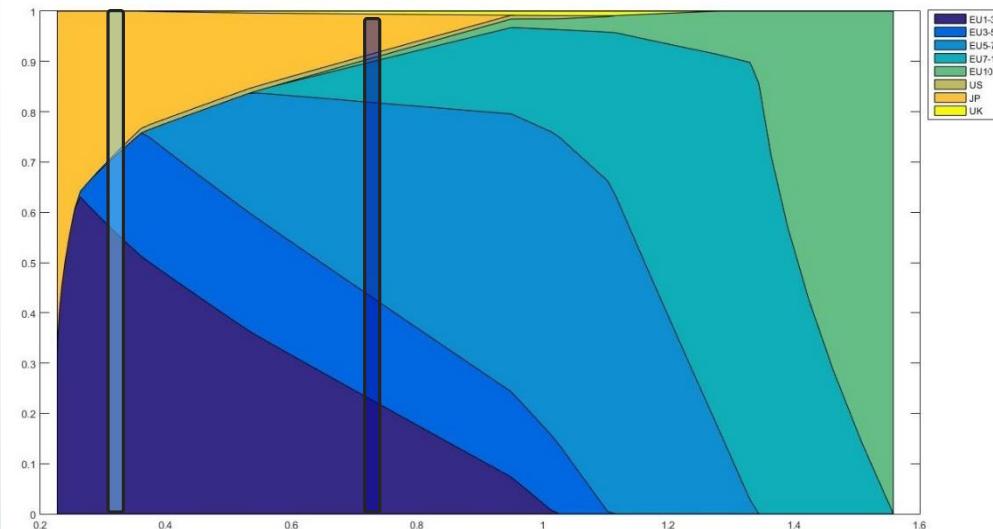


- Constrained Equilibrium moments EF has a lower return MaxSh portfolio
- Overall positions are less remunerative for the same level of risk
- Offers way less risks for low return positions

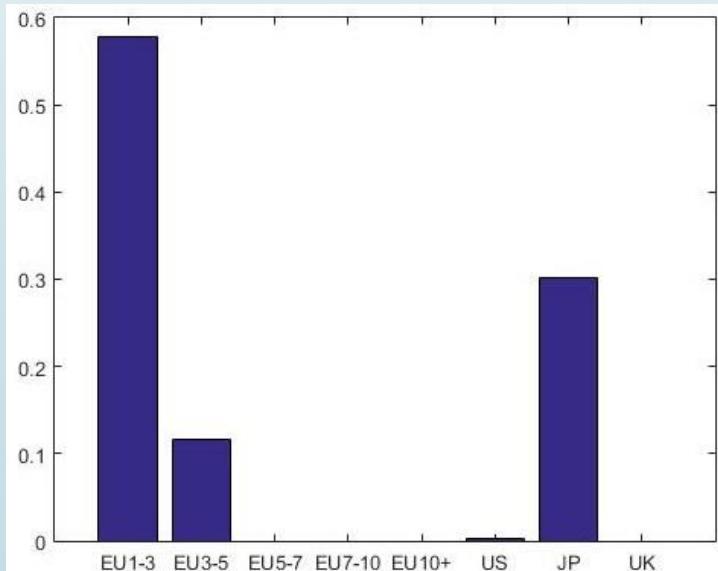
Strategic Assets Allocation

EF Con. EqM – Weights/risk area plot

2010-2016 sample

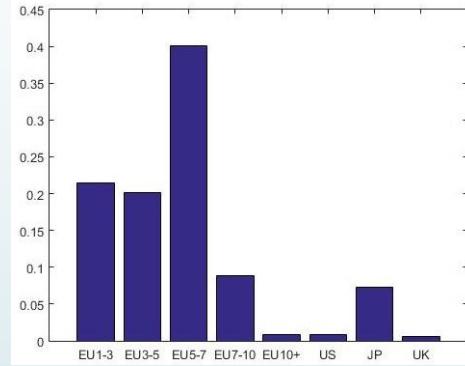


EF Constrained MaxSh Portfolio, $rs/rr = 0.30/0.22$

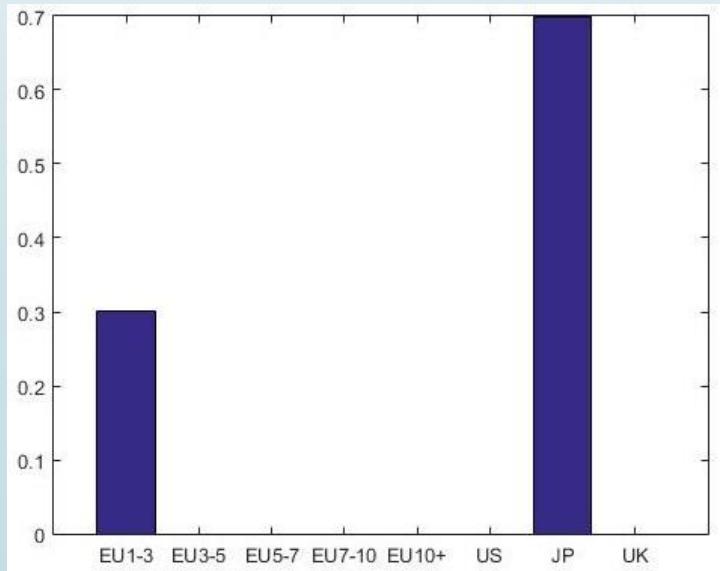


- MaxSh Portfolio shows a better level of diversification.

EF Constrained B-Portfolio, $rs/rr = 0.74/0.59$



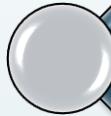
EF Constrained GMV-Portfolio, $rs/rr = 0.22/0.11$



Strategic Asset Allocation



Time comparison – Assets Correlations



Time comparison EF Sample Moments



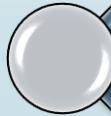
Time comparison EF Sample Moments – Weights plot



*Time comparison - Unconstrained Sample Moments vs
Unconstrained Equilibrium Moments*



Time comparison EF Equilibrium Moments



Time comparison EF Equilibrium Moments – Weights plot

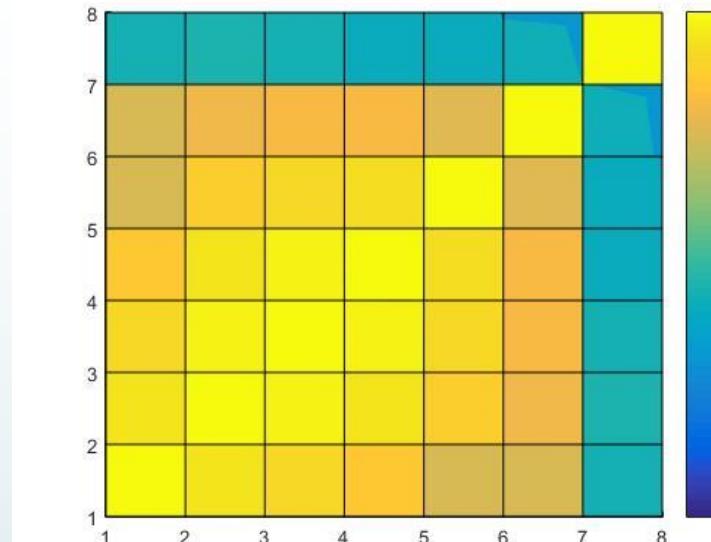


Benchmark Cumulated return simulation

Strategic Assets Allocation

Time comparison – Assets Correlations

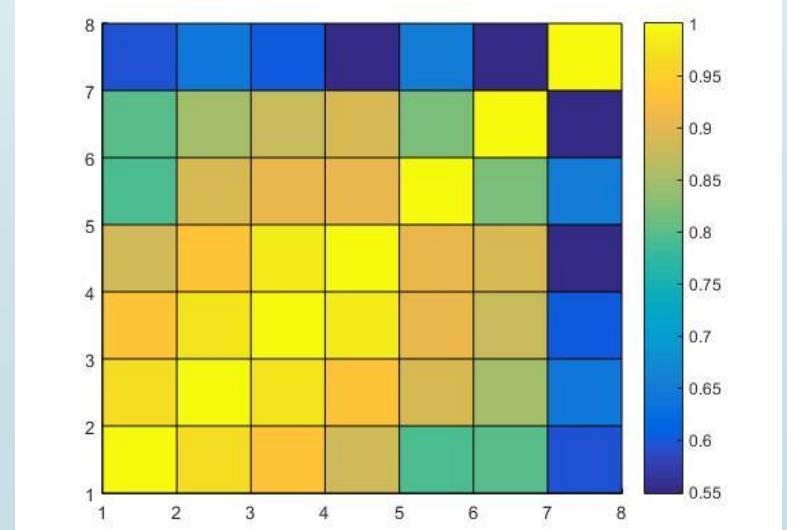
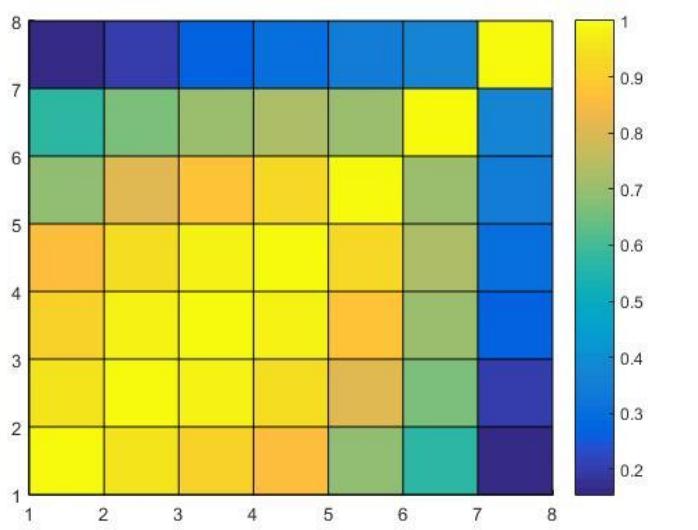
Full Sample



- High correlation for all assets over the full time sample
- UK seems to be the least correlated
- Correlation fades over time

2005-2010 sample

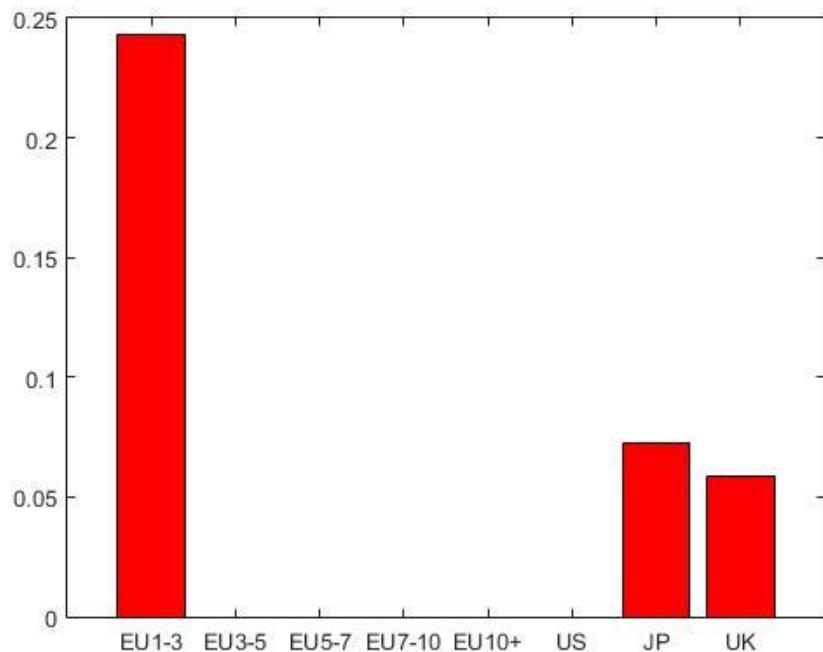
2010-2016 sample



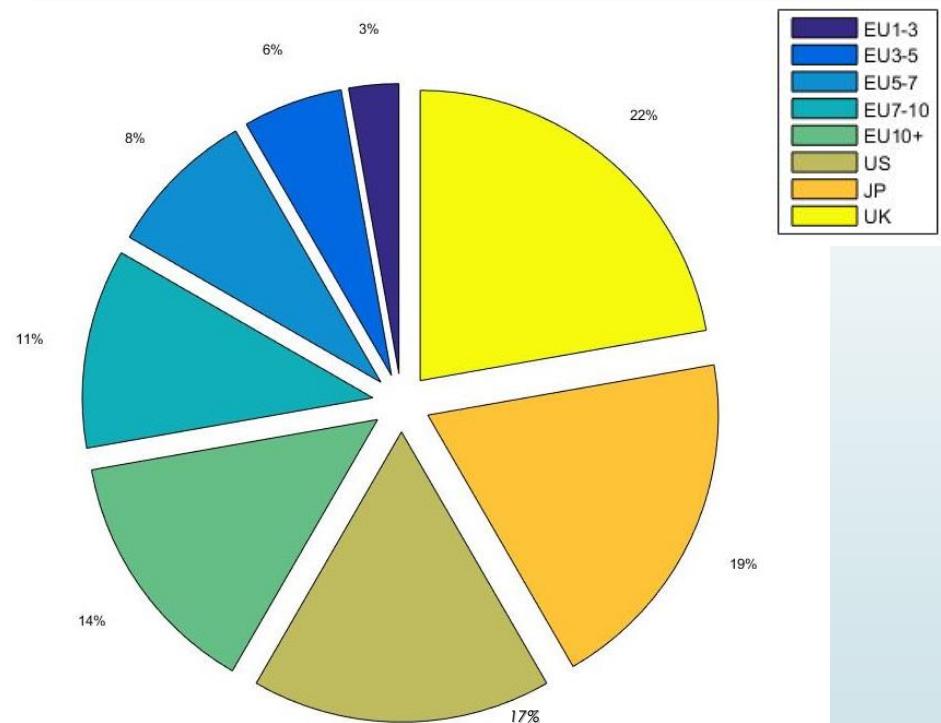
Strategic Assets Allocation

Time comparison – Assets Correlations

MaxSh – relative RC



Equally budgeted – Risk contribution

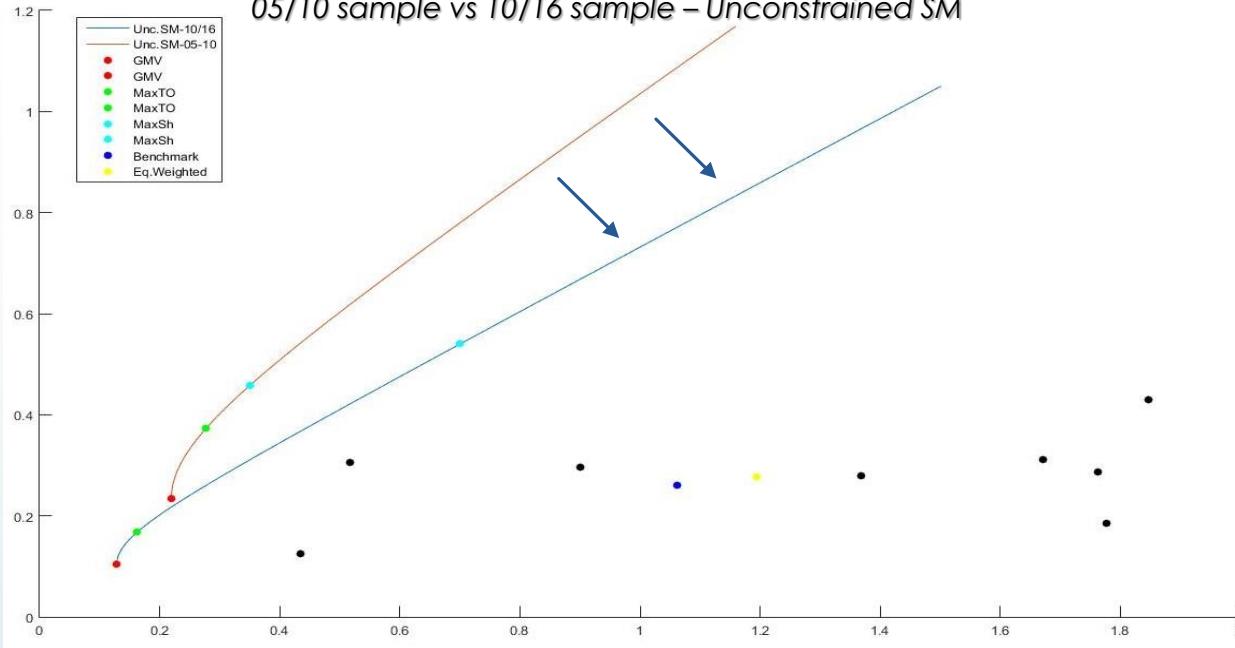


- Non-budgeted MS contribution mainly features high relative risk contribution for EU1-3
- Eq.Budgeted Rc features high level of risk for US,JP,UK, and a very low level for EU1-3
- The risk contribution increases along with the maturity for EU CB

Strategic Assets Allocation

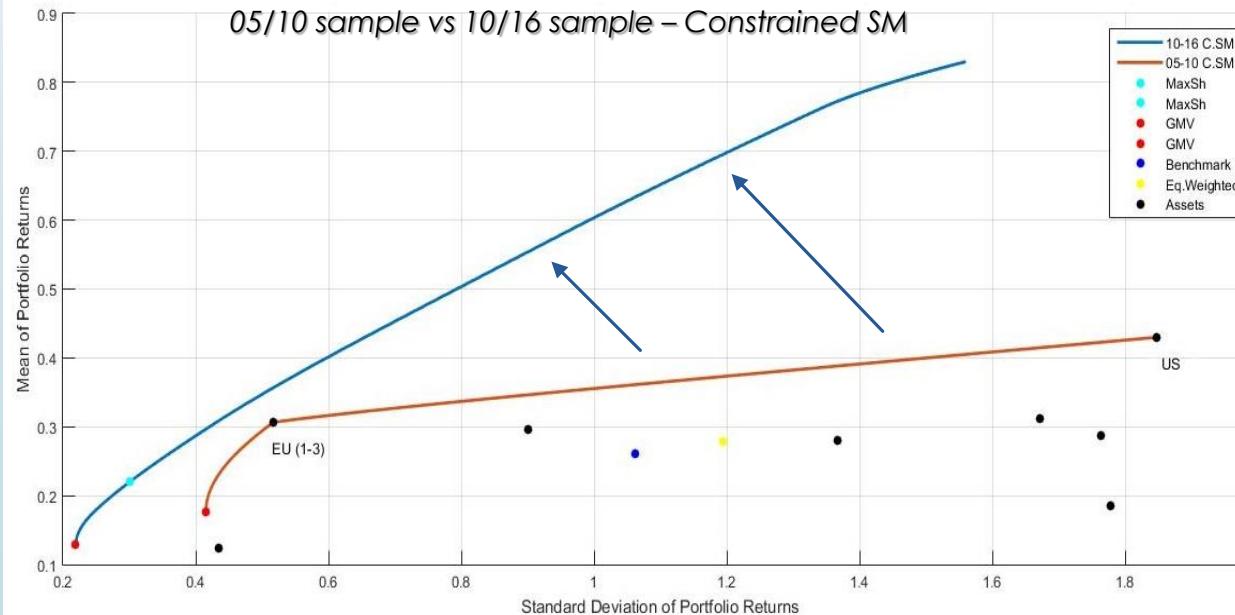
Time comparison EF SM

05/10 sample vs 10/16 sample – Unconstrained SM



- EF Unc.SM moved towards a lower risk/return area
- MaxSh Portfolio greatly increased in risk ($R_f = 0.09$ for both)

05/10 sample vs 10/16 sample – Constrained SM

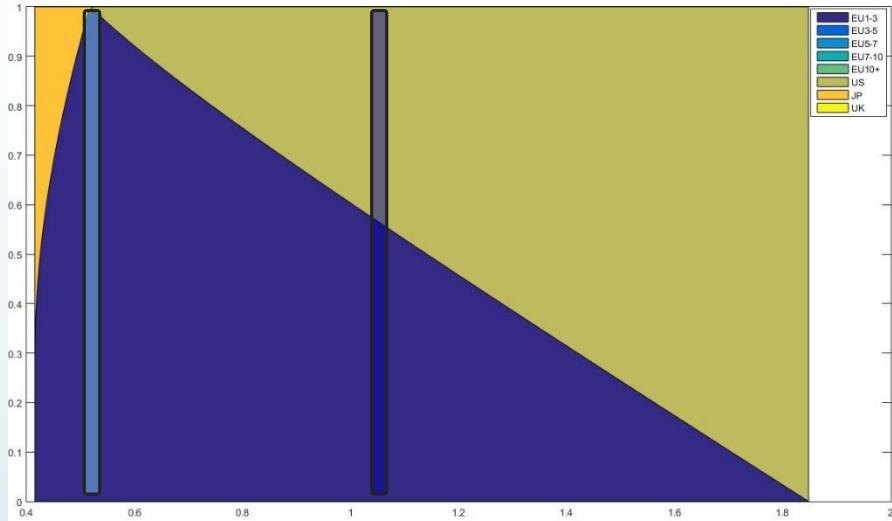


- Constrained counterpart had the opposite trend over time
- MaxSh portfolio is overlapped with EU(1-3) asset
- Risk level above 0.3 is more efficient in the recent sample

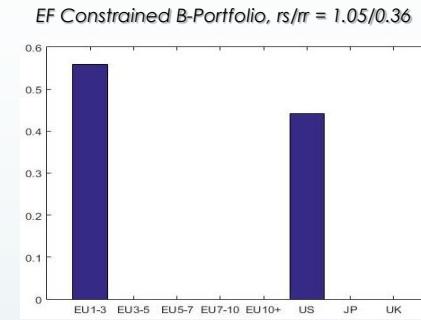
Strategic Assets Allocation

Time comparison EF SM – Weights plot

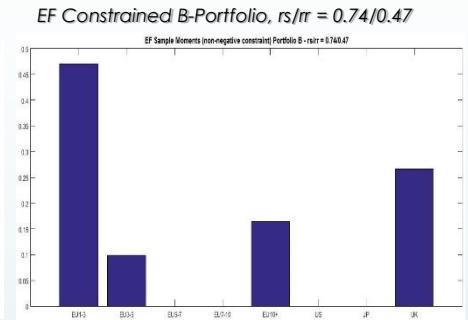
2005-2010 sample



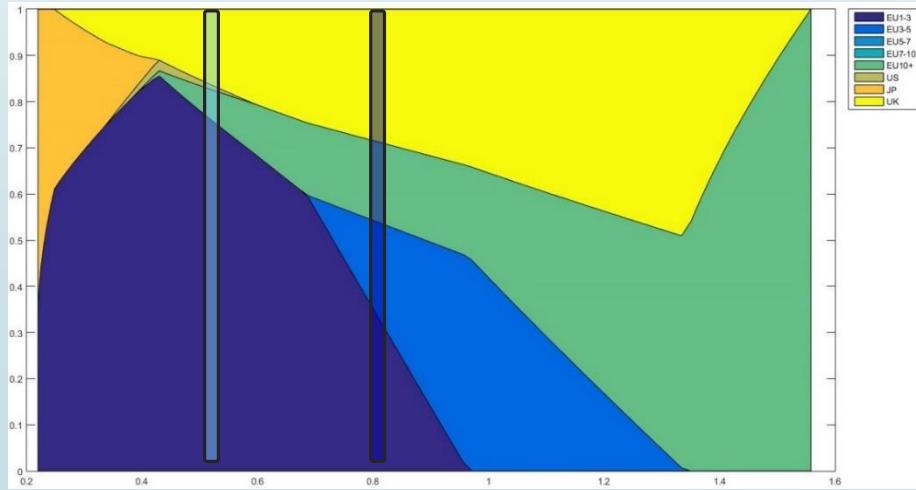
2005-2010 sample



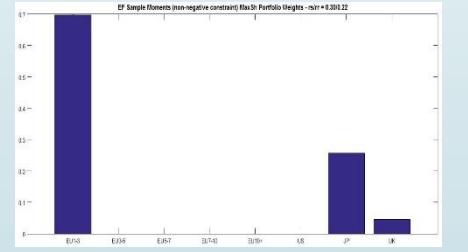
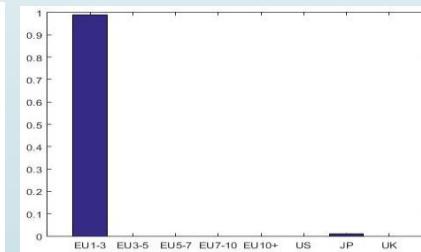
2010-2016 sample



2010-2016 sample

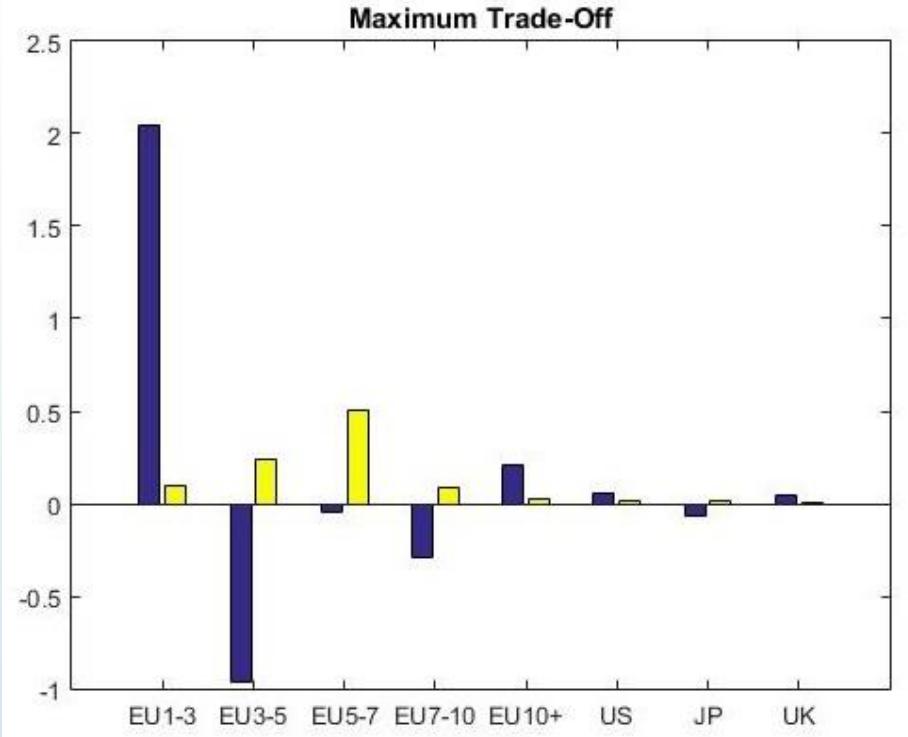
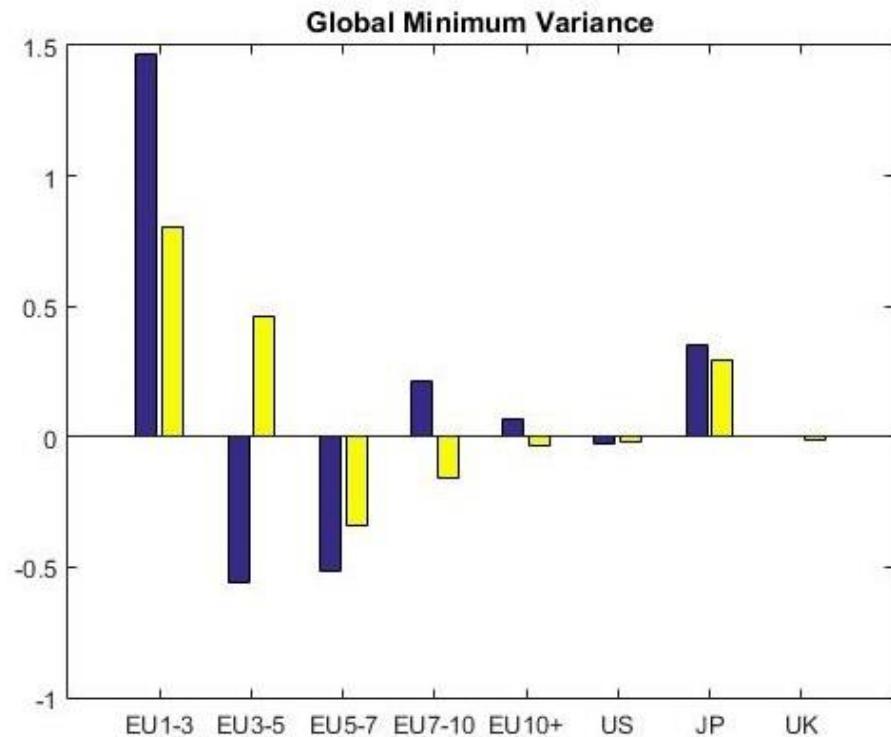


EF Constrained MaxSh Portfolio, $rs/rr = 0.51/0.30$ EF Constrained MaxSh Portfolio, $rs/rr = 0.30/0.22$



Strategic Assets Allocation

Unc.SM vs Unc.EqM – Time comparison
05-10 sample only

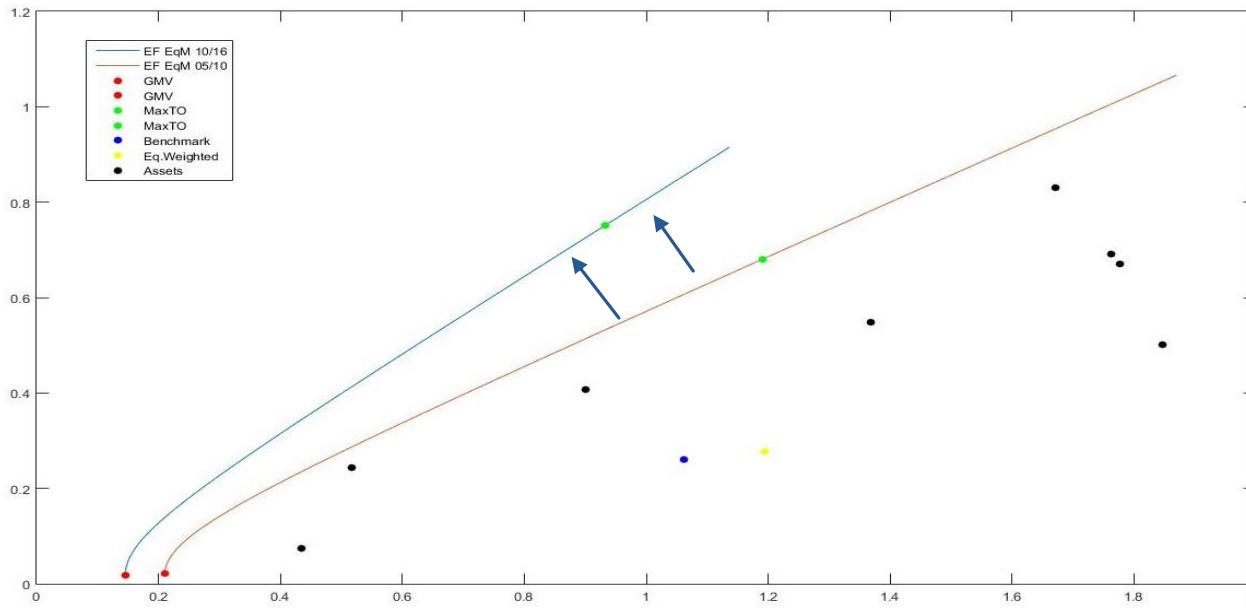


- EF EqM weights for GMV portfolio show an higher degree of diversification, less investment on (EU1-3)
- MaxTO portfolio is composed by non-negative weights only

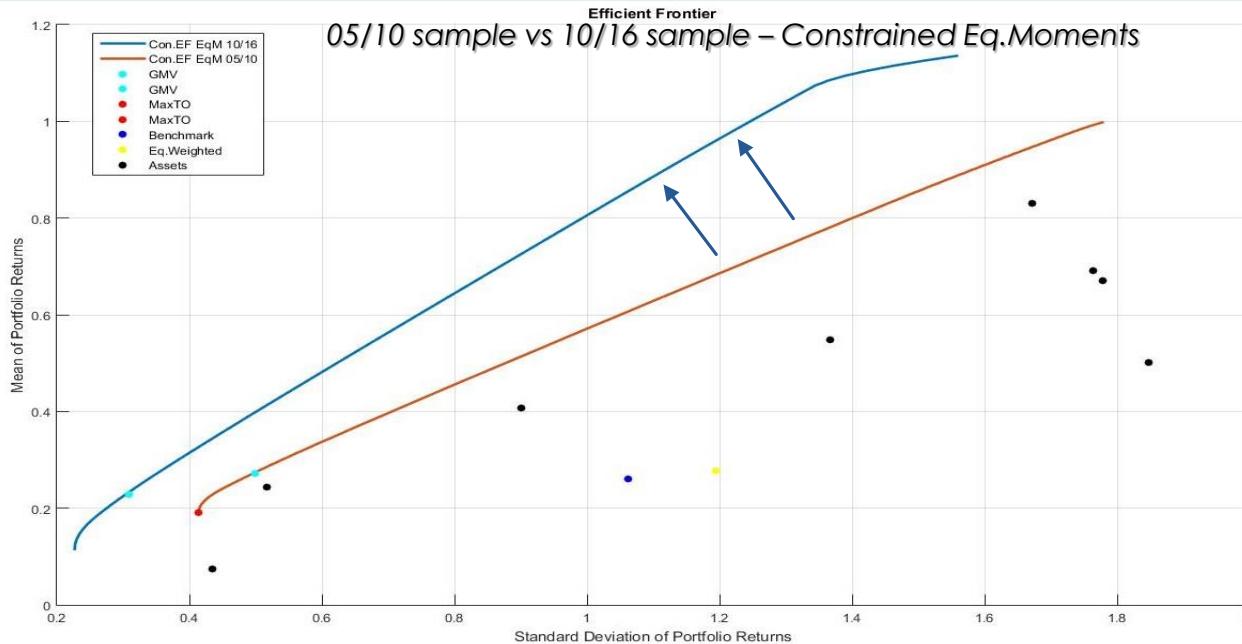
Strategic Assets Allocation

Time comparison EF Eq.M

05/10 sample vs 10/16 sample – Unconstrained Eq.Moments



- EF Unc.EqM moved towards a more efficient risk/return area

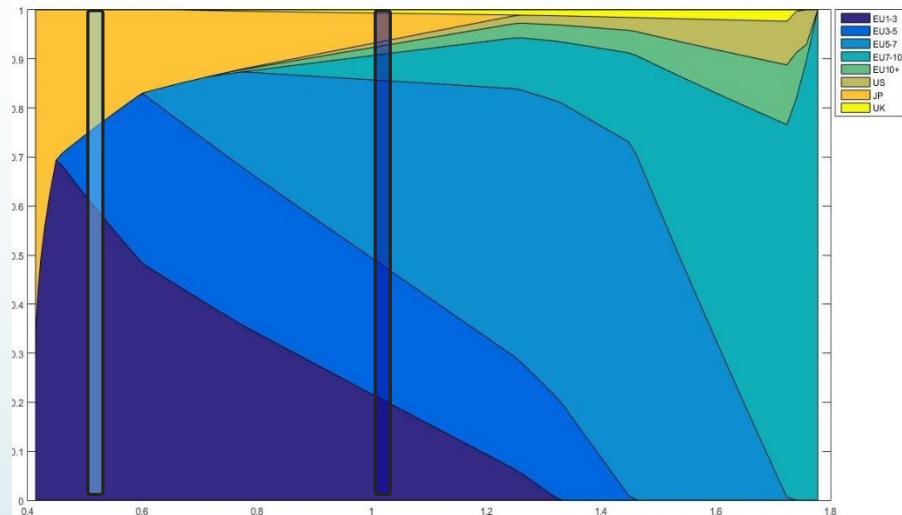


- Con. moved towards a more efficient risk/return area
- EqM shows an improvement of the portfolio over time

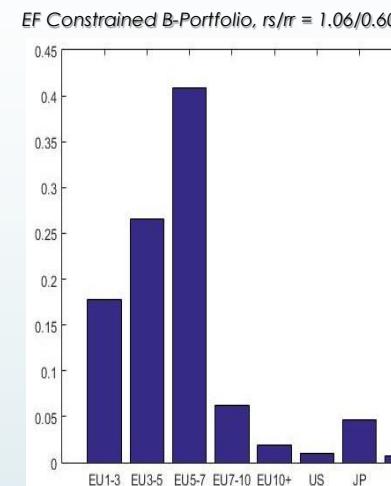
Strategic Assets Allocation

Time comparison EF Eq.M – Weights plot

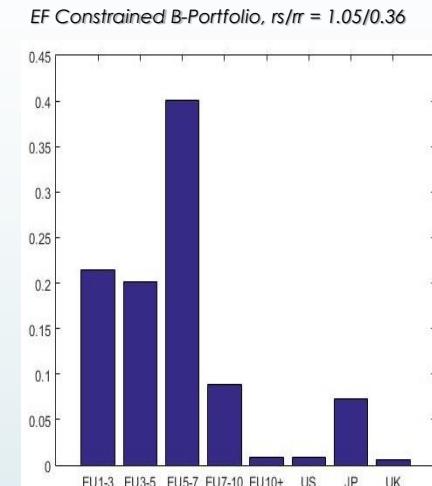
2005-2010 sample



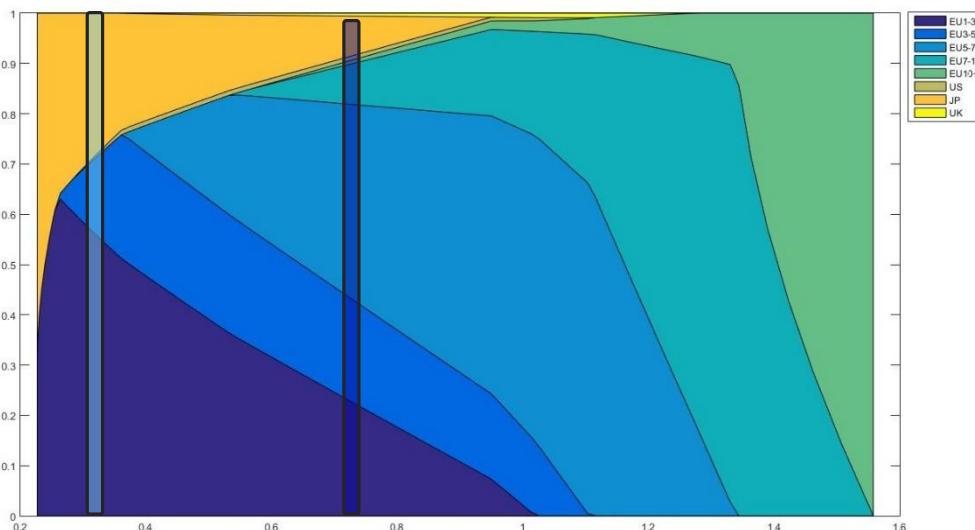
2005-2010 sample



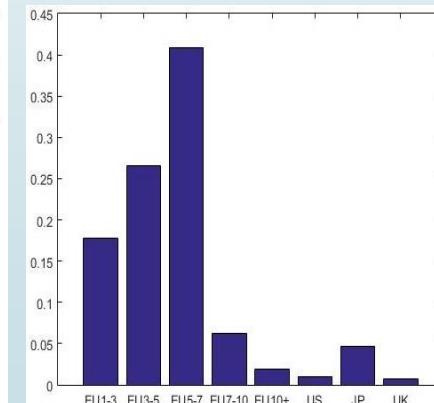
2010-2016 sample



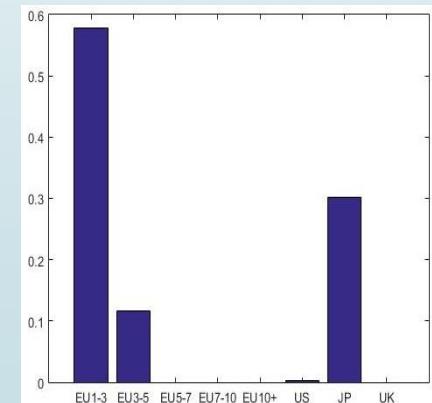
2010-2016 sample



EF Constrained MaxSh Portfolio, $rs/rr = 0.49/0.27$

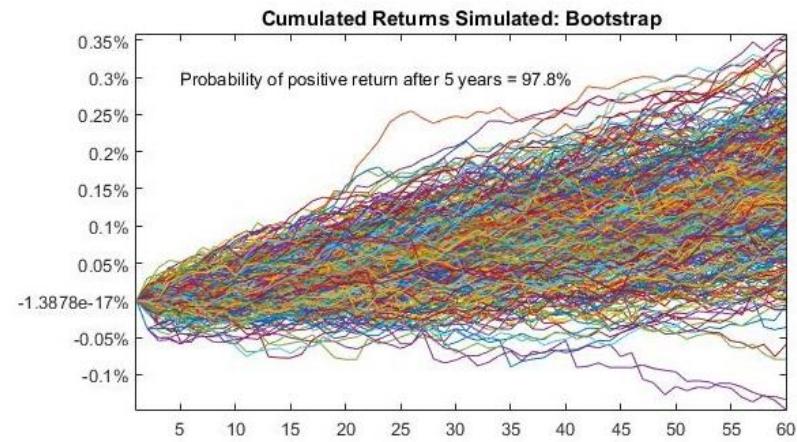
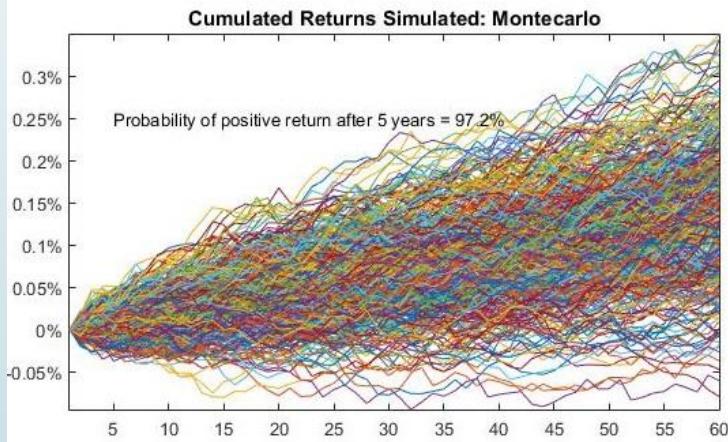
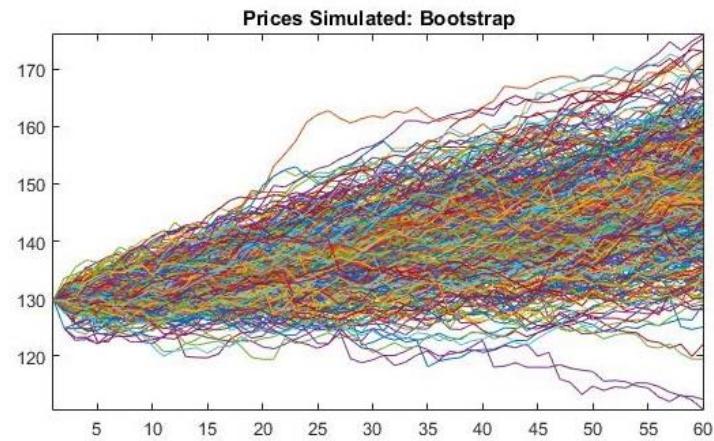
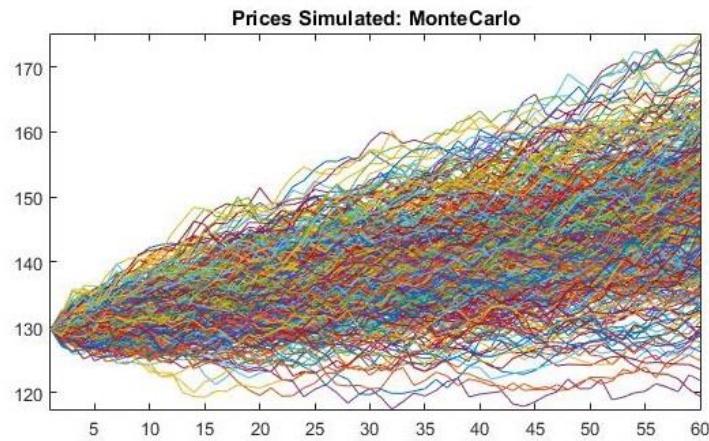


EF Constrained MaxSh Portfolio, $rs/rr = 0.51/0.30$



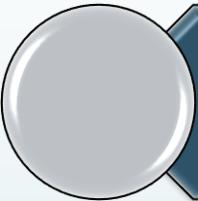
Strategic Assets Allocation

Benchmark Cumulated return simulation

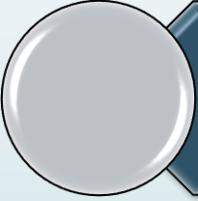


- Probability of positive returns after 5 years = 97.2% (Montecarlo Simulation - Nr. of Simulations = 500)
- Probability of positive returns after 5 years = 97.8% (Bootstrap Simulation - Nr. of Simulations = 500)

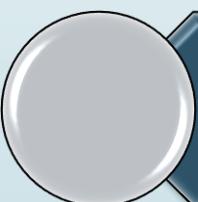
Monthly Tactical Choices



Group volatility cones and correlations



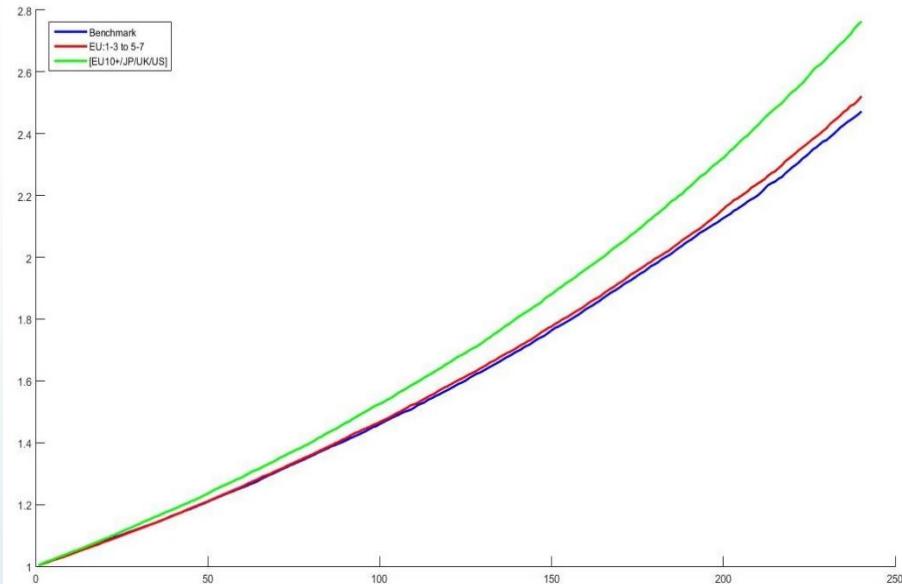
Portfolio Constraints Layout



Portfolio Constraints: Target benchmark

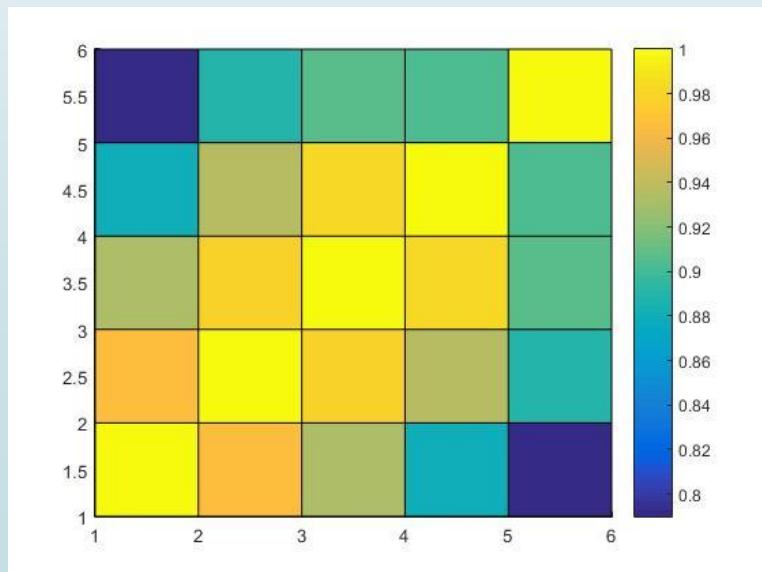
Monthly Tactical Choices

Group volatility cones and correlations

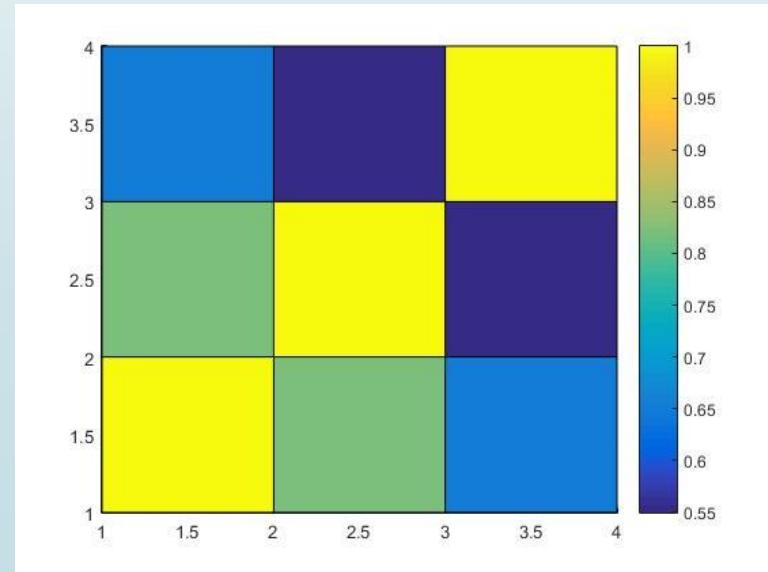


EU CB by maturity

- EU CB assets appear as less risky
- Non-EU group is less safe with EU10+, the riskier asset



US, JP, UK CB



Monthly Tactical Choices

Portfolio Constraints Layout

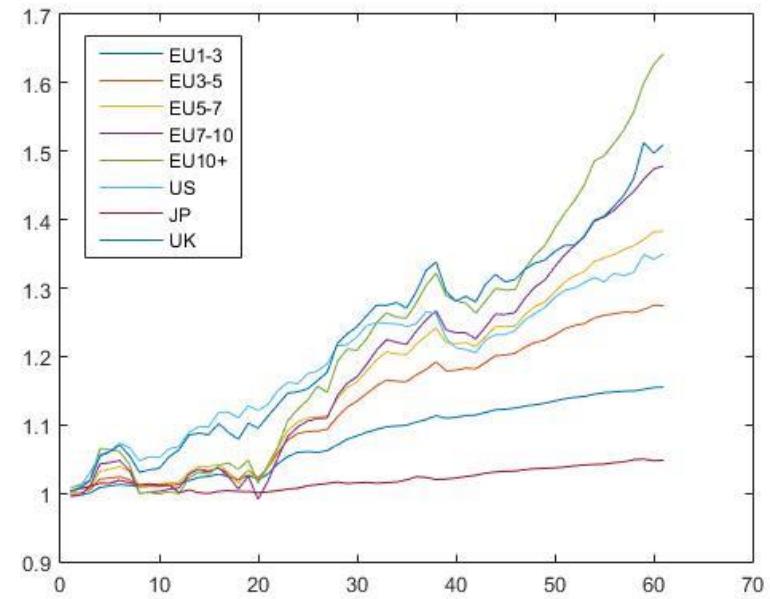
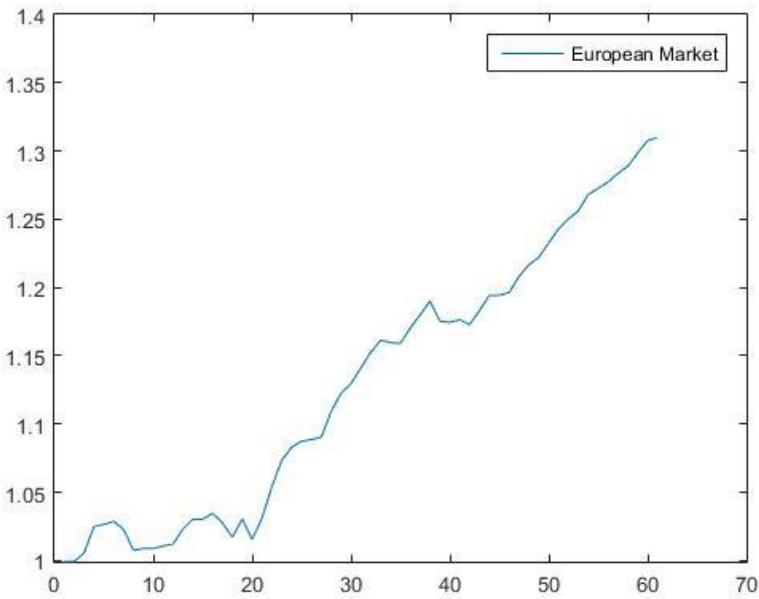
Methods: rr/rs	Sample M/Sample M	Equilibrium moment/EWMA
Default	GMV - Default	MaxSh - Default
Lower Bound	GMV – Lower Bound	MaxSh – Lower Bound
Turnover	GMV - Turnover	MaxSh - Turnover

Constraints Type	Parameter set #1 EU group	Parameter set #2 Short-term group	Parameter set #3
Group	Mainly EU	10% in High Risk	No Group
Lower Bound	10%	1%	10%
Turnover	0.1%	0.5%	0.5%

Monthly Tactical Choices

Portfolio Constraints: Target benchmark

Benchmark and assets cumulated returns



- . European Market shows an increase in the last 5 years
- . JP asset evolution is very plain

Monthly Tactical Choices

SM vs Eqilibrium Moments /EWMA weights

Turnover

Cumulated Returns

C.Returns Δ -Tracking

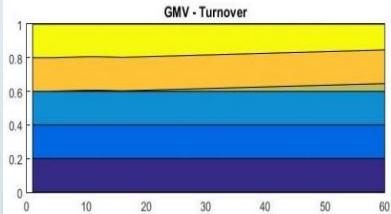
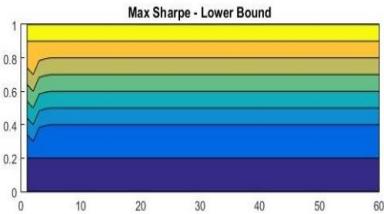
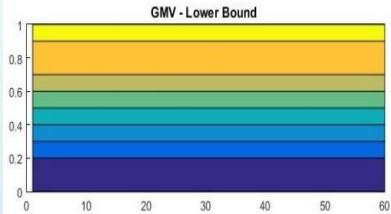
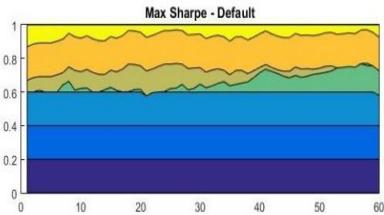
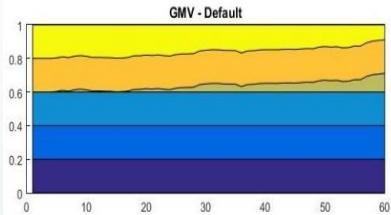
Performance Measurement

Conclusions

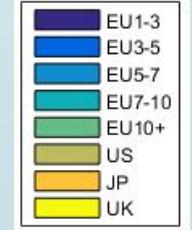
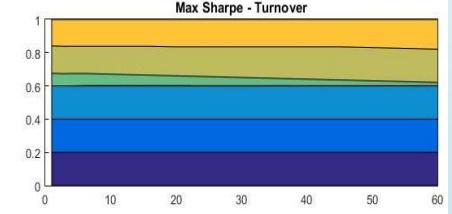
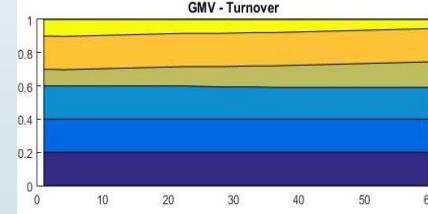
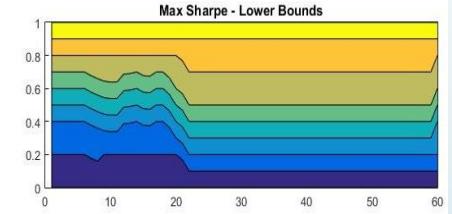
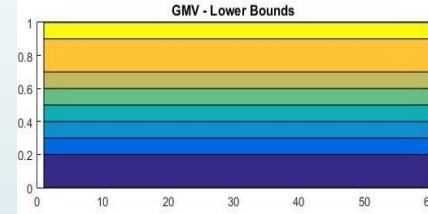
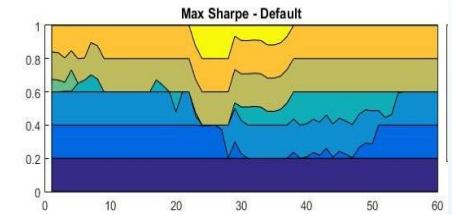
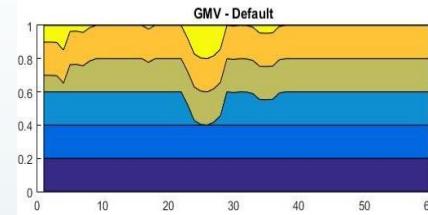
Monthly Tactical Choices

EU Group: SM vs Eq.M/EWMA wts

Sample Moments



Eq. Moments

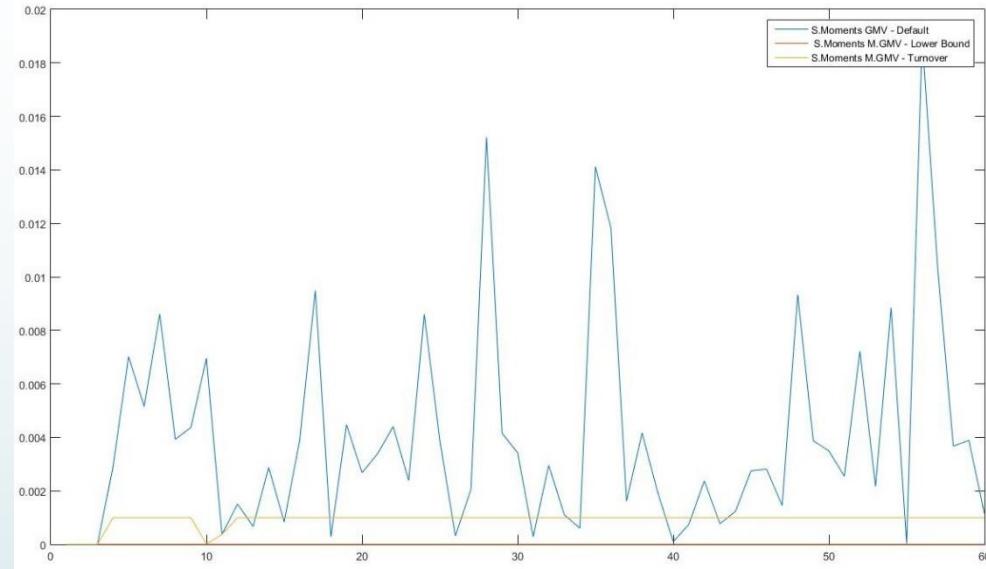


- Portfolios evaluated using SM are very likely to be effective due to less transaction costs
- The turnover in both SM and EqM is extremely slow

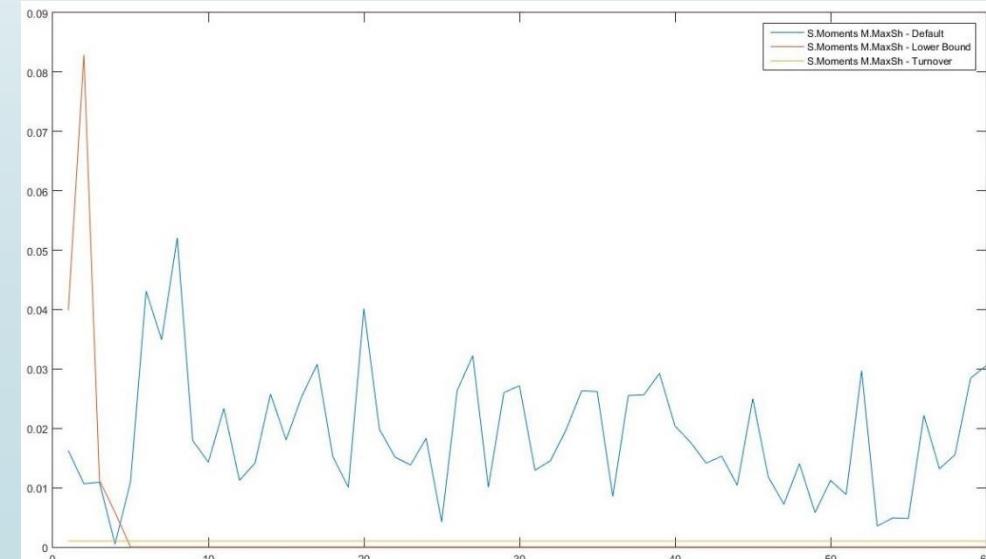
Monthly Tactical Choices

EU Group: Turnover

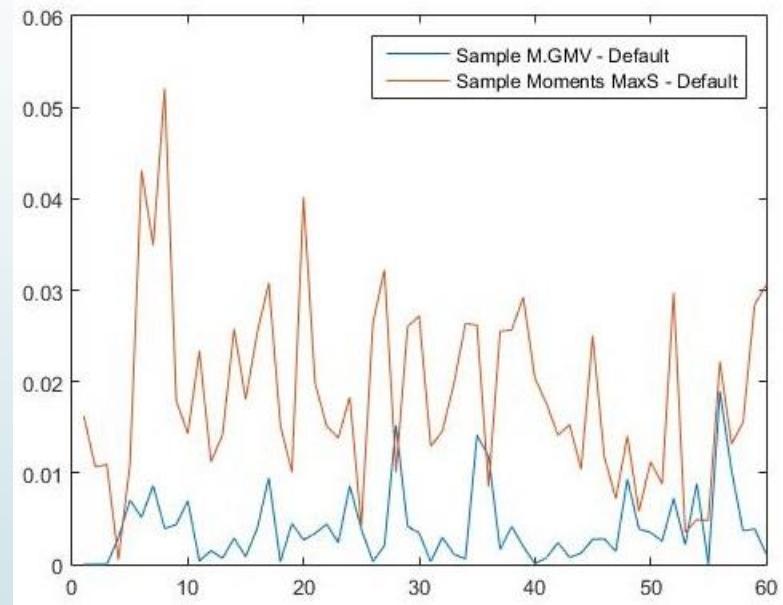
Turnover by constraints - GMV



Turnover by constraints - MS



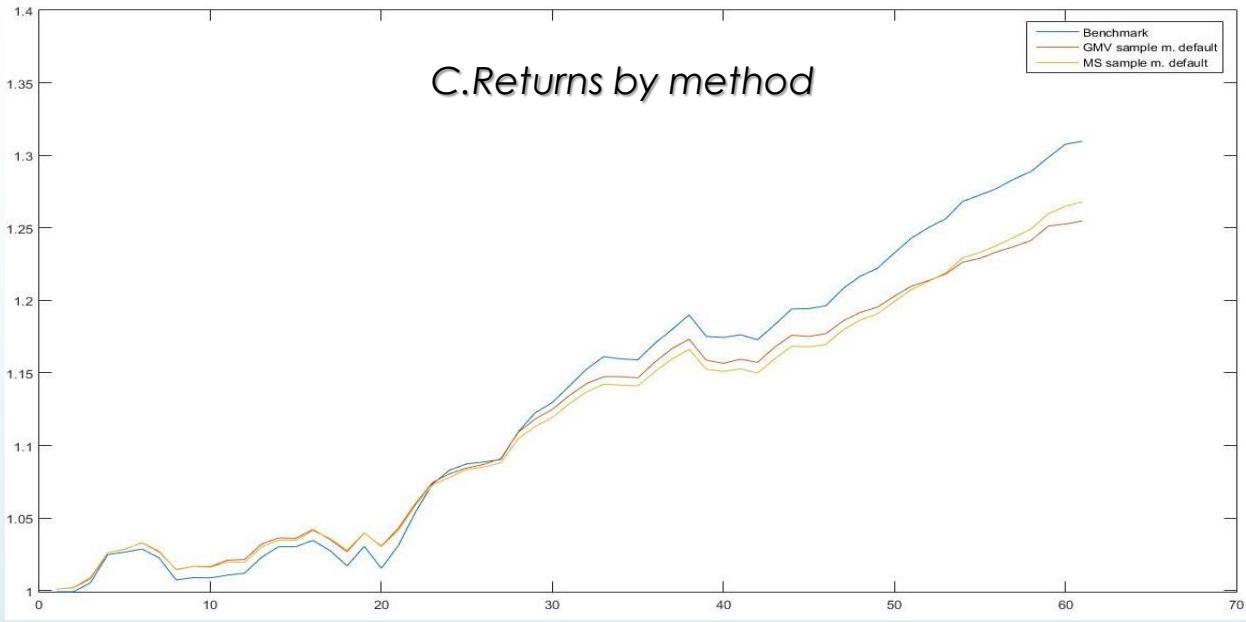
Turnover by method



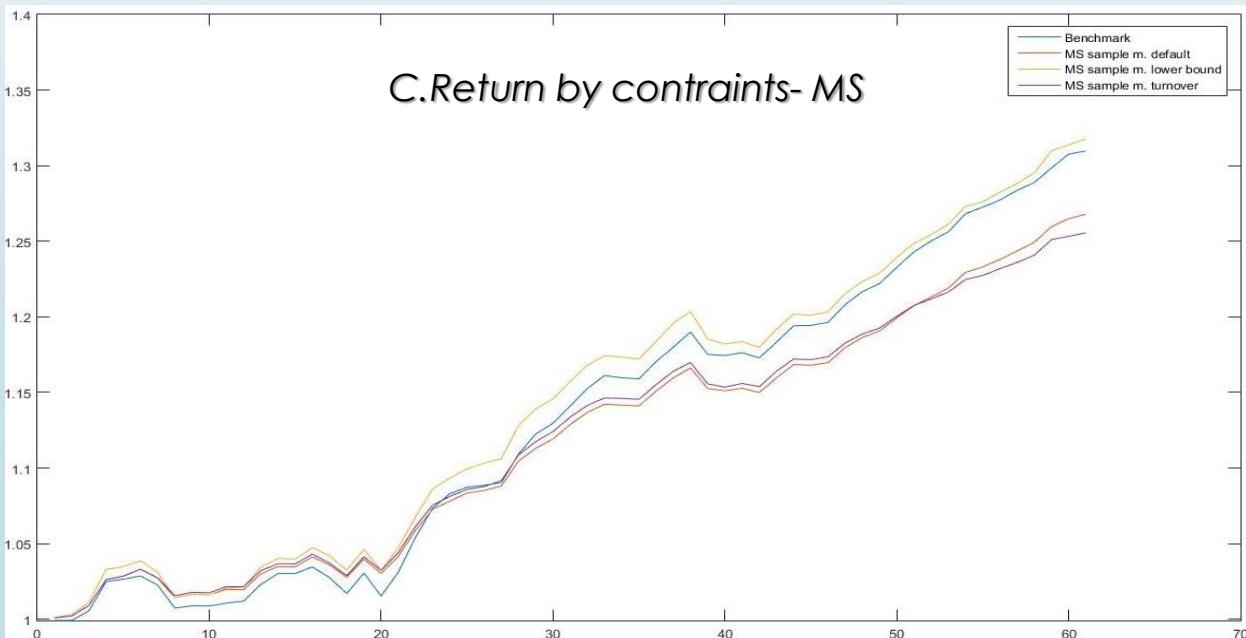
- Turnover portfolio is steady due to how we constructed it.
- Lower bound portfolio seems to be less likely to have its weights changed over time.

Monthly Tactical Choices

EU Group: Cumulated Returns



- Benchmark returns are higher after the first 25 months
- Both GMV and MS are better than the benchmark in the first 25 months

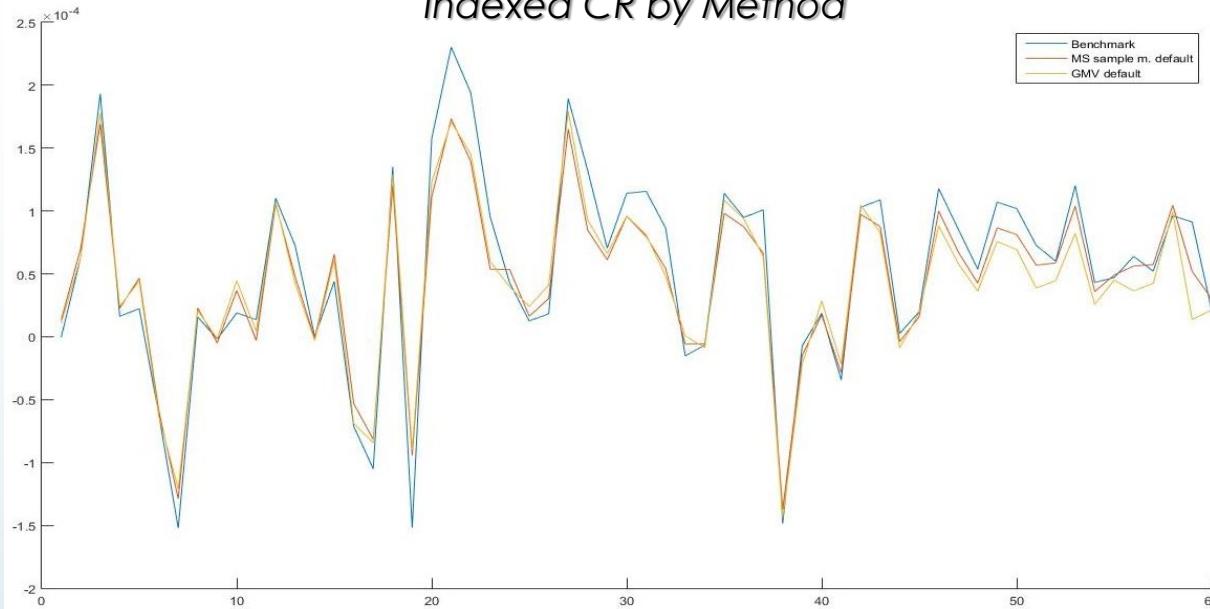


- MS with turnover is still below the benchmark after the first 25 months
- MS sample with lower bound is performing better than the benchmark

Monthly Tactical Choices

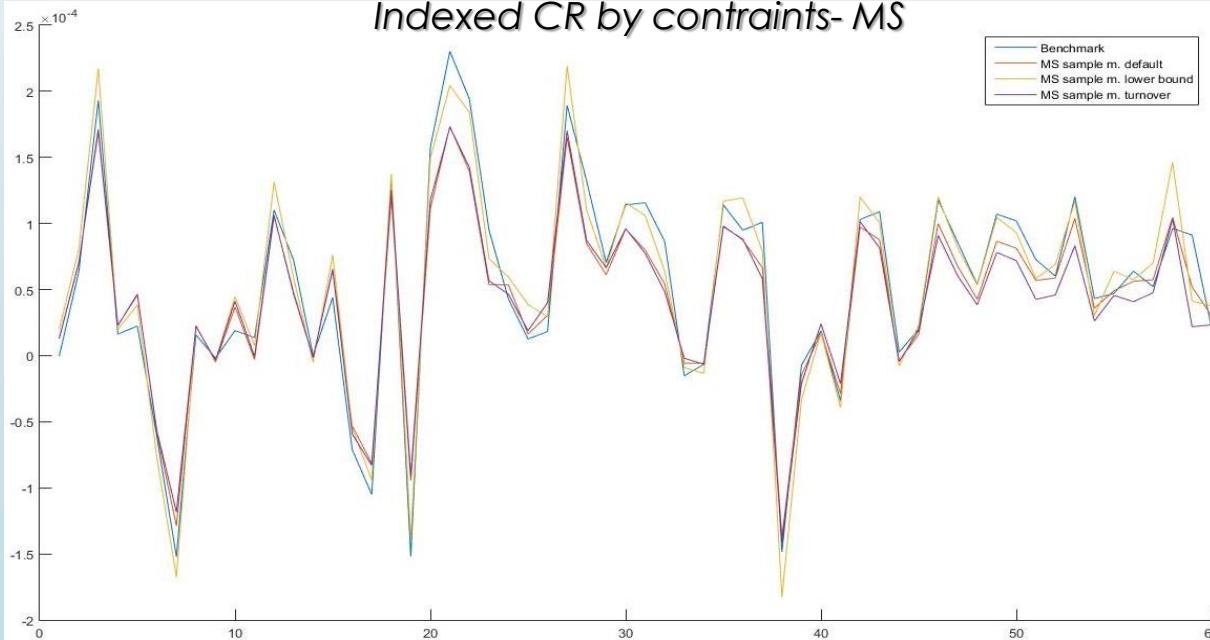
EU Group: C.Returns Δ-Tracking

Indexed CR by Method



- The variations of the benchmark are, on average, higher than the ones of the other two portfolios.

Indexed CR by constraints- MS



- MS computed with sample moments method and constrained with a lower bound seems to anticipate the movements of the benchmark index.

Monthly Tactical Choices

EU Group: Performance Measurement

Strategy	Mean	StDev	Min	Max				
'Market'	0.446	0.74471	-1.4882	2.2333	<ul style="list-style-type: none"> Market ptf has a very high std. Dev. Lower bound portfolios also yield high std. Dev 			
'GMV sample Default'	0.37456	0.60971	-1.2309	1.7665				
'GMV sample lower bound'	0.4231	0.69929	-1.5529	2.0392				
'GMV sample turnover'	0.38129	0.61467	-1.2399	1.7665				
'MS sample Default'	0.39164	0.59711	-1.2539	1.677				
'MS sample lower bound'	0.45607	0.75209	-1.6264	2.1479				
'MS sample turnover'	0.37555	0.59329	-1.2095	1.6961				
'GMV eq/EW Default'	0.35426	0.57433	-1.1769	1.7165				
'GMV eq/EW lower bound'	0.4231	0.69929	-1.5529	2.0392				
'GMV eq/EW turnover'	0.36163	0.58557	-1.2143	1.6713				
'MS eq/EW Default'	0.36506	0.63776	-1.4008	1.9367				
'MS eq/EW lower bound'	0.44121	0.75284	-1.6905	2.1546				
'MS eq/EW turnover'	0.37275	0.62344	-1.306	1.8054				
Strategy	Sh	So	Tr	VaR	ES	Cal	Ste	FT
'Market'	0.59889	0.77795	0.446	0.39688	0.31778	0.29852	0.37585	1.5619
'GMV sample Default'	0.61432	0.82288	0.4719	0.4465	0.3427	0.3043	0.39288	1.6139
'GMV sample lower bound'	0.60504	0.77638	0.46561	0.42044	0.303	0.27119	0.36724	1.54
'GMV sample turnover'	0.62031	0.83813	0.47729	0.45385	0.34739	0.30751	0.39835	1.6321
'MS sample Default'	0.65589	0.86502	0.49895	0.46518	0.35181	0.31095	0.41619	1.688
'MS sample lower bound'	0.6064	0.77756	0.46209	0.41627	0.30574	0.27917	0.37167	1.5484
'MS sample turnover'	0.633	0.84232	0.48495	0.4505	0.34826	0.31049	0.40677	1.6546
'GMV eq/EW Default'	0.61682	0.82934	0.4806	0.43268	0.33878	0.30101	0.40143	1.6387
'GMV eq/EW lower bound'	0.60504	0.77638	0.46561	0.42044	0.303	0.27119	0.36724	1.54
'GMV eq/EW turnover'	0.61757	0.81597	0.47527	0.43654	0.3372	0.29781	0.39616	1.6172
'MS eq/EW Default'	0.5724	0.73212	0.44739	0.39444	0.29042	0.2606	0.35407	1.4753
'MS eq/EW lower bound'	0.58606	0.73016	0.45598	0.41089	0.28631	0.25984	0.3504	1.4701
'MS eq/EW turnover'	0.59788	0.7724	0.4582	0.40712	0.30989	0.28424	0.37459	1.5557

Monthly Tactical Choices

EU Group: Performance Measurement

Strategy	CI	Sh	So	Tr	VaR	ES	Cal	Ste	FT
	—	—	—	—	—	—	—	—	—
'Market'	69	10	7	13	12	7	6	7	7
'GMV sample Default'	41	6	5	6	4	4	4	6	6
'GMV sample lower bound'	71	8	9	7	7	10	10	10	10
'GMV sample turnover'	26	3	3	4	2	3	3	4	4
'MS sample Default'	8	1	1	1	1	1	1	1	1
'MS sample lower bound'	69	7	8	9	9	9	9	9	9
'MS sample turnover'	17	2	2	2	3	2	2	2	2
'GMV eq/EW Default'	34	5	4	3	6	5	5	3	3
'GMV eq/EW lower bound'	79	9	10	8	8	11	11	11	11
'GMV eq/EW turnover'	43	4	6	5	5	6	7	5	5
'MS eq/EW Default'	98	13	12	12	13	12	12	12	12
'MS eq/EW lower bound'	98	12	13	11	10	13	13	13	13
'MS eq/EW turnover'	75	11	11	10	11	8	8	8	8

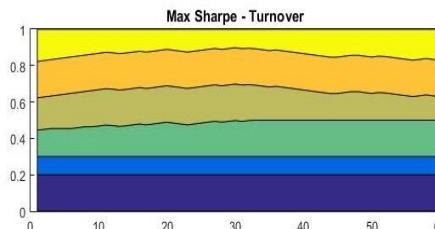
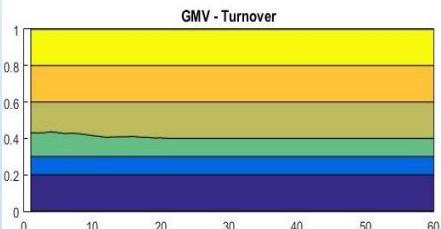
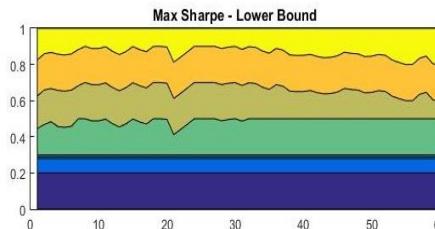
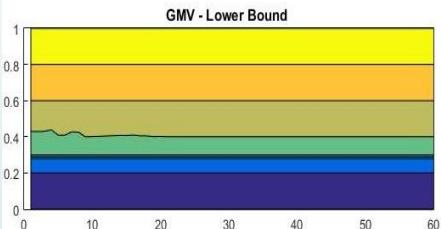
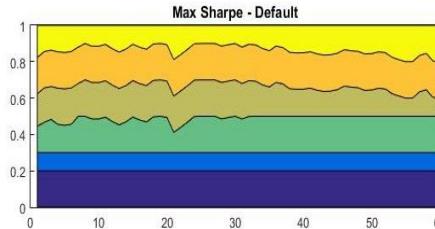
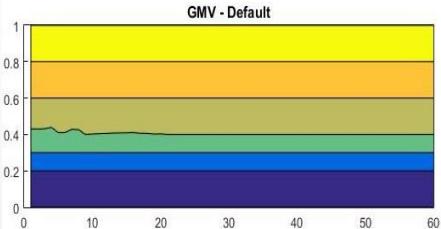
- MS Sample Default appears to be an optimal choice
- Market portfolio doesn't seem to be an appealing choice

Strategy	TE	TEV	SemiTEV	IR	SemiIR
	—	—	—	—	—
'GMV sample Default'	-0.071442	0.045958	0.15652	-1.5545	-0.45644
'GMV sample lower bound'	-0.0229	0.03568	0.12194	-0.64182	-0.1878
'GMV sample turnover'	-0.064707	0.046327	0.15725	-1.3967	-0.41151
'MS sample Default'	-0.054358	0.040495	0.14895	-1.3424	-0.36494
'MS sample lower bound'	0.010068	0.025507	0.093036	0.39472	0.10821
'MS sample turnover'	-0.070445	0.047605	0.15101	-1.4798	-0.46648
'GMV eq/EW Default'	-0.091743	0.066851	0.17575	-1.3724	-0.52202
'GMV eq/EW lower bound'	-0.0229	0.03568	0.12194	-0.64182	-0.1878
'GMV eq/EW turnover'	-0.084373	0.053512	0.15925	-1.5767	-0.52981
'MS eq/EW Default'	-0.080944	0.056269	0.18807	-1.4385	-0.43039
'MS eq/EW lower bound'	-0.0047927	0.048115	0.14296	-0.099609	-0.033524
'MS eq/EW turnover'	-0.073251	0.04094	0.13739	-1.7892	-0.53316

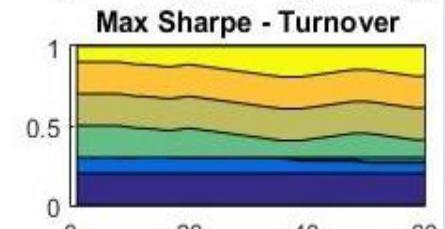
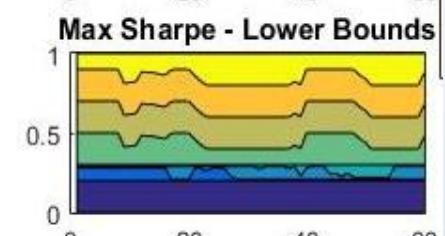
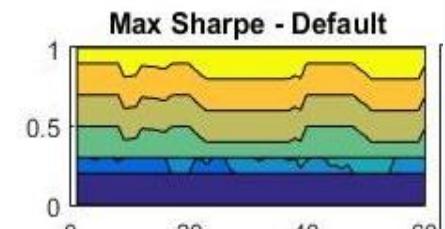
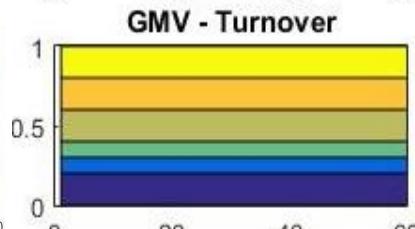
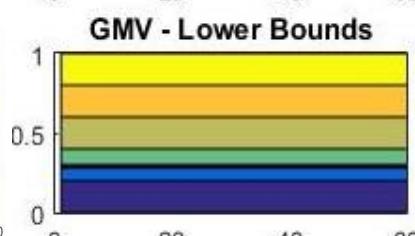
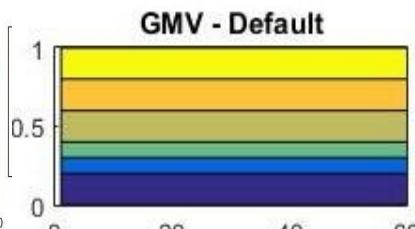
Monthly Tactical Choices

ST group: SM vs Eq.M/EWMA wts

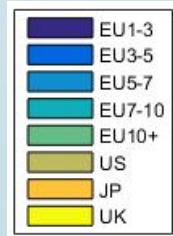
Sample Moments



Eq. Moments



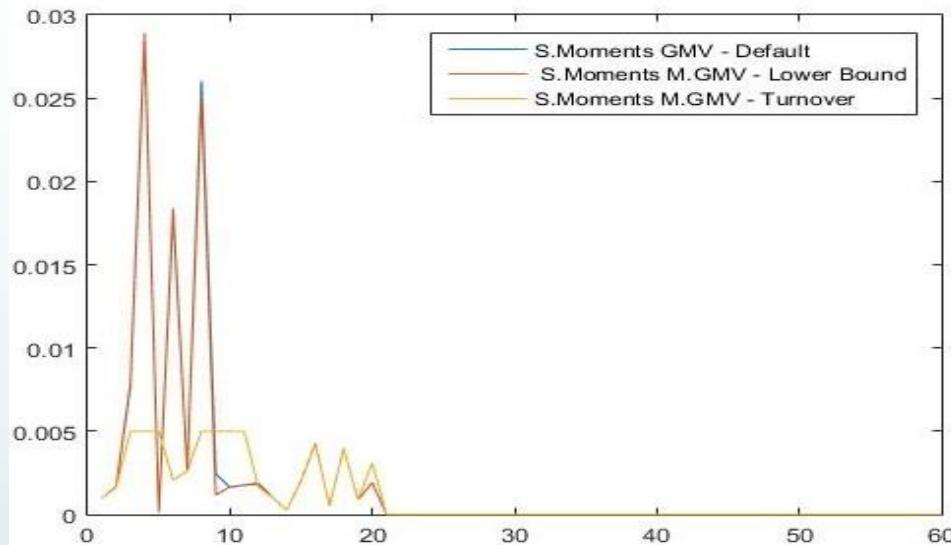
- Assets like US and EU 10+ are more likely to be included in this subgroup



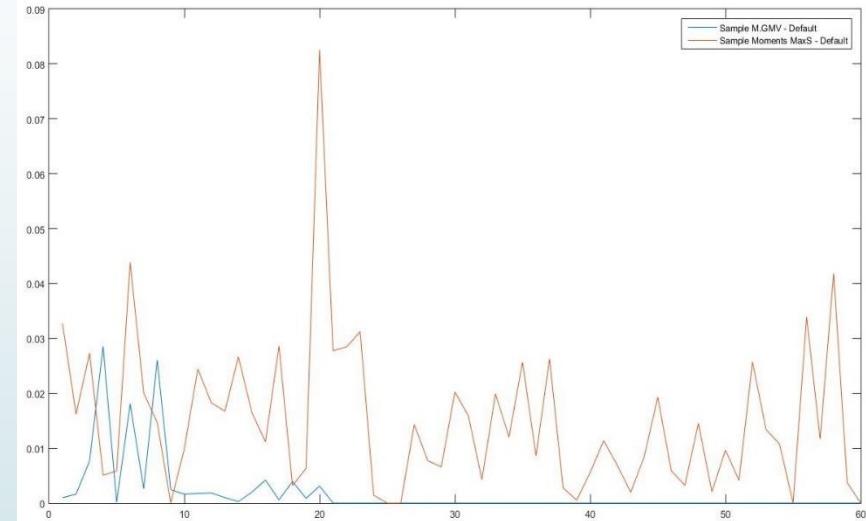
Monthly Tactical Choices

ST group : Turnover

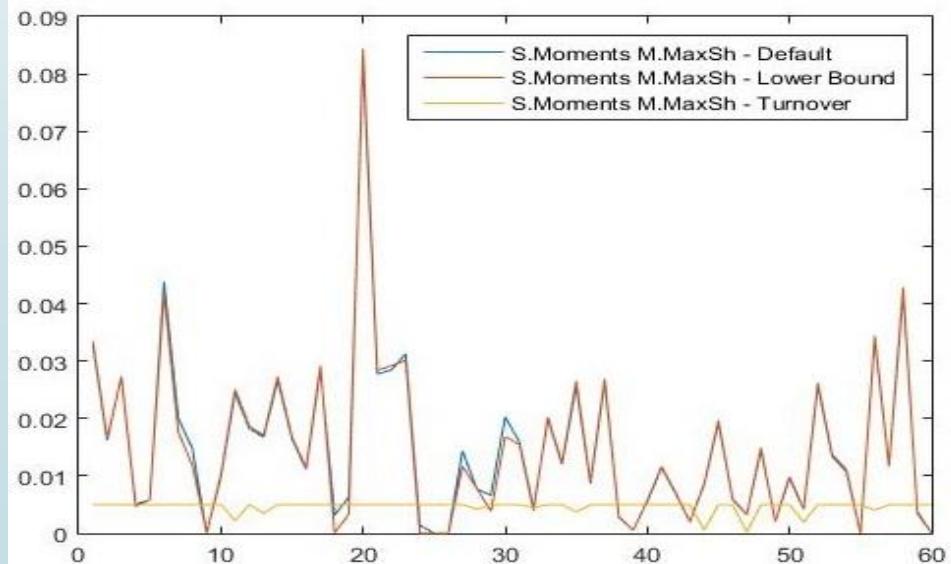
Turnover by constraints - GMV



Turnover by method



Turnover by constraints - MS

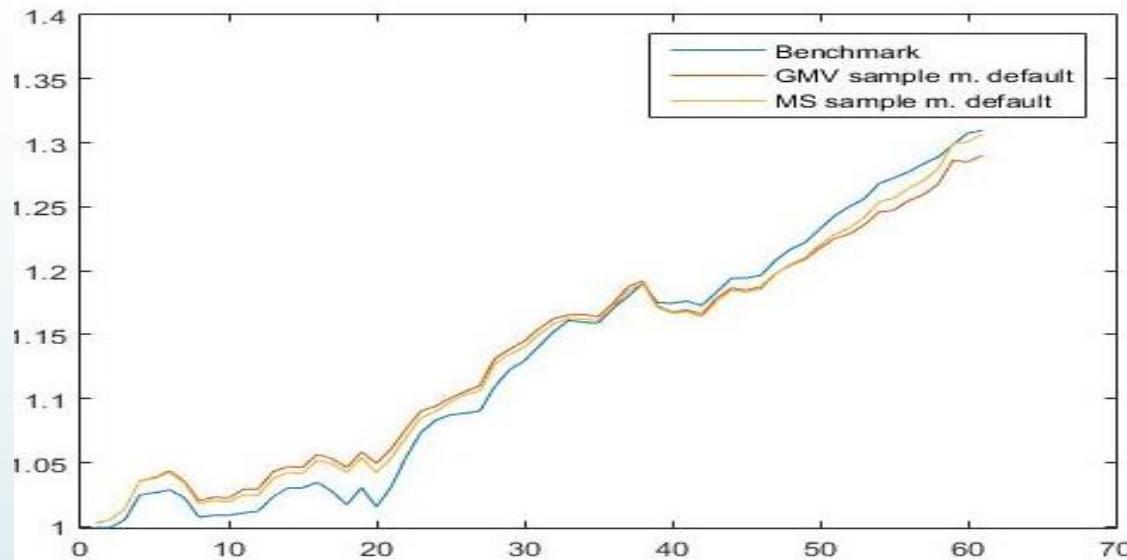


- In the first graph the turnover has very steep spikes at the beginning of the period observed but after the 20th month the portfolio weights stabilize.

Monthly Tactical Choices

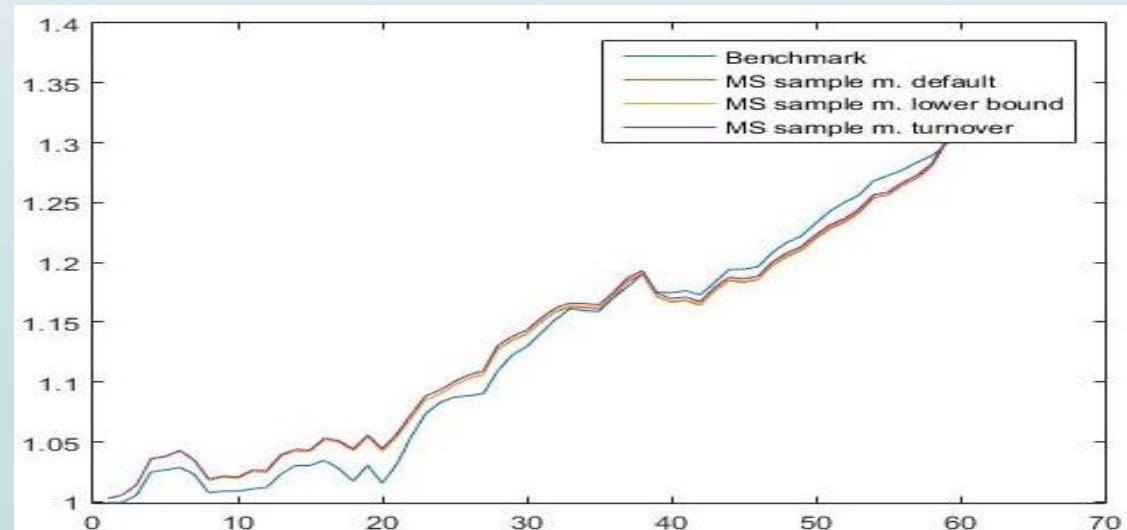
ST Group: Cumulated Returns

C.Returns by method



- The portfolios are closer to each other with respect to the previous group (EU)

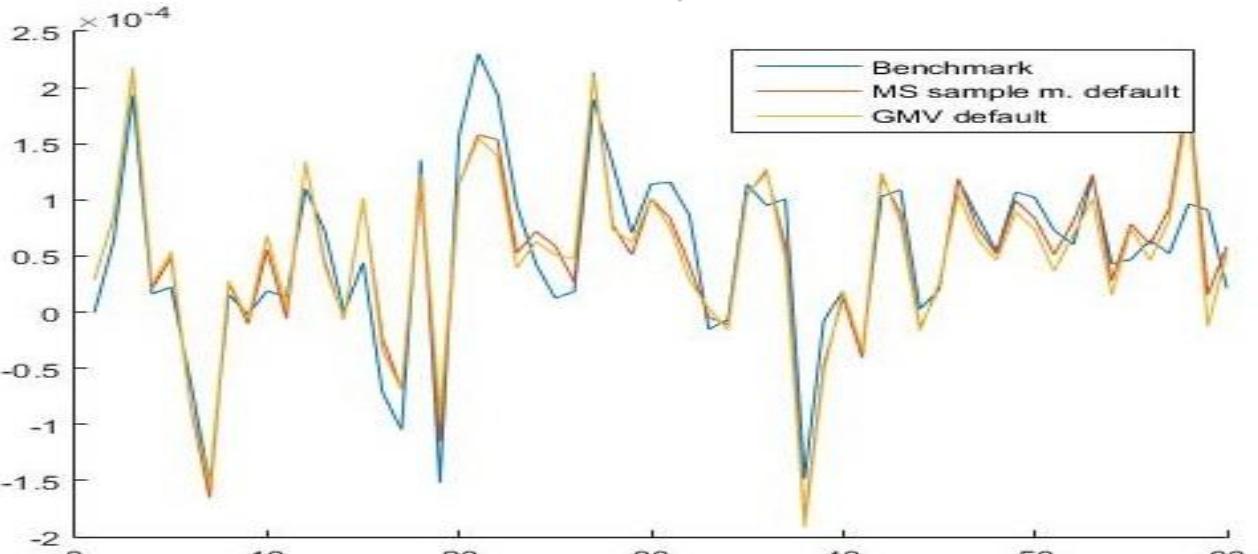
C.Return by constraints- MS



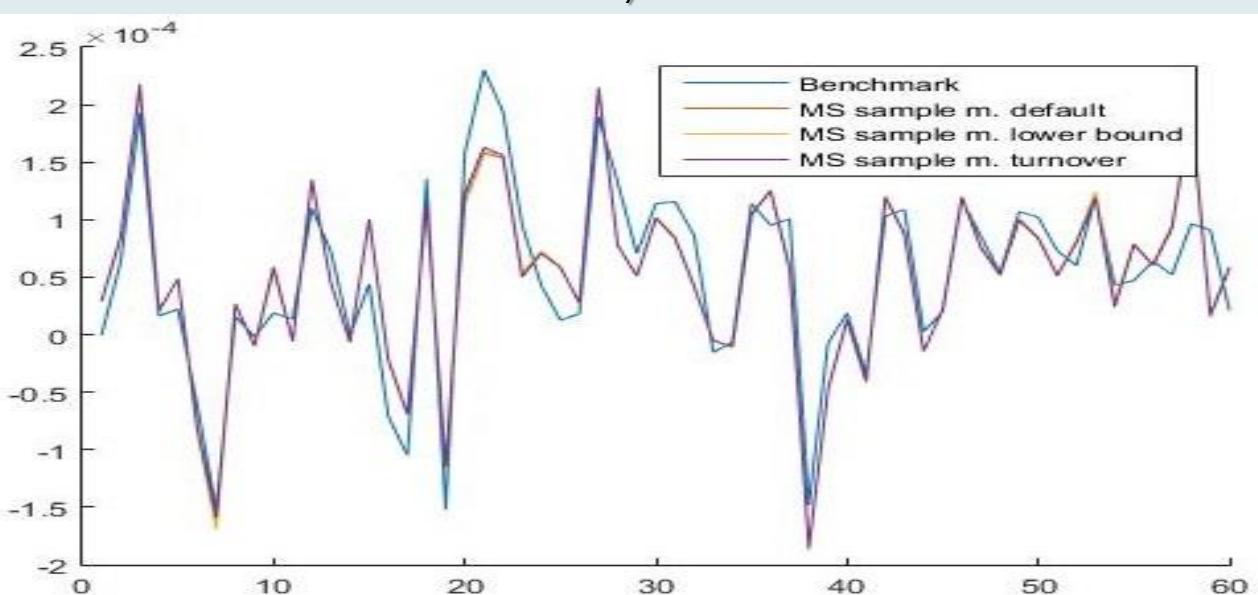
- The benchmark portfolio still manages to yield higher returns in the last 20 months.

Monthly Tactical Choices

ST Group: C.Returns Δ-Tracking
Indexed CR by Method



Indexed CR by constraints- MS



- Once again, the benchmark indexes seems to be anticipated by our portfolios

Monthly Tactical Choices

ST Group: Performance Measurement

Strategy	Mean	StDev	Min	Max				
'Market'	0.446	0.74471	-1.4882	2.2333	Benchmark portfolio has the highest std. Dev.			
'GMV sample Default'	0.42101	0.68844	-1.6088	2.15				
'GMV sample lower bound'	0.42506	0.69776	-1.6263	2.1745				
'GMV sample turnover'	0.42003	0.68825	-1.6088	2.1446				
'MS sample Default'	0.44213	0.7079	-1.5991	2.1296				
'MS sample lower bound'	0.44588	0.71821	-1.6317	2.1566				
'MS sample turnover'	0.44447	0.7051	-1.5523	2.143				
'GMV eq/EW Default'	0.42246	0.68192	-1.6088	2.0703				
'GMV eq/EW lower bound'	0.42634	0.69149	-1.6263	2.0964				
'GMV eq/EW turnover'	0.42246	0.68192	-1.6088	2.0703				
'MS eq/EW Default'	0.43515	0.72495	-1.7023	2.1862				
'MS eq/EW lower bound'	0.43506	0.72662	-1.6985	2.2019				
'MS eq/EW turnover'	0.42847	0.71303	-1.6255	2.1806				
Strategy	Sh	So	Tr	VaR	ES	Cal	Ste	FT
'Market'	0.59889	0.77795	0.446	0.39688	0.31778	0.29852	0.37585	1.5619
'GMV sample Default'	0.61154	0.80275	0.50712	0.51572	0.31932	0.26168	0.38959	1.5769
'GMV sample lower bound'	0.60918	0.79678	0.50416	0.50974	0.31652	0.26137	0.38624	1.5675
'GMV sample turnover'	0.61029	0.80112	0.50583	0.51453	0.31858	0.26108	0.38869	1.5741
'MS sample Default'	0.62457	0.79981	0.50682	0.47602	0.31172	0.27515	0.38713	1.5823
'MS sample lower bound'	0.62083	0.79267	0.50303	0.46905	0.30817	0.27194	0.383	1.5701
'MS sample turnover'	0.63036	0.82017	0.51003	0.48812	0.31932	0.28634	0.39628	1.6132
'GMV eq/EW Default'	0.61951	0.82127	0.51395	0.53128	0.32585	0.26258	0.39822	1.6029
'GMV eq/EW lower bound'	0.61656	0.8139	0.5104	0.52338	0.32234	0.26215	0.39404	1.5914
'GMV eq/EW turnover'	0.61951	0.82127	0.51395	0.53128	0.32585	0.26258	0.39822	1.6029
'MS eq/EW Default'	0.60024	0.73707	0.49001	0.45524	0.28988	0.25563	0.36249	1.4978
'MS eq/EW lower bound'	0.59874	0.73447	0.48876	0.45006	0.28894	0.25614	0.36106	1.4942
'MS eq/EW turnover'	0.60091	0.76766	0.49089	0.47034	0.29853	0.26359	0.37265	1.5296

Monthly Tactical Choices

ST Group: Performance Measurement

Strategy	CI	Sh	So	Tr	VaR	ES	Cal	Ste	FT
'Market'	76	12	10	13	13	7	1	10	10
'GMV sample Default'	45	7	5	5	4	4	9	5	6
'GMV sample lower bound'	66	9	8	8	6	8	10	8	9
'GMV sample turnover'	56	8	6	7	5	6	11	6	7
'MS sample Default'	47	2	7	6	8	9	3	7	5
'MS sample lower bound'	62	3	9	9	10	10	4	9	8
'MS sample turnover'	26	1	3	4	7	5	2	3	1
'GMV eq/EW Default'	18	4	1	1	1	1	6	2	2
'GMV eq/EW lower bound'	35	6	4	3	3	3	8	4	4
'GMV eq/EW turnover'	24	5	2	2	2	2	7	1	3
'MS eq/EW Default'	94	11	12	11	11	12	13	12	12
'MS eq/EW lower bound'	101	13	13	12	12	13	12	13	13
'MS eq/EW turnover'	78	10	11	10	9	11	5	11	11

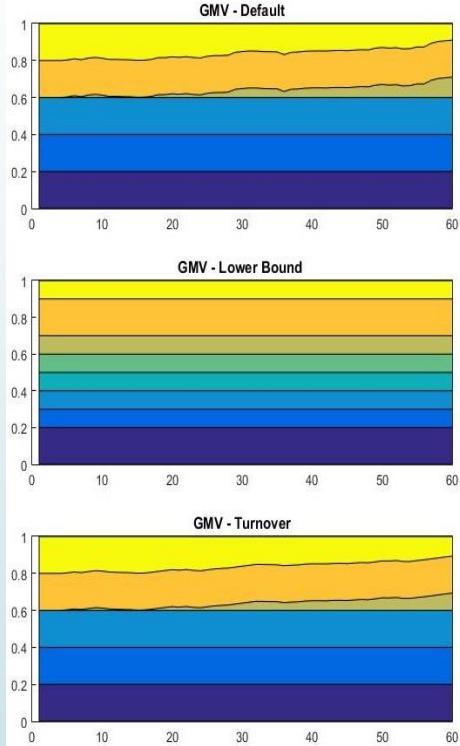
- GMW eq/EW lower bound portfolio appears to be the best one, closely followed by GMW eq/EW Turnover

Strategy	TE	TEV	SemiTEV	IR	SemiIR
'GMV sample Default'	-0.024993	0.1077	0.20822	-0.23206	-0.12003
'GMV sample lower bound'	-0.020938	0.10629	0.21062	-0.19699	-0.099411
'GMV sample turnover'	-0.025965	0.10723	0.20814	-0.24215	-0.12475
'MS sample Default'	-0.003865	0.088094	0.17734	-0.043873	-0.021794
'MS sample lower bound'	-0.00011513	0.087233	0.17383	-0.0013198	-0.00066232
'MS sample turnover'	-0.0015279	0.085147	0.17421	-0.017945	-0.0087705
'GMV eq/EW Default'	-0.023543	0.10788	0.20897	-0.21824	-0.11266
'GMV eq/EW lower bound'	-0.01966	0.10624	0.21062	-0.18505	-0.093342
'GMV eq/EW turnover'	-0.023543	0.10788	0.20897	-0.21824	-0.11266
'MS eq/EW Default'	-0.010851	0.095141	0.19533	-0.11405	-0.055554
'MS eq/EW lower bound'	-0.01094	0.09525	0.19184	-0.11485	-0.057025
'MS eq/EW turnover'	-0.017533	0.094868	0.19176	-0.18481	-0.091429

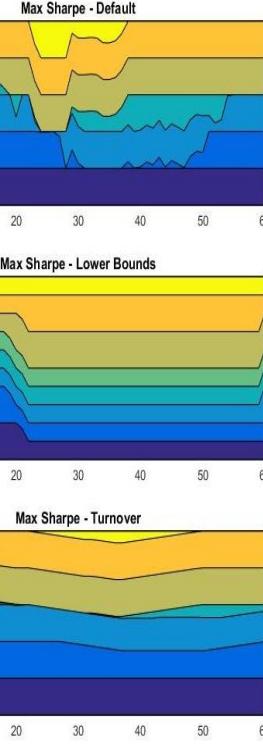
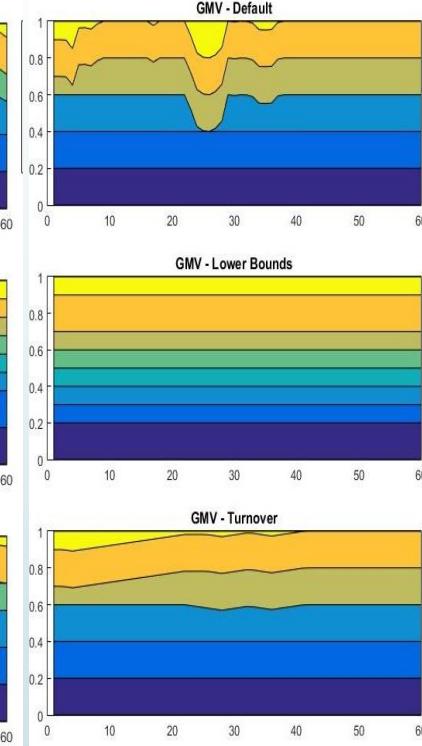
Monthly Tactical Choices

NO group: SM vs Eq.M/EWMA wts

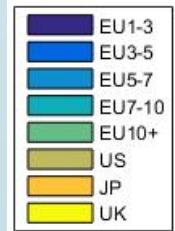
Sample Moments



Eq. Moments



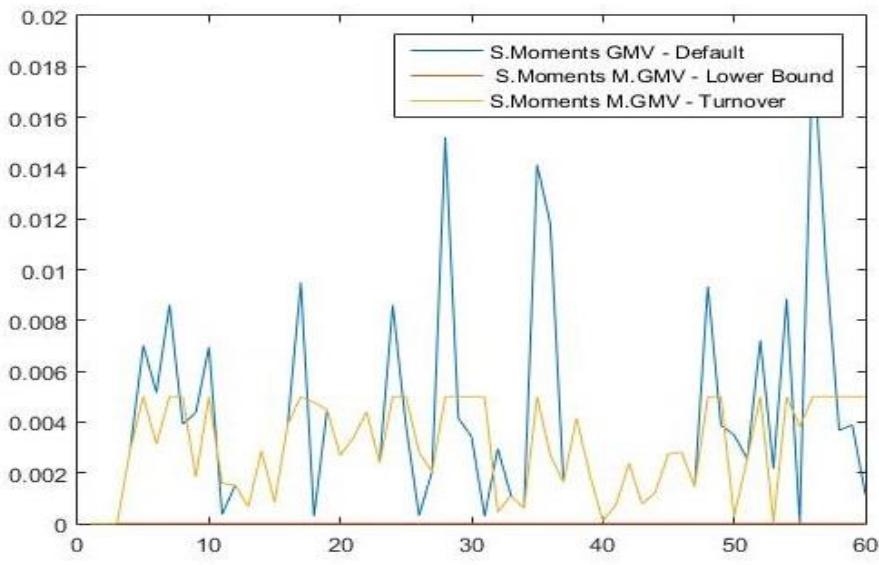
- Eq. Moments method evaluates a more unstable portfolio composition with respect to Sample Moments method.
- The Max Sharpe portfolio of both methods includes riskier assets which is expected, given the higher return (and riskyness) of that asset.



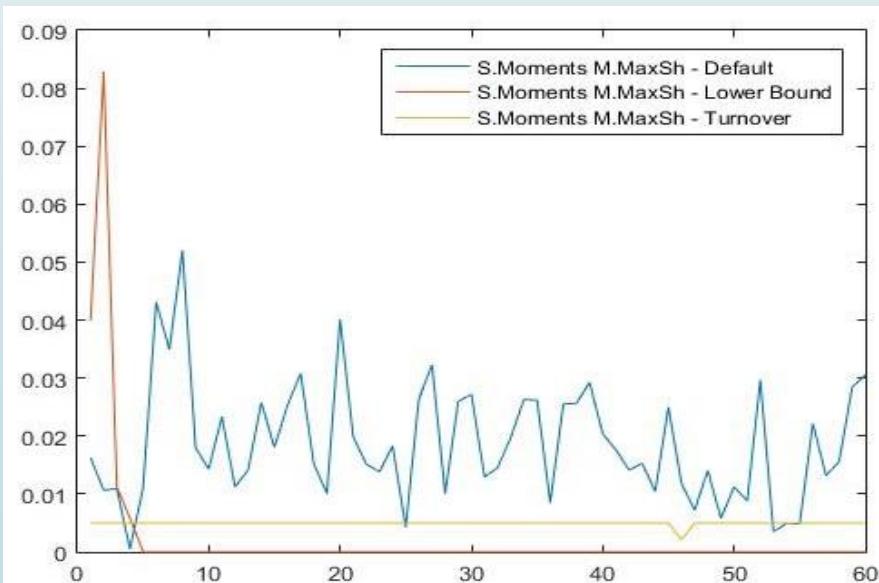
Monthly Tactical Choices

NO group : Turnover

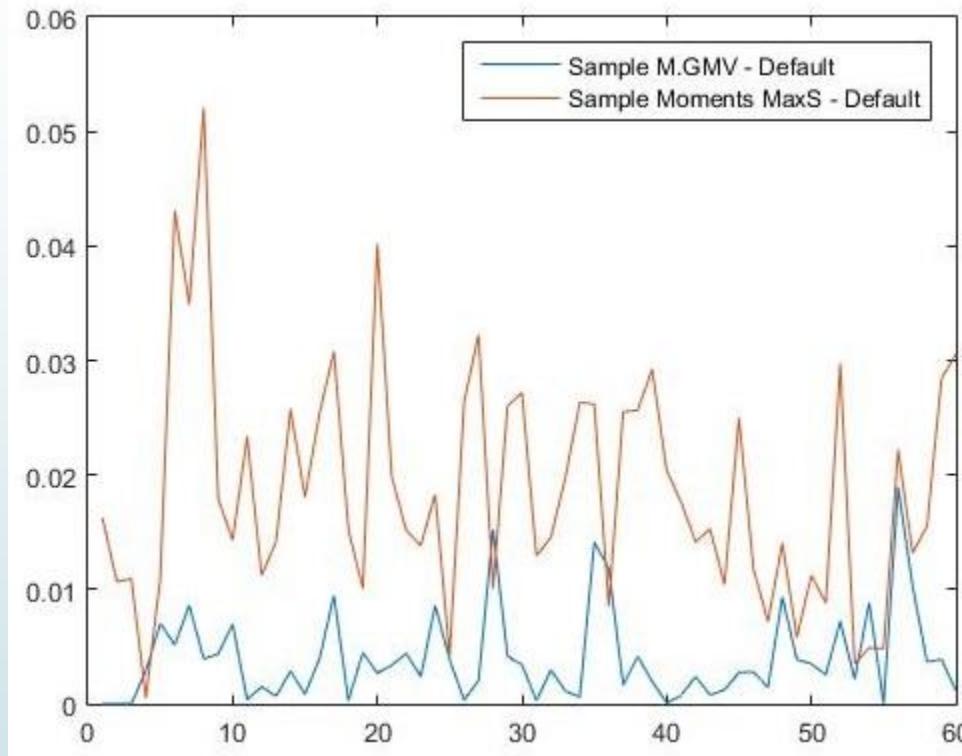
Turnover by constraints - GMV



Turnover by constraints - MS



Turnover by method

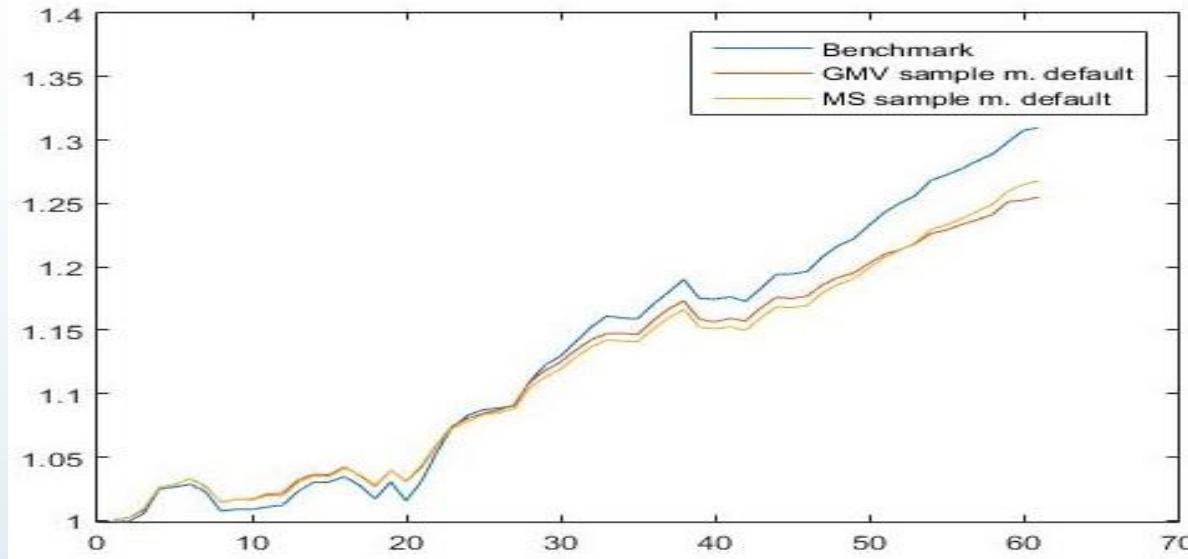


- . The turnover seems to not to be stable enough with the exception of the constrained portfolios.

Monthly Tactical Choices

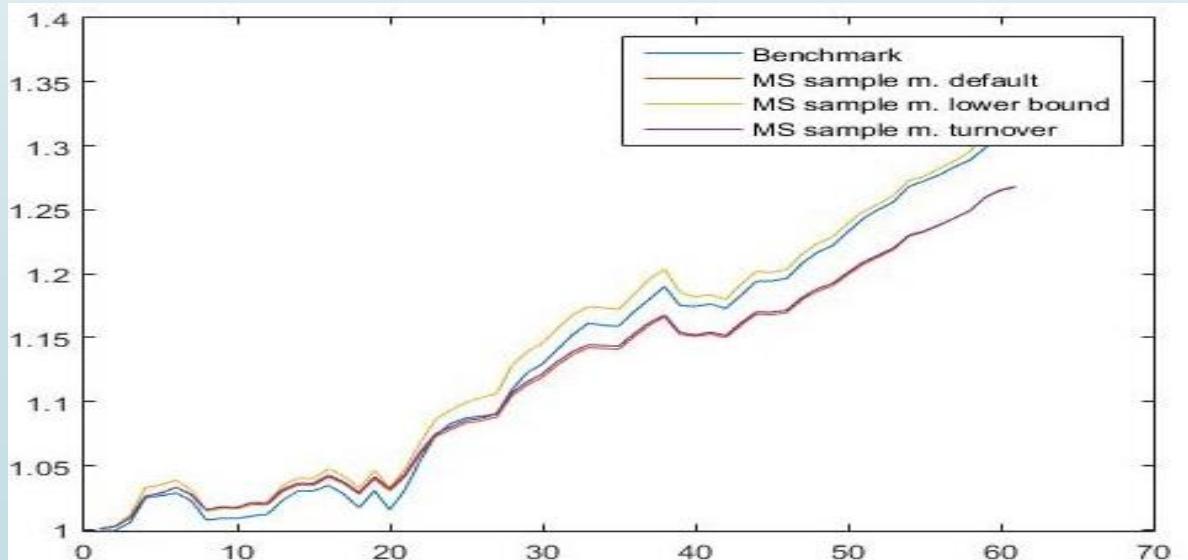
NO Group: Cumulated Returns

C.Returns by method



- The non-constrained portfolios struggle once more to beat the benchmark in the long run

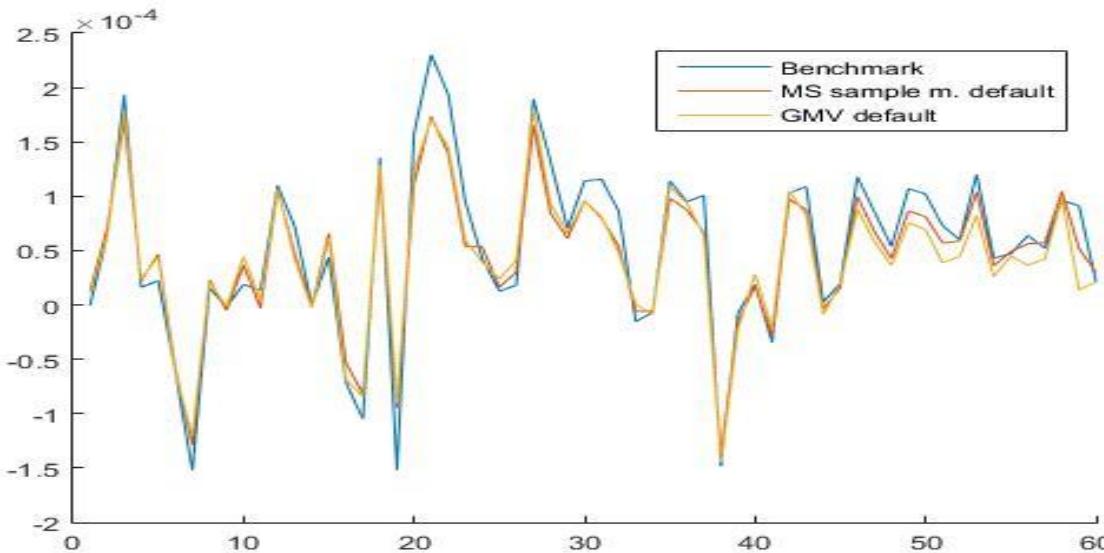
C.Return by constraints- MS



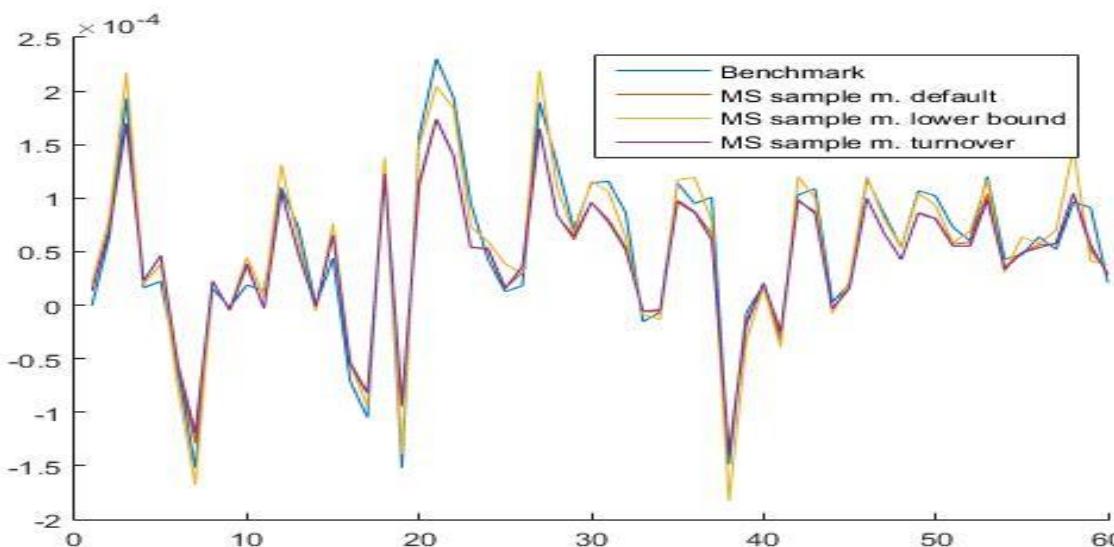
- We managed to find a portfolio outperforming the benchmark and, not surprisingly, is the lower-bound one once again.

Monthly Tactical Choices

NO Group: C.Returns Δ-Tracking
Indexed CR by Method



Indexed CR by constraints- MS



- . The delta cumulated returns analysis tells us once more that our portfolios manage to anticipate the movements of the benchmark

Monthly Tactical Choices

NO Group: Performance Measurement

Strategy	Mean	StDev	Min	Max
'Market'	0.446	0.74471	-1.4882	2.2333
'GMV sample Default'	0.37456	0.60971	-1.2309	1.7665
'GMV sample lower bound'	0.4231	0.69929	-1.5529	2.0392
'GMV sample turnover'	0.37553	0.61006	-1.2309	1.7665
'MS sample Default'	0.39164	0.59711	-1.2539	1.677
'MS sample lower bound'	0.45607	0.75209	-1.6264	2.1479
'MS sample turnover'	0.3922	0.59172	-1.1859	1.6872
'GMV eq/EW Default'	0.35426	0.57433	-1.1769	1.7165
'GMV eq/EW lower bound'	0.4231	0.69929	-1.5529	2.0392
'GMV eq/EW turnover'	0.34899	0.57438	-1.1935	1.681
'MS eq/EW Default'	0.36506	0.63776	-1.4008	1.9367
'MS eq/EW lower bound'	0.44121	0.75284	-1.6905	2.1546
'MS eq/EW turnover'	0.35665	0.59689	-1.2962	1.7848

- . The std. Deviation of the market portfolio is no longer the highest one
- . The proportion between the mean and the std dev of the MS sample turnover portfolio suggests us that it could be an optimal choice

Strategy	Sh	So	Tr	VaR	ES	Cal	Ste	FT
'Market'	0.59889	0.77795	0.446	0.39688	0.31778	0.29852	0.37585	1.5619
'GMV sample Default'	0.61432	0.82288	0.4719	0.4465	0.3427	0.3043	0.39288	1.6139
'GMV sample lower bound'	0.60504	0.77638	0.46561	0.42044	0.303	0.27119	0.36724	1.54
'GMV sample turnover'	0.61557	0.8245	0.47294	0.44743	0.34341	0.30509	0.39369	1.6166
'MS sample Default'	0.65589	0.86502	0.49895	0.46518	0.35181	0.31095	0.41619	1.688
'MS sample lower bound'	0.6064	0.77756	0.46209	0.41627	0.30574	0.27917	0.37167	1.5484
'MS sample turnover'	0.66282	0.88938	0.5046	0.46885	0.36398	0.33072	0.42792	1.7249
'GMV eq/EW Default'	0.61682	0.82934	0.4806	0.43268	0.33878	0.30101	0.40143	1.6387
'GMV eq/EW lower bound'	0.60504	0.77638	0.46561	0.42044	0.303	0.27119	0.36724	1.54
'GMV eq/EW turnover'	0.6076	0.79244	0.46968	0.42415	0.3282	0.2924	0.38661	1.59
'MS eq/EW Default'	0.5724	0.73212	0.44739	0.39444	0.29042	0.2606	0.35407	1.4753
'MS eq/EW lower bound'	0.58606	0.73016	0.45598	0.41089	0.28631	0.25984	0.3504	1.4701
'MS eq/EW turnover'	0.5975	0.76154	0.463	0.4278	0.31101	0.27514	0.3733	1.5393

Monthly Tactical Choices

NO Group: Performance Measurement

Strategy	CI	Sh	So	Tr	VaR	ES	Cal	Ste	FT
'Market'	69	10	7	13	12	7	6	7	7
'GMV sample Default'	37	5	5	5	4	4	4	5	5
'GMV sample lower bound'	71	8	9	7	8	10	10	10	9
'GMV sample turnover'	29	4	4	4	3	3	3	4	4
'MS sample Default'	16	2	2	2	2	2	2	2	2
'MS sample lower bound'	69	7	8	10	10	9	8	9	8
'MS sample turnover'	8	1	1	1	1	1	1	1	1
'GMV eq/EW Default'	30	3	3	3	5	5	5	3	3
'GMV eq/EW lower bound'	79	9	10	8	9	11	11	11	10
'GMV eq/EW turnover'	50	6	6	6	7	6	7	6	6
'MS eq/EW Default'	98	13	12	12	13	12	12	12	12
'MS eq/EW lower bound'	99	12	13	11	11	13	13	13	13
'MS eq/EW turnover'	73	11	11	9	6	8	9	8	11

- As expected, the MS sample turnover is performing extremely well
- The MS sample lower bound portfolio is the only one with a positive Tracking Error.

Strategy	TE	TEV	SemiTEV	IR	SemiIR
'GMV sample Default'	-0.071442	0.045958	0.15652	-1.5545	-0.45644
'GMV sample lower bound'	-0.0229	0.03568	0.12194	-0.64182	-0.1878
'GMV sample turnover'	-0.070465	0.046015	0.15682	-1.5314	-0.44934
'MS sample Default'	-0.054358	0.040495	0.14895	-1.3424	-0.36494
'MS sample lower bound'	0.010068	0.025507	0.093036	0.39472	0.10821
'MS sample turnover'	-0.053797	0.042605	0.14681	-1.2627	-0.36642
'GMV eq/EW Default'	-0.091743	0.066851	0.17575	-1.3724	-0.52202
'GMV eq/EW lower bound'	-0.0229	0.03568	0.12194	-0.64182	-0.1878
'GMV eq/EW turnover'	-0.09701	0.060329	0.17098	-1.608	-0.56737
'MS eq/EW Default'	-0.080944	0.056269	0.18807	-1.4385	-0.43039
'MS eq/EW lower bound'	-0.0047927	0.048115	0.14296	-0.099609	-0.033524
'MS eq/EW turnover'	-0.089354	0.056483	0.17282	-1.582	-0.51704

Monthly Tactical Choices

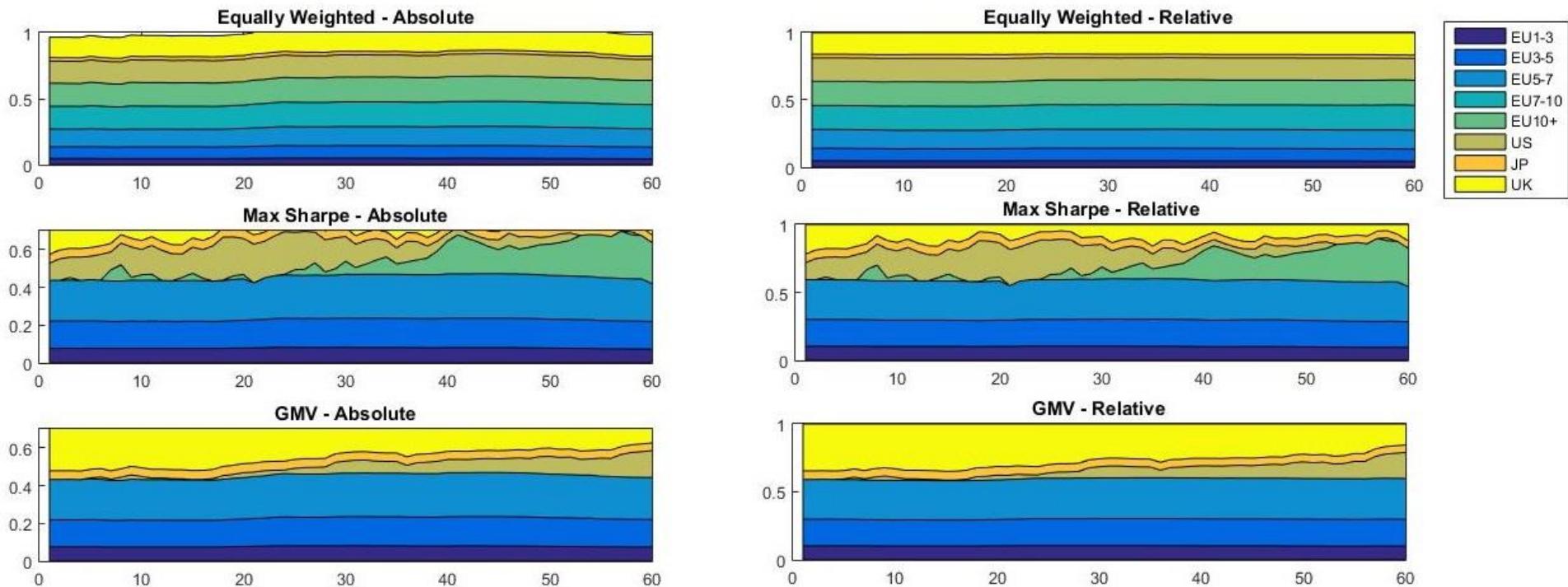
Conclusions

Methods: rr/rs	Sample M/Sample M	Equilibrium moment/EWMA	
Default	GMV - Default	MaxSh - Default	
Lower Bound	GMV – Lower Bound	MaxSh – Lower Bound	
Turnover	GMV - Turnover	MaxSh - Turnover	
Constraints Type	Parameter set #1 EU group	Parameter set #2 Short-term group	Parameter set #3
Group	Mainly EU	10% in High Risk	No Group
Lower Bound	10%	1%	10%
Turnover	0.1%	0.5%	0.5%

- . If we had to choose a portfolio for an investor who wants a safe investment we would suggest the Max Sharpe turnover portfolio computed within the third subgroup using the sample moments method.
- . If instead we wanted a riskier portfolio choice, the Max Sharpe constrained with a lower bound computed within the third subgroup using the sample moments method appears to be the most optimal choice, given that it manages to outperform the benchmark.

Monthly Tactical Choices

Conclusions – Risk Contribution



- . Absolute risk weight is bigger in EqW, compared to MaxSh and GMV, which is the least risky
- . Relative Risk contribution doesn't change over time for equally weighted
- . Relative Risk of assets is proportional to maturity for EU's ones, while JP,UK,US are way more risky

Resampled Efficient Frontier

Introduction

Comparison vs historical approach

Comparison vs EU Group Weights

Comparison vs Sample Moments and Eqilibrium Moments

Resampled Efficient Frontier Introduction

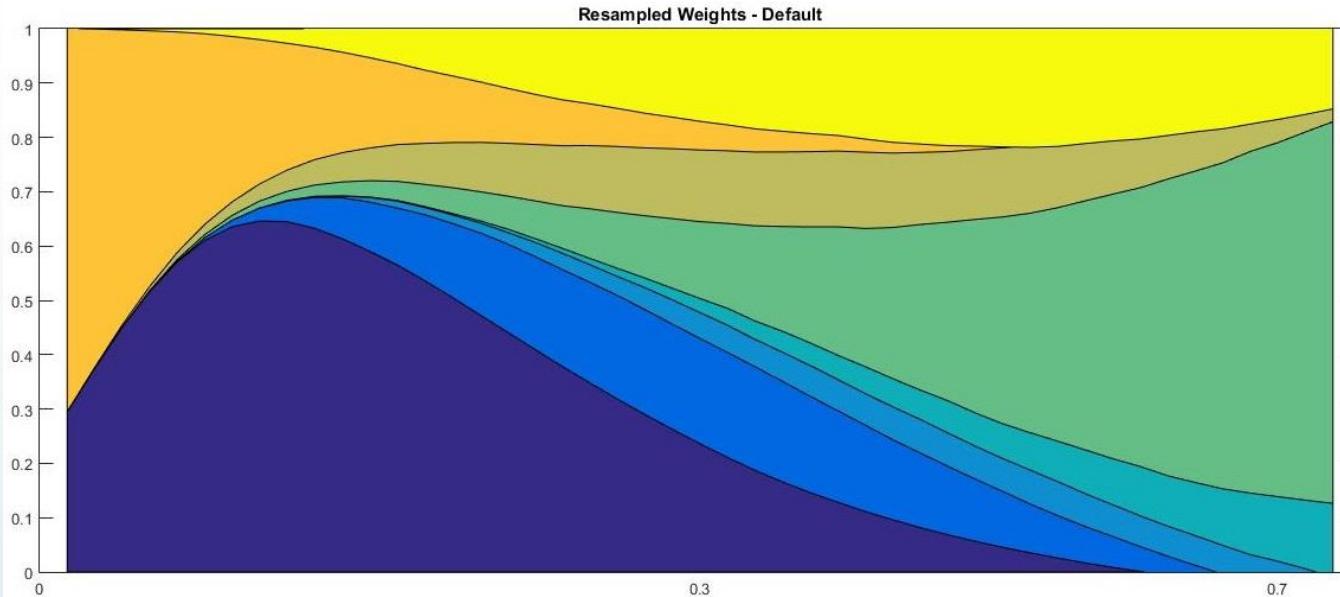
Markovitz's limitations

- Markovitz optimizers tend to maximize estimation errors which affects correct measurement of the weights
- Mkw EF tend to underweight securities with low expected returns and positive correlation (Michaud & Litterman)
- Mean-variance models are often unstable.

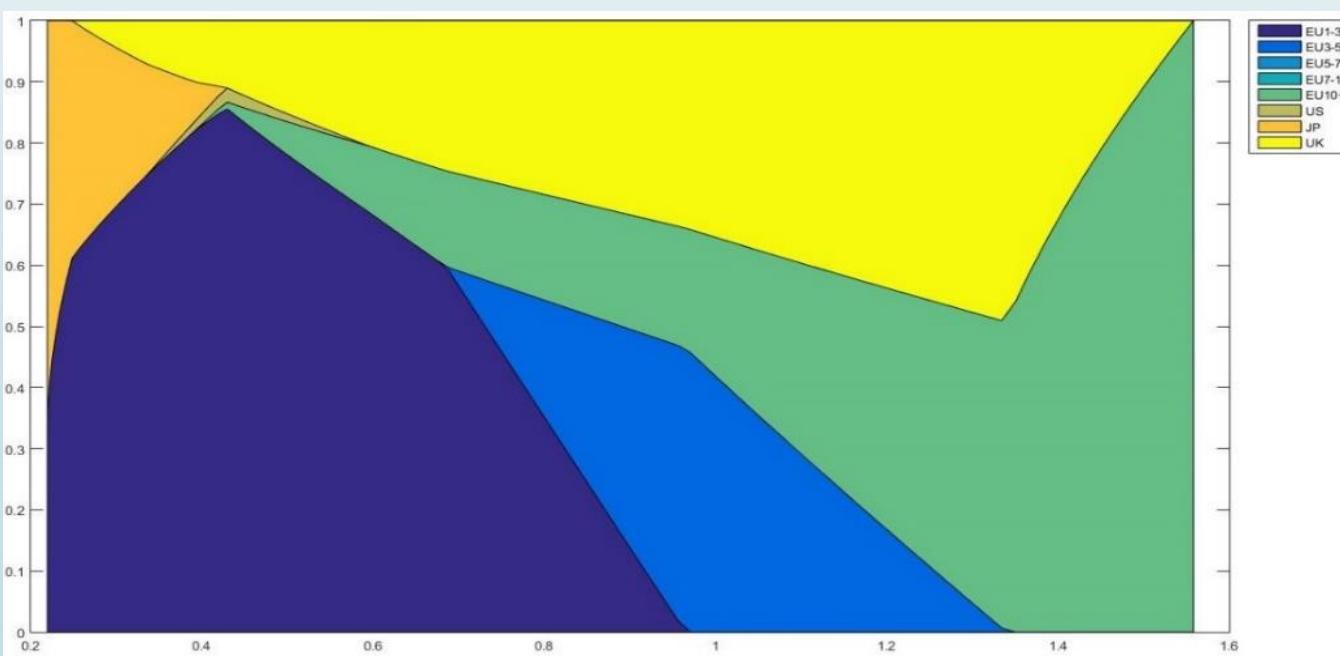
Resampled Efficient Frontier

- Resampled method is based on Resampling optimization inputs.
- Resampling is a Monte Carlo simulation procedure to create alternative optimization inputs.
- Resampled Efficiency is an averaging process that distills all the alternative efficient frontiers into a new efficient frontier and new set of optimized portfolios.

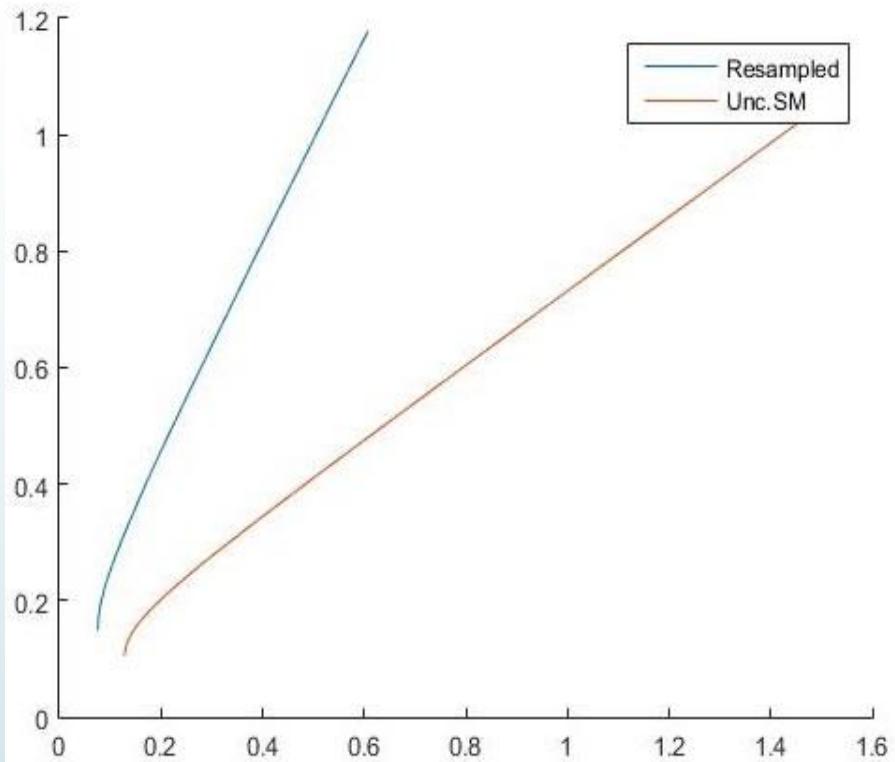
Resampled Efficient Frontier Comparison vs historical approach



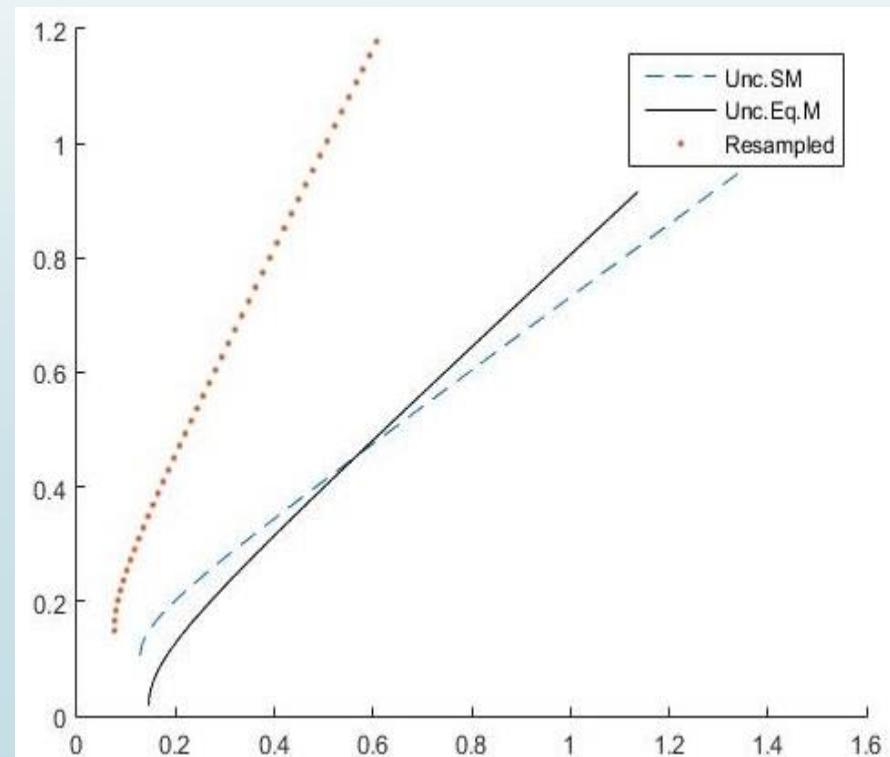
- Resampled EF has more diversified weights due to its lower risk evaluation of assets
- GMV has the same weight composition



Resampled Efficient Frontier Comparison vs SM & EqM



- Resampled EF is at a very low level of risk if compared to the other methods
- If EF SM overestimates risks for our assets, riskier portfolio choices for higher level of return might be viable



Chow-Kritzman

Introduction

Turbulence Measure

Portfolio dispersion: inliers vs outliers

CK EF and weights over time

Chow-Kritzman RF Introduction

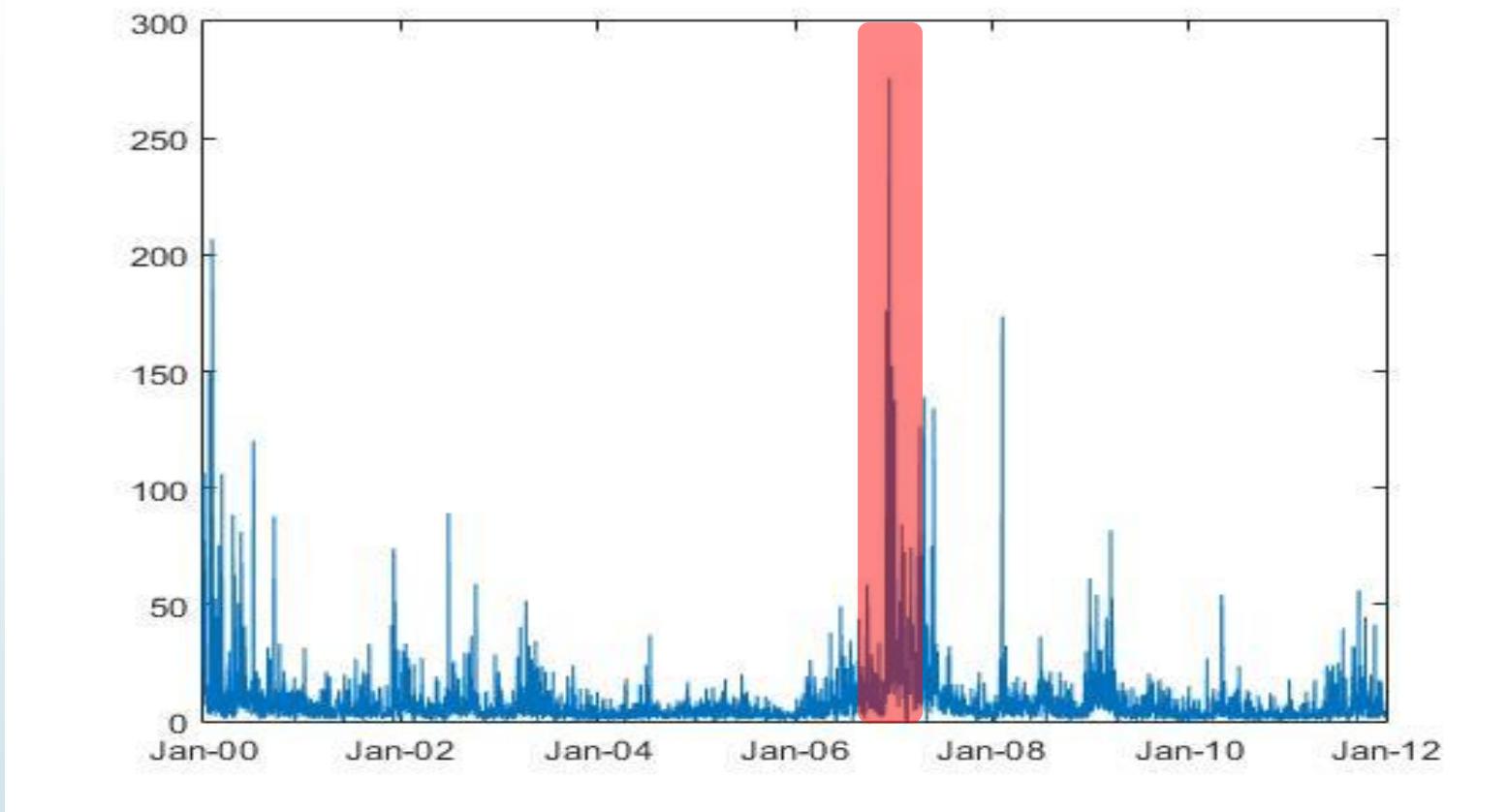
Markovitz's limitations

- Markovitz doesn't account for different levels of uncertainty associated with the input assets
- Dynamic changes in uncertainty might affect the historical sample mean conversion into the expected returns

Chow-Kritzman Resampled Frontier approach

- CK RF uses a conditional covariance approach, distinguishing between two state of volatility in the market: high and low
- The RF is splitted between inliers value and outliers value for improved accuracy

Chow-Kritzman RF Turbulence measure

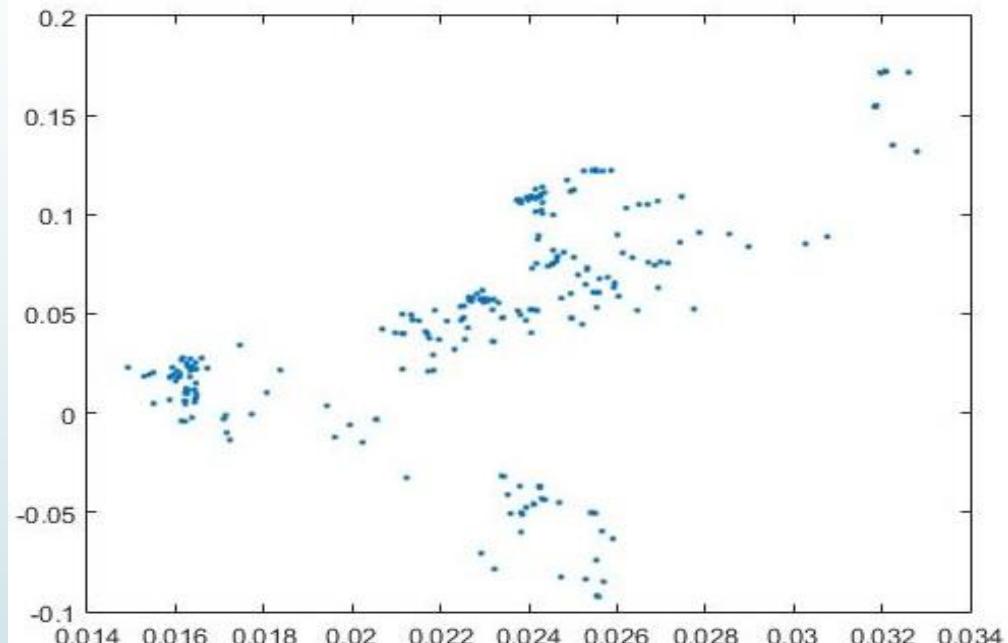


- Turbulence measures high volatility periods in the sample
- Peaks in the measure happen before 2001 and 2008

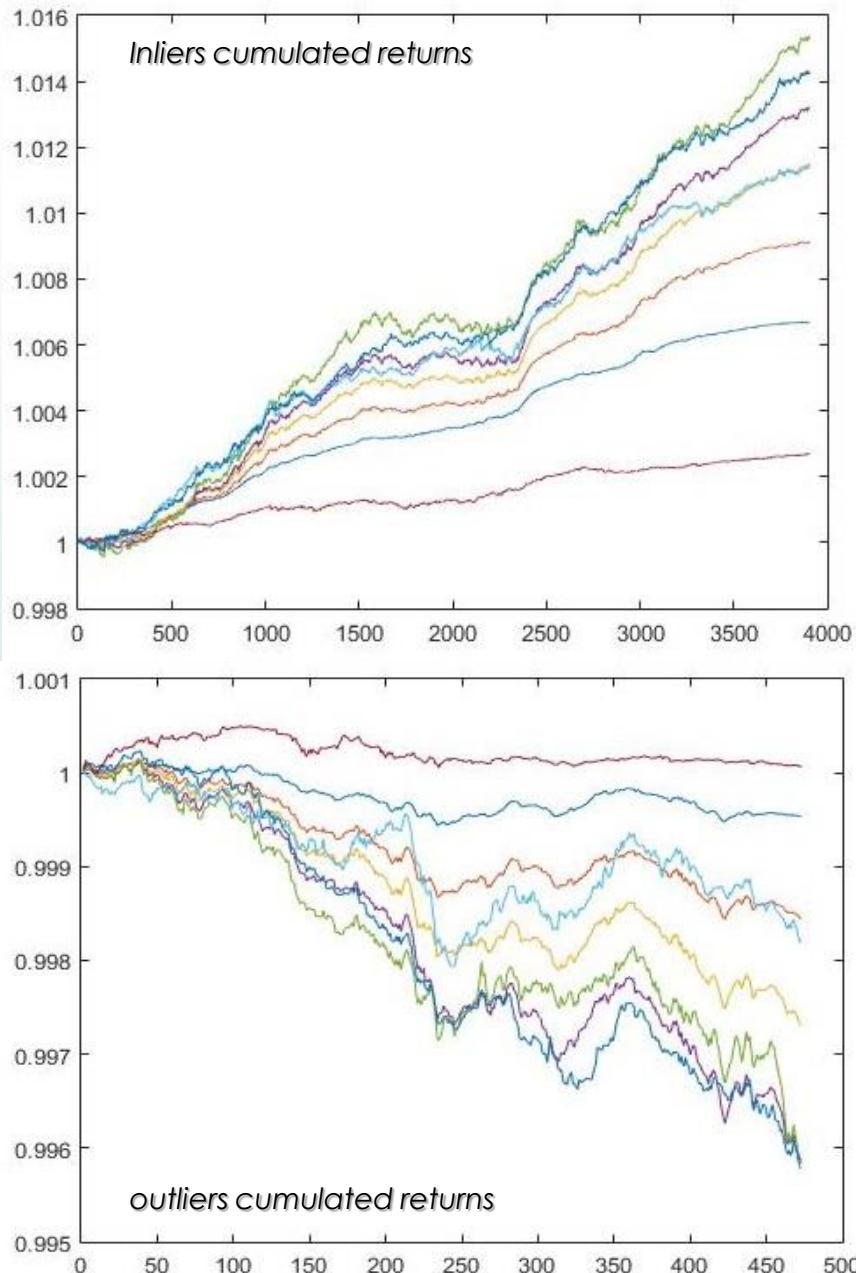
Chow-Kritzman RF

Portfolio dispersion: inliers vs outliers

Portafolio frontier

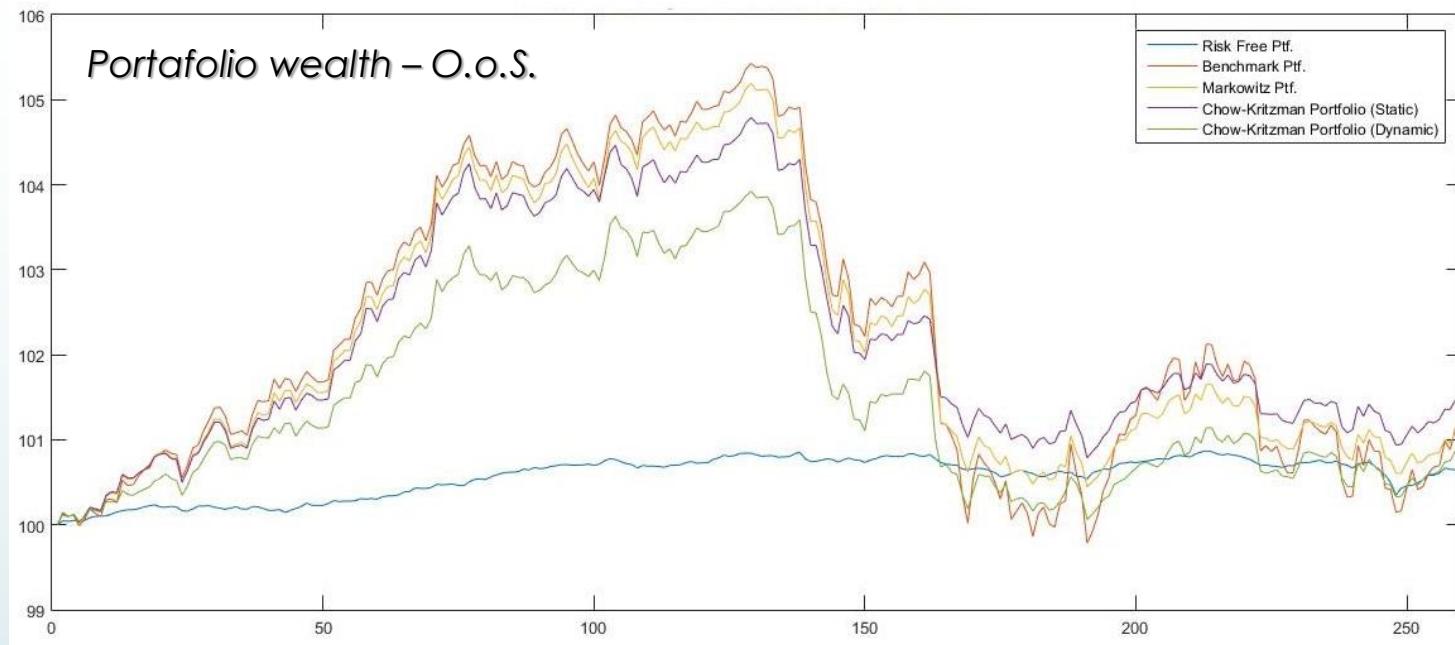


- Portafolio Frontier shows two clusters of outliers
- Inliers cumulated return have a positive trend while outliers drag the return down

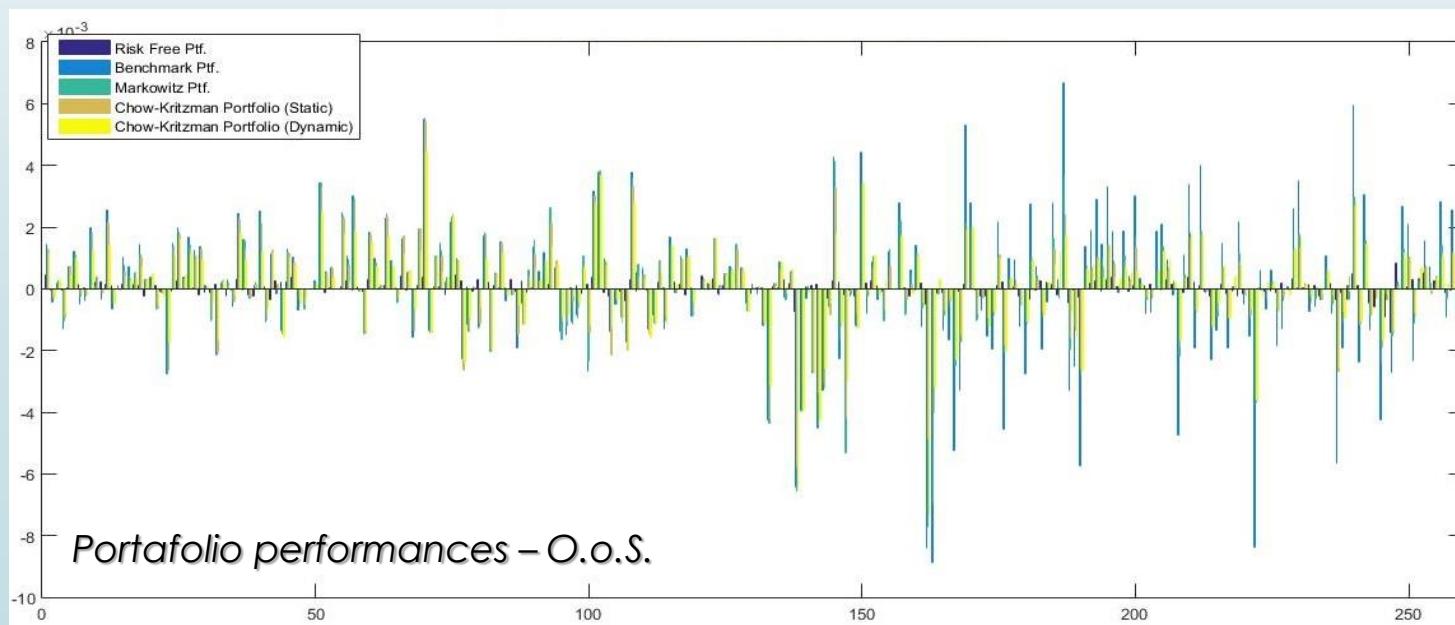


Chow-Kritzman RF

Portfolios wealth and performances

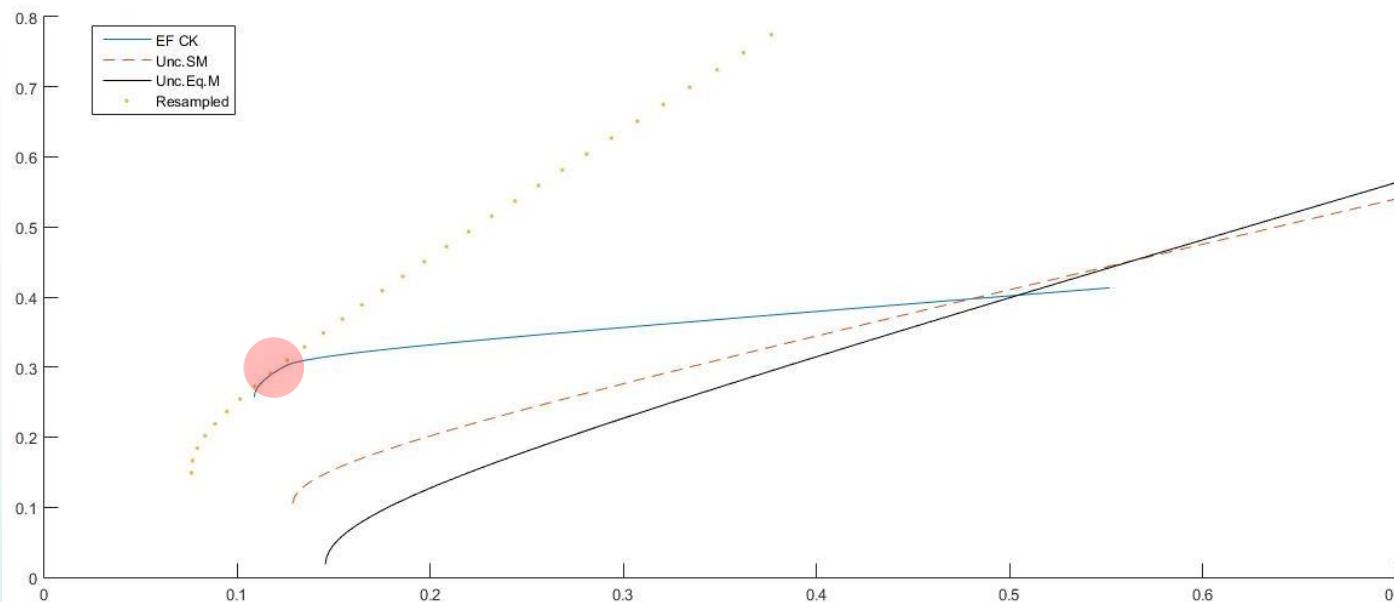


- Portfolio wealth is higher for Mkw methods and benchmark during high return levels
- For low returns CK outperforms Mkw

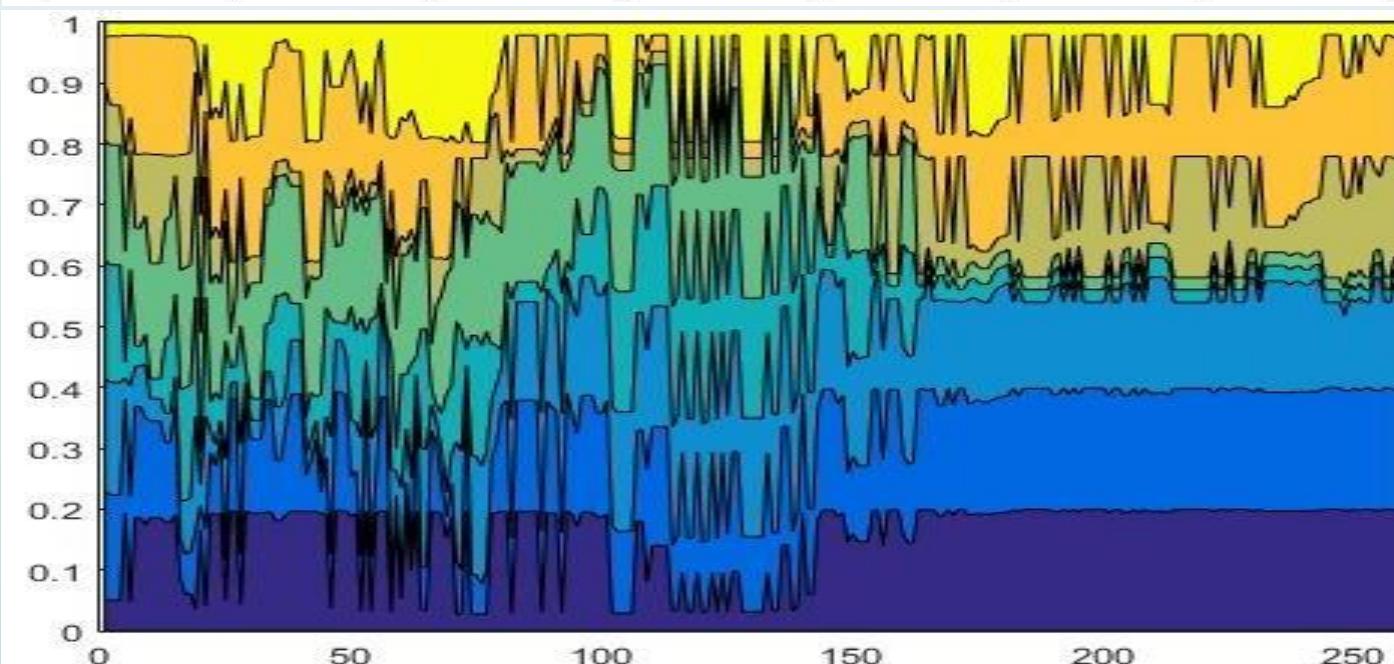


- Portafolio performances of CK method seems to be on par with Mkw method for the first part, much less so in the second
- Static CK is always better performing than Dynamic CK

Chow-Kritzman RF CK EF and weights over time



- CK EF estimates higher values for returns than SM EF
- Red area might be comprised of optimal portfolios (for its given level of risk)



- Stable weights are located in the second half of the sample

Risk Management - VaR

Introduction

*Distribution for full sample –
Benchmark Vs Portfolio*

*Distribution for last year sample
– Benchmark Vs Portfolio*

Conclusions

Risk Management – VaR

Introduction

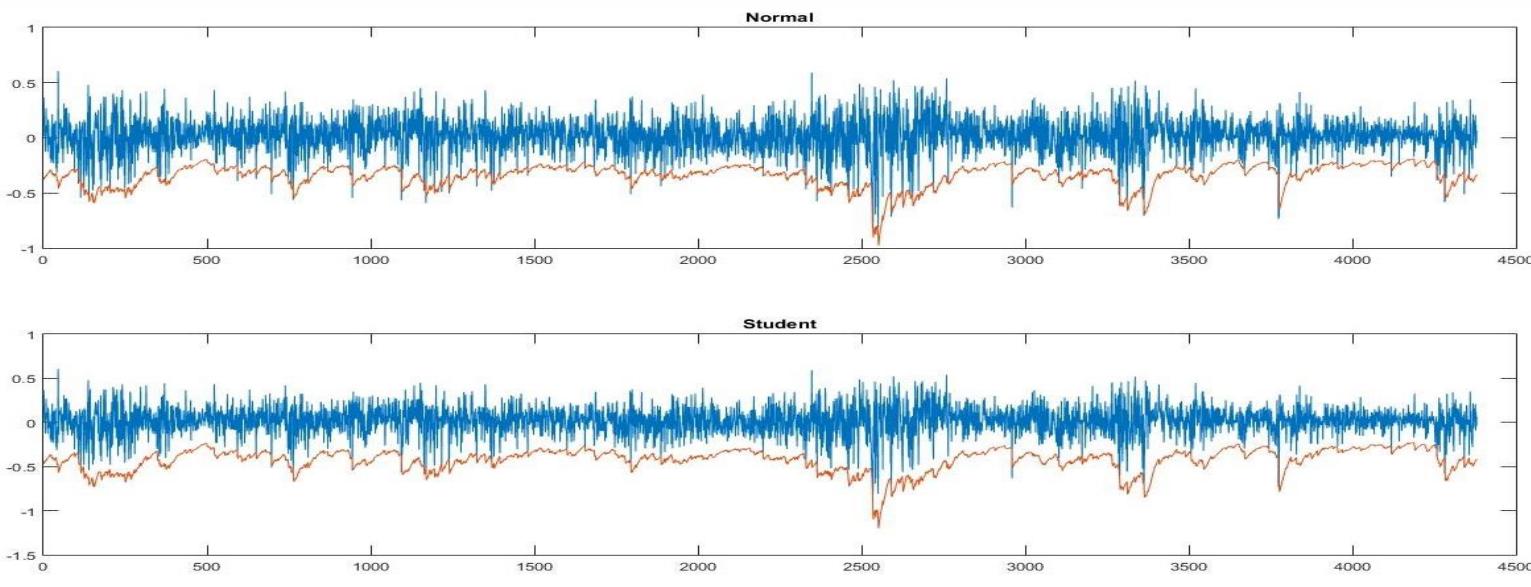
- *Risk management is the process of identification, analysis and either acceptance or mitigation of uncertainty in investment decision-making.*
- *The VaR is the most known/adopted risk measure in financial institutions.*

- *Value at risk is a statistical technique used to measure and quantify the level of financial risk within a firm or investment portfolio over a specific time frame.*

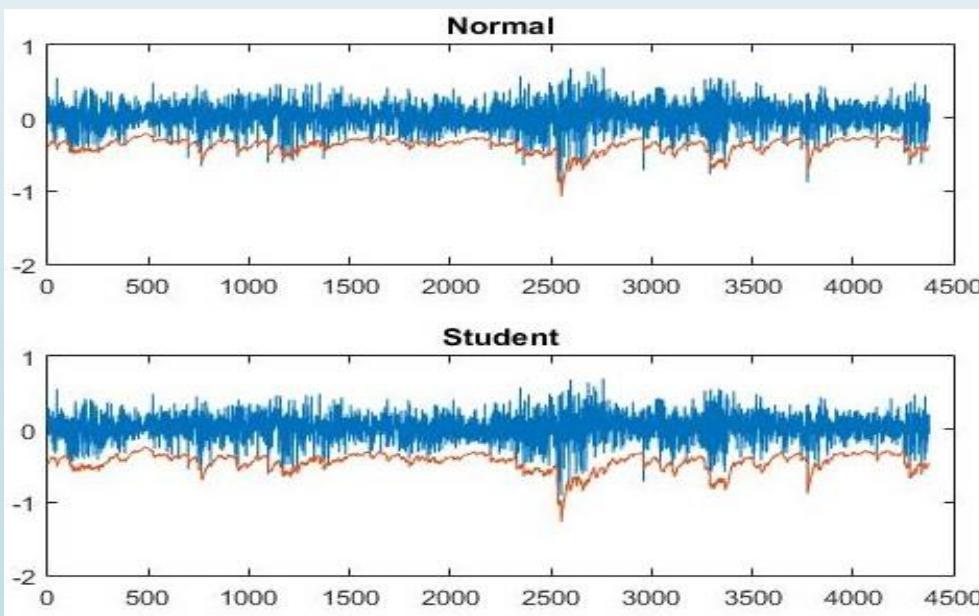
Risk Management - VaR

Distribution for full sample – Bmk Vs Portfolio

Benchmark



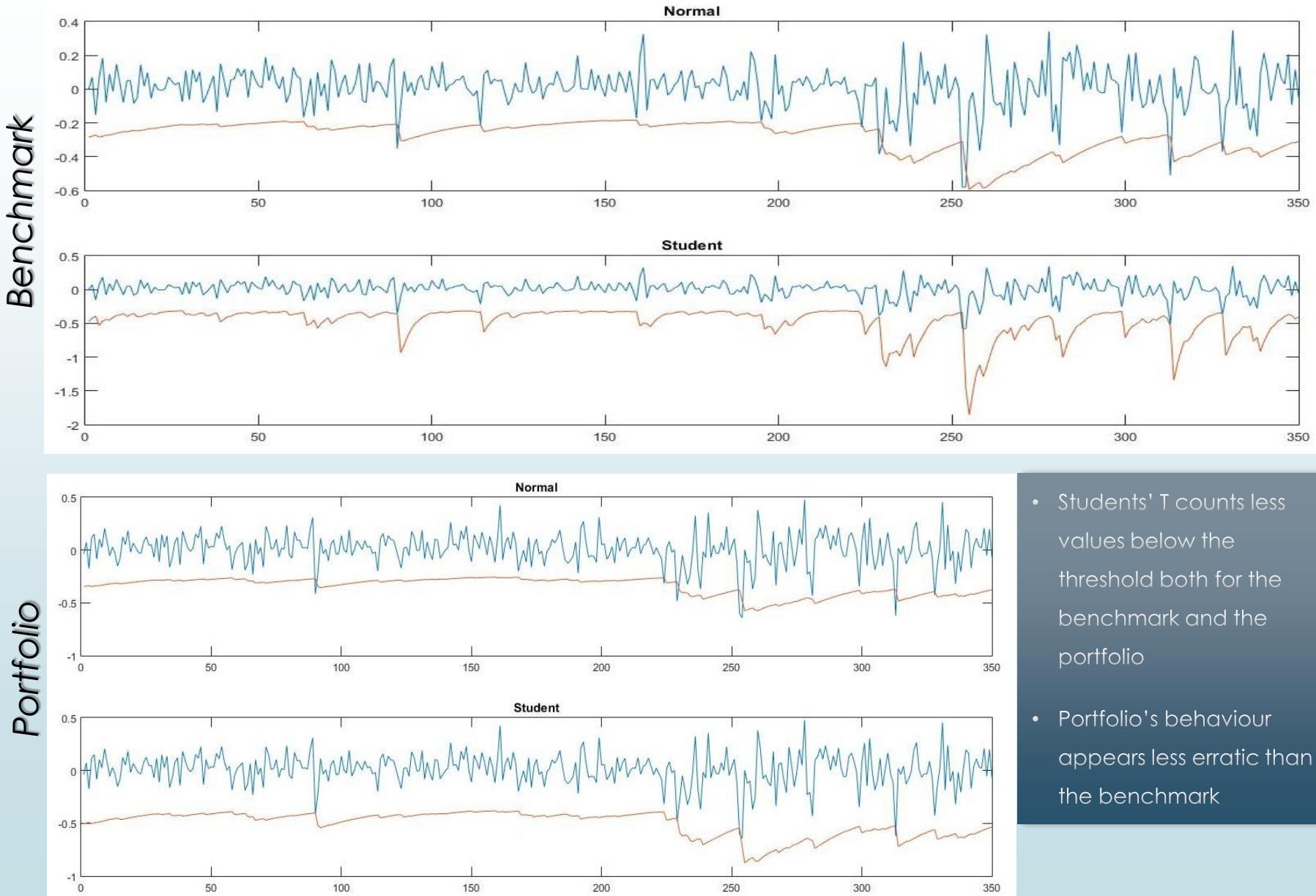
Portfolio



- Students' T counts less values below the threshold both for the benchmark and the portfolio

Risk Management - VaR

Distribution for last year sample – Bmk Vs Portfolio



- Students' T counts less values below the threshold both for the benchmark and the portfolio
- Portfolio's behaviour appears less erratic than the benchmark

Conclusions

- From the overall work we found two valuable portfolios choices: the MS lower bound computed with Sample Moments for risk lover investors and a lower risk portfolio that would be the Maximum sharpe portfolio with Sample Moments turnover constraints for safer investments.
- Resampled Efficient Frontier suggest that the risk is overestimated while the Chow-Kritzman approach suggest that returns are underestimated.
- Even if that is the case both our portfolios would be better off.
- Ultimately our portfolios could just be better than we estimated.



Thanks for your attention