T- model

Diversification is the only free lunch

Date: 28 September 2017

Modelled by: Langyu Gu

Not to be smart, but to be diversified

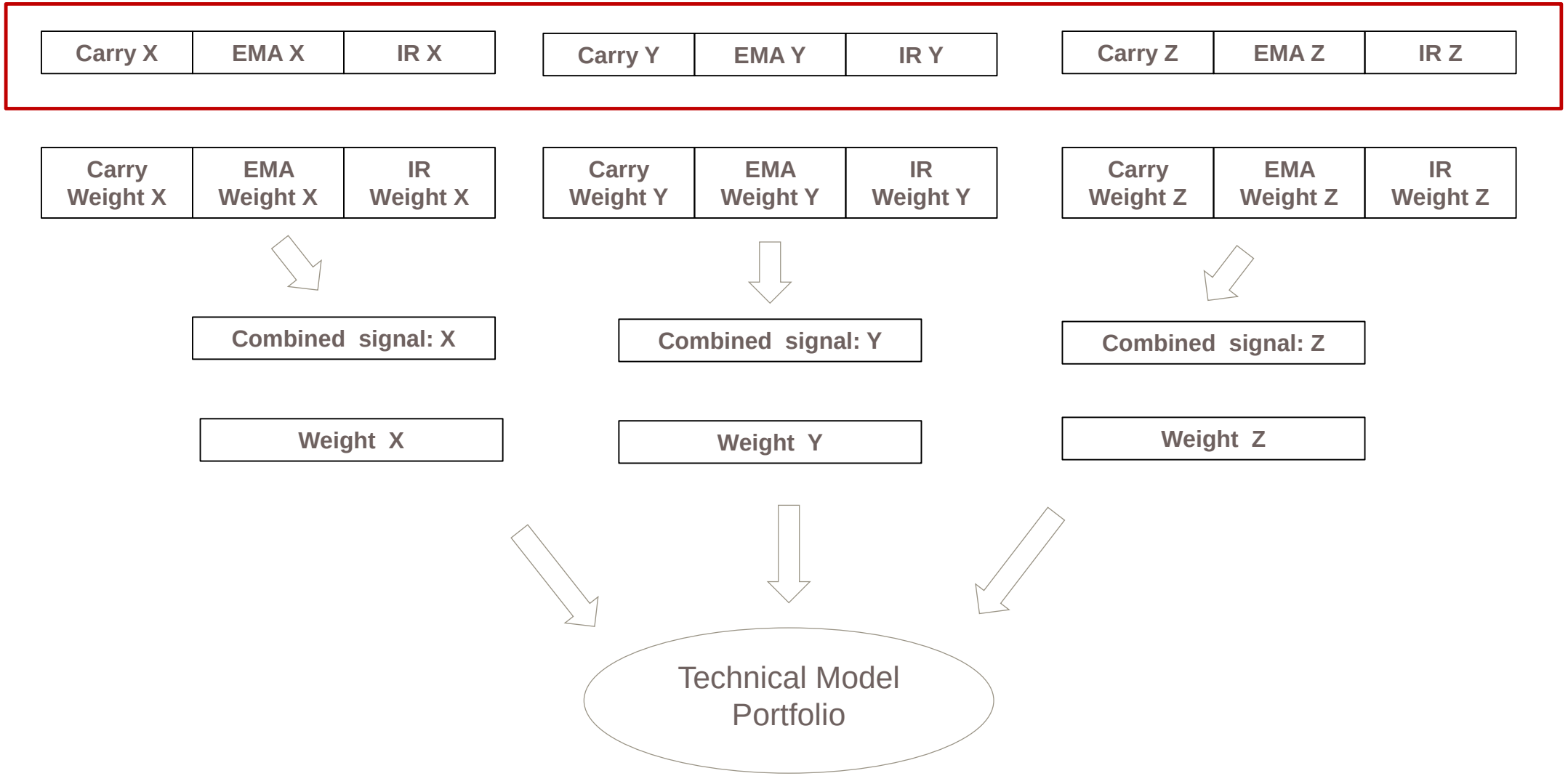
As an asset manager, our goal is to deliver stable and positive returns consistently regardless market conditions. In a market crisis, the traditional assets tend to be highly correlated, the diversification benefit of traditional assets is limited, which results in portfolio exposing to excessive risk and losses. Therefore, the task of seeking diversification or reducing portfolio correlations has become essential, which I think is more important than seeking new alpha opportunities.

Throughout the past three decades, asset managers actually have been seeking diversification all the time. We have seen a path of investing in Emerging market equity in 1990s, popularity of Alternatives (Private Equity, Commodities, Real Estates) in 2000s and to lately smart factor investing.

However, when a diversification becomes popular, crowded investing diminishes its benefit and it becomes no longer profitable. For instance, correlations between traditional assets, including emerging markets, have been rising for the past decades.

The spirit of Technical model is to seek diversification throughout the construction. We aim to maximise diversification benefit from all aspects.

Structure


Carry X
EMA X
IR X
Carry Y
EMA Y
IR Y
Carry Z
EMA Z
IR Z
Carry Weight X
EMA Weight X
IR Weight X
Carry Weight Y
EMA Weight Y
IR Weight Y
Carry Weight Z
EMA Weight Z
IR Weight Z
Combined signal: X
Combined signal: Y
Combined signal: Z
Weight X
Weight Y
Weight Z
Technical Model Portfolio

Factor construction

There is not a single strategy would make money forever. Momentum strategy works in trending market but mean-reversion strategy works when a factor has gone too extreme. The combination of momentum and mean-reversion strategies, empirically, produces better performance over individual one of them.

All type of strategy signals can be split into 6 categories:

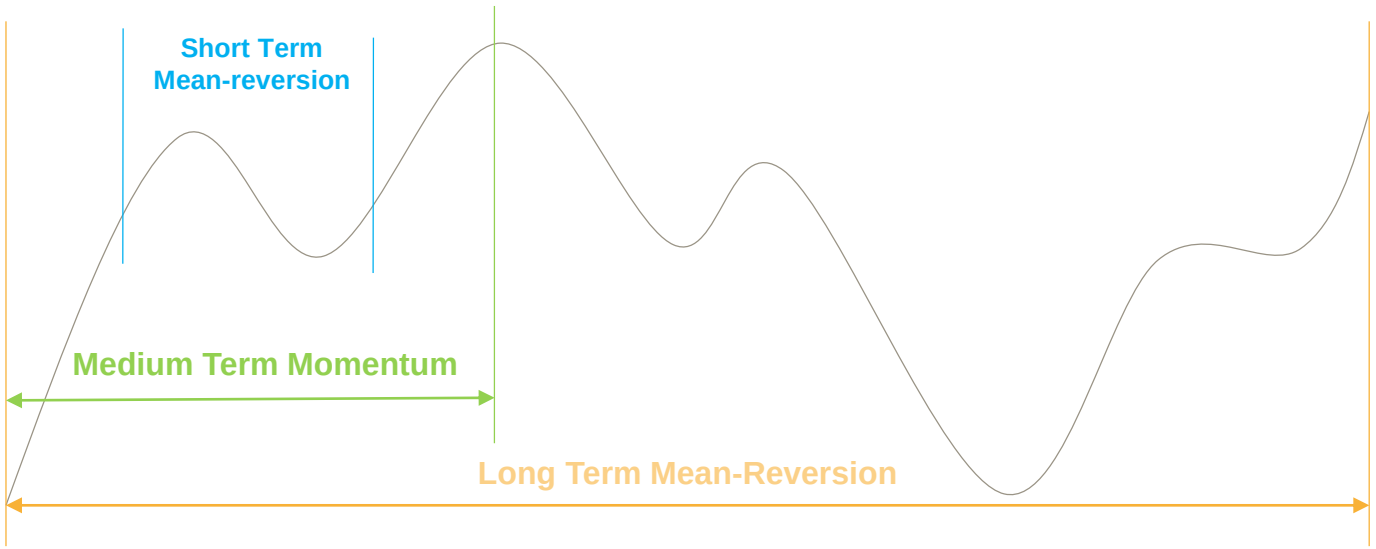
Short-term Momentum	Medium-term Momentum	Long-term Momentum
Short-term Mean-reversion	Medium-term Mean-reversion	Long-term Mean-reversion

Momentum strategy:

- Stop-loss system
- Positive skew

Mean-reversion strategy:

- Catch falling knives
- Negative skew



Factor constructions – Mean reversion

Two elements: Carry and Information ratio

Carry signal: assuming asset price status quo, expect the second nearest futures price fall to the nearest futures price and earn the yield throughout the terms of the contract.

$$C_t = \frac{F_t - S_t}{S_t}$$

where: F_t is first expiring contract; S_t is second expiring contract.

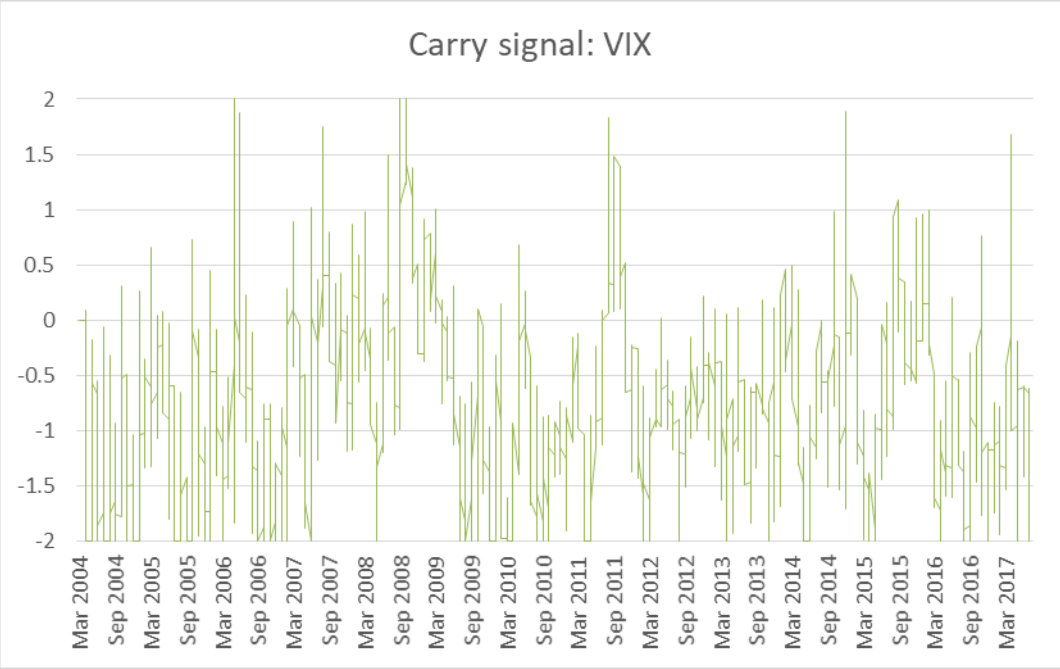
Information ratio (ST/MT/LT): rolling information ratio of an asset. It expects the overvalued asset underperforming in various time horizon.

$$IR_t = \frac{r_t^i - BMK_t}{TE_t}$$

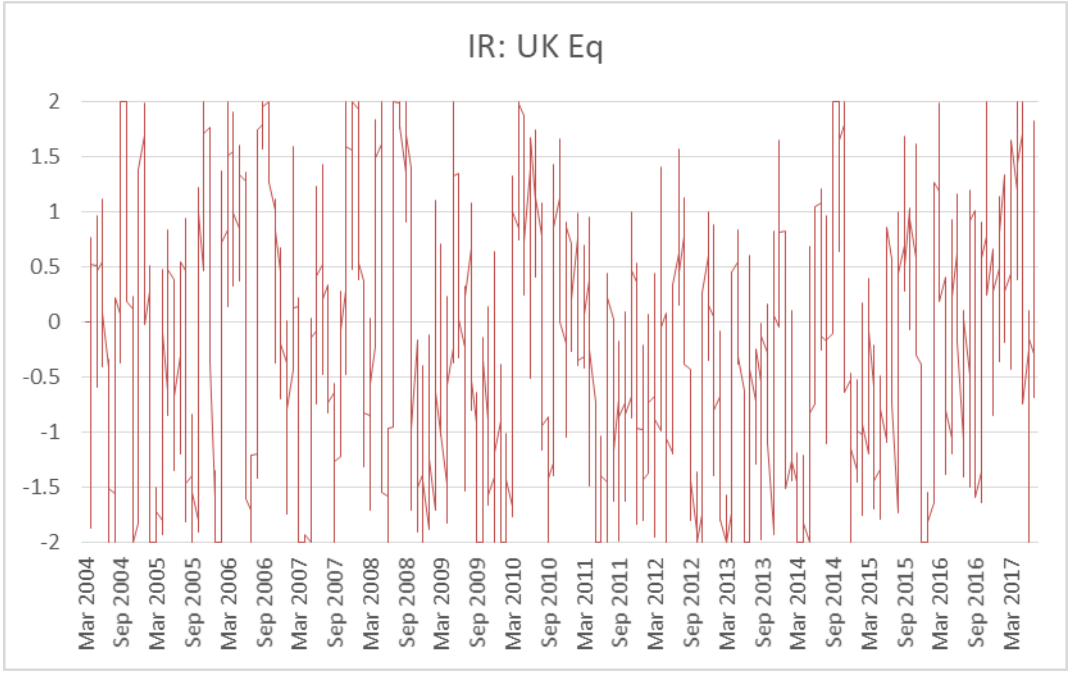
where $BMK_t = \frac{1}{N}\sum_i^N r_t^i$; TE_t is active risk to BMK.

Factor constructions – Mean reversion

Carry signal of VIX



IR signal of UKX



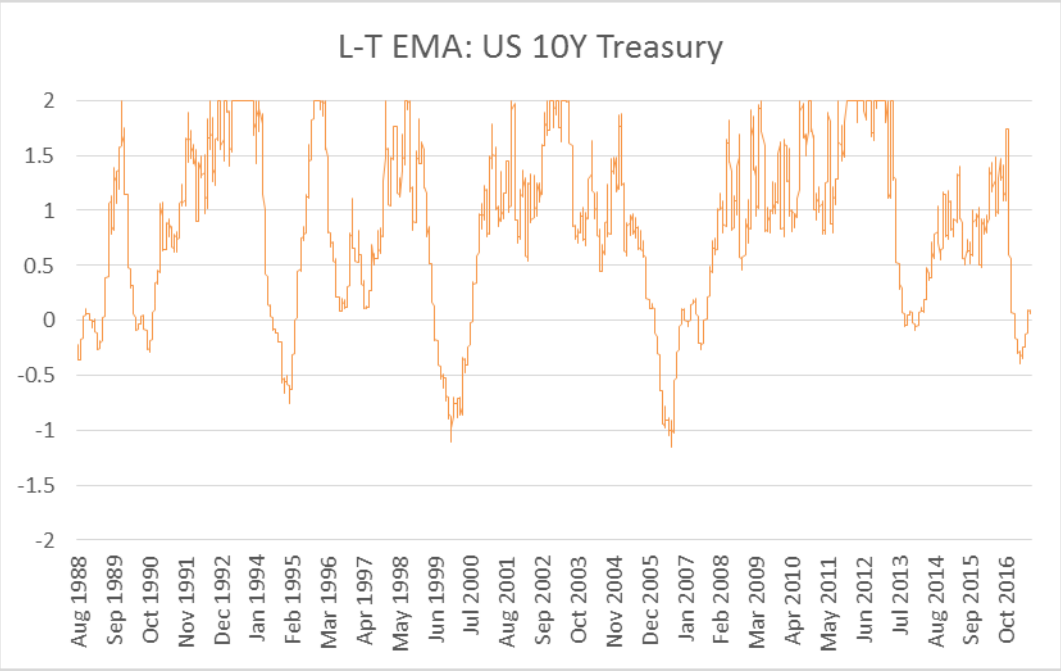
Factor constructions – Momentum

EMA cross-over: (ST/MT/LT)

Positive signal when short-leg EMA (Exponential moving average) crosses long-leg EMA upward; Negative signal when short-leg EMA crosses long-leg EMA downward.

$$E_t = \frac{EMA_{Fast} - EMA_{Slow}}{P_t * \sigma_t}$$

where σ_t is volatility of underlying.



Dynamic tuning engine

A good set of variations(parameters) should work well on various instruments. It is especially true for price based strategies. It is also the best way to avoid overfitting by stopping individually tailoring rule for every instrument.

Hence, the “core” set of parameters is defined by the best sharp ratio across all instruments. And all market conditions. Fixed income instruments and Equity instruments behave fundamentally different, therefore the core parameters are analysed in separate groups.

In the system, to find the second and third sets of parameters does not rely on the performance or sharpe ratio. Instead, the correlation is the key selection criteria. It is because of that:

(1) It is very difficult to significantly prove that one set of rules outperforms the others.

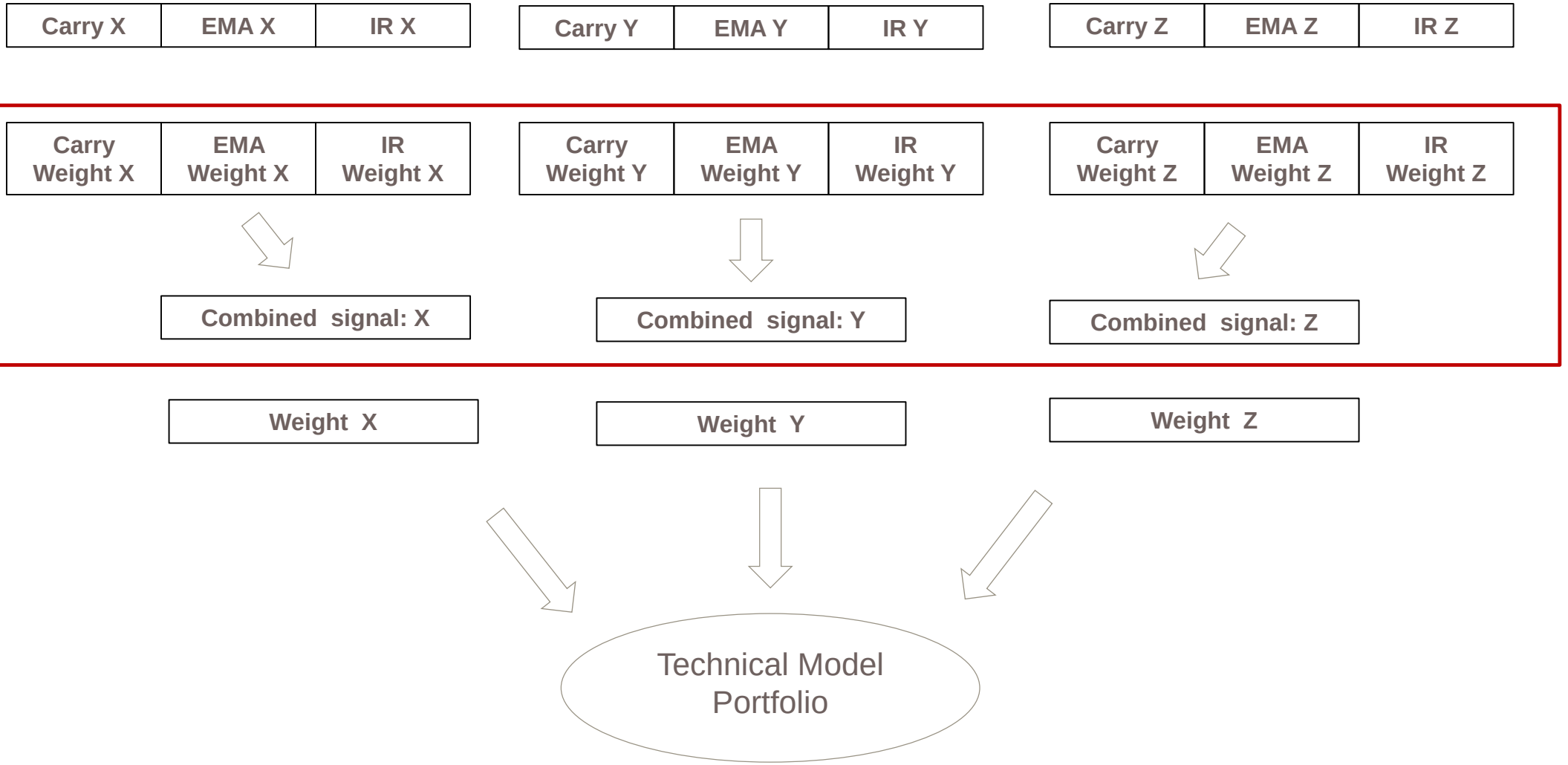
(2) expected low correlated strategies provide diversification benefit.

The table shows the number of years required to be significant that one strategy is better than another

	Correlation between strategies				
Sharpe Ratio advantage	**-1.0**	**0.0**	**0.5**	**0.8**	**0.95**
0.1	47	47	46	44	37
0.25	46	45	40	32	10
0.5	41	37	25	10	3

Source: Systematic Trading

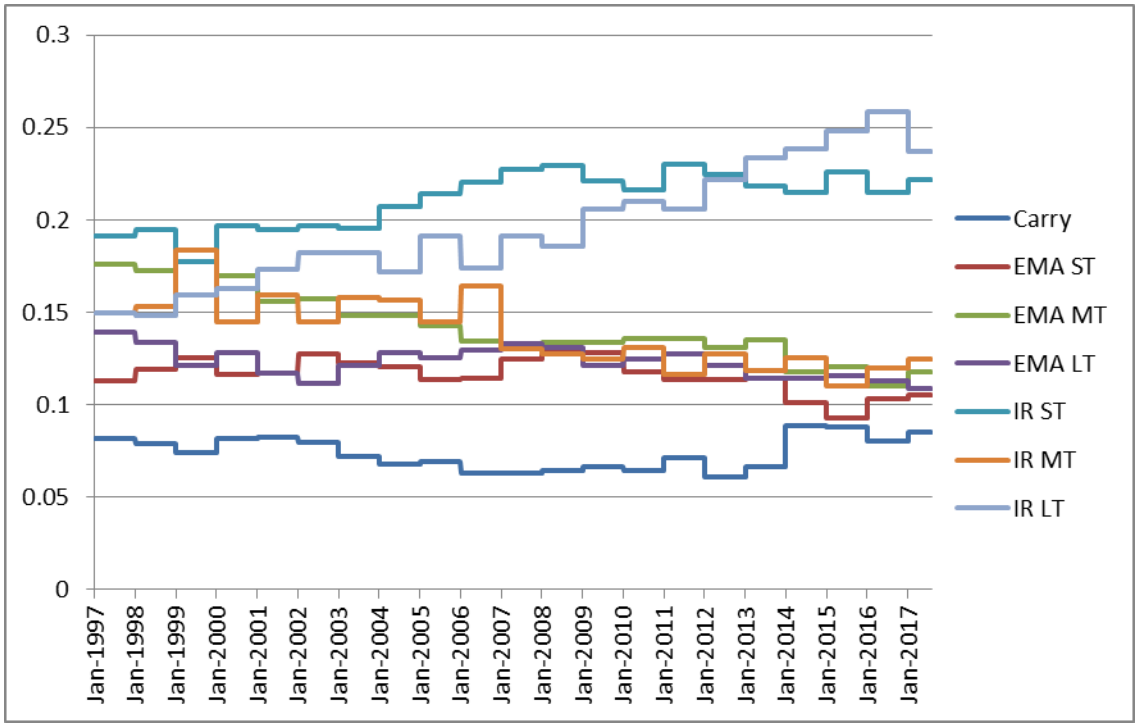
Structure


Carry X
EMA X
IR X
Carry Y
EMA Y
IR Y
Carry Z
EMA Z
IR Z
Carry Weight X
EMA Weight X
IR Weight X
Carry Weight Y
EMA Weight Y
IR Weight Y
Carry Weight Z
EMA Weight Z
IR Weight Z
Combined signal: X
Combined signal: Y
Combined signal: Z
Weight X
Weight Y
Weight Z
Technical Model Portfolio

Combining signals

Maximum sharpe ratio optimisation (similar to Mean variance optimisation) gives the most diversified portfolio. It is the way to seek estimated weights among sub-strategies and construct the final signal for an instrument.

US Eq: Dynamic weights of sub-strategies



US Eq: Average correlation between sub-strategies

	Carry	EMA ST	EMA MT	EMA LT	IR ST	IR MT	IR LT
Carry	1.00	-0.26	-0.15	-0.28	0.04	-0.07	0.11
EMA ST		1.00	0.71	0.62	-0.27	-0.03	-0.63
EMA MT			1.00	0.54	-0.68	-0.35	-0.92
EMA LT				1.00	-0.19	0.01	-0.47
IR ST					1.00	0.64	0.58
IR MT						1.00	0.39
IR LT							1.00

To avoid overfitting

The big problem with strategy construction is that the model is easily get overfitted, after all sorts of optimisation, parameter tuning etc. Model is considered overfitted when it only works for the past in a particular market environment but it works poorly in more general market.

Overfitting is the biggest “criminal” in the finance field. All hard works and analysis could be “wasted” if a model is overfitted/overanalysed.

Several quantitative techniques to avoid overfitting:

- Monte Carlo simulation
- Cross validation
- Simple bootstrapping
- Complex bootstrapping

Preserve detailed characteristic of an instrument/strategy

Generate >10,000 simulations

Include all types of market environments

Pitfall: a few of simulated time series might be unrealistic

Trading cost as a vital factor

Actual return = market return – (trading cost + commission).

We try hard to estimate the market return and often fail to do so. Cost, however, is generally certain and easier to predict. In certain instrument or strategy, costs could be the “deal breaker” even the strategy looks amazing before costs. It is especially true for high frequency strategies.

T-model has considered trading costs seriously and the costs are involved in every part of analysis and simulations.

Annualised turnover and cost in Sharpe Ratio term in the simulated back-test based on a $100m portfolio.

	Turnover	Cost S.R
US Eq	57	0.06
UK Eq	67	0.05
GER Eq	26	0.02
JP Eq	59	0.13
US Gov	55	0.45
GER Gov	66	0.15
UK Gov	49	0.24
JP Gov	93	0.28

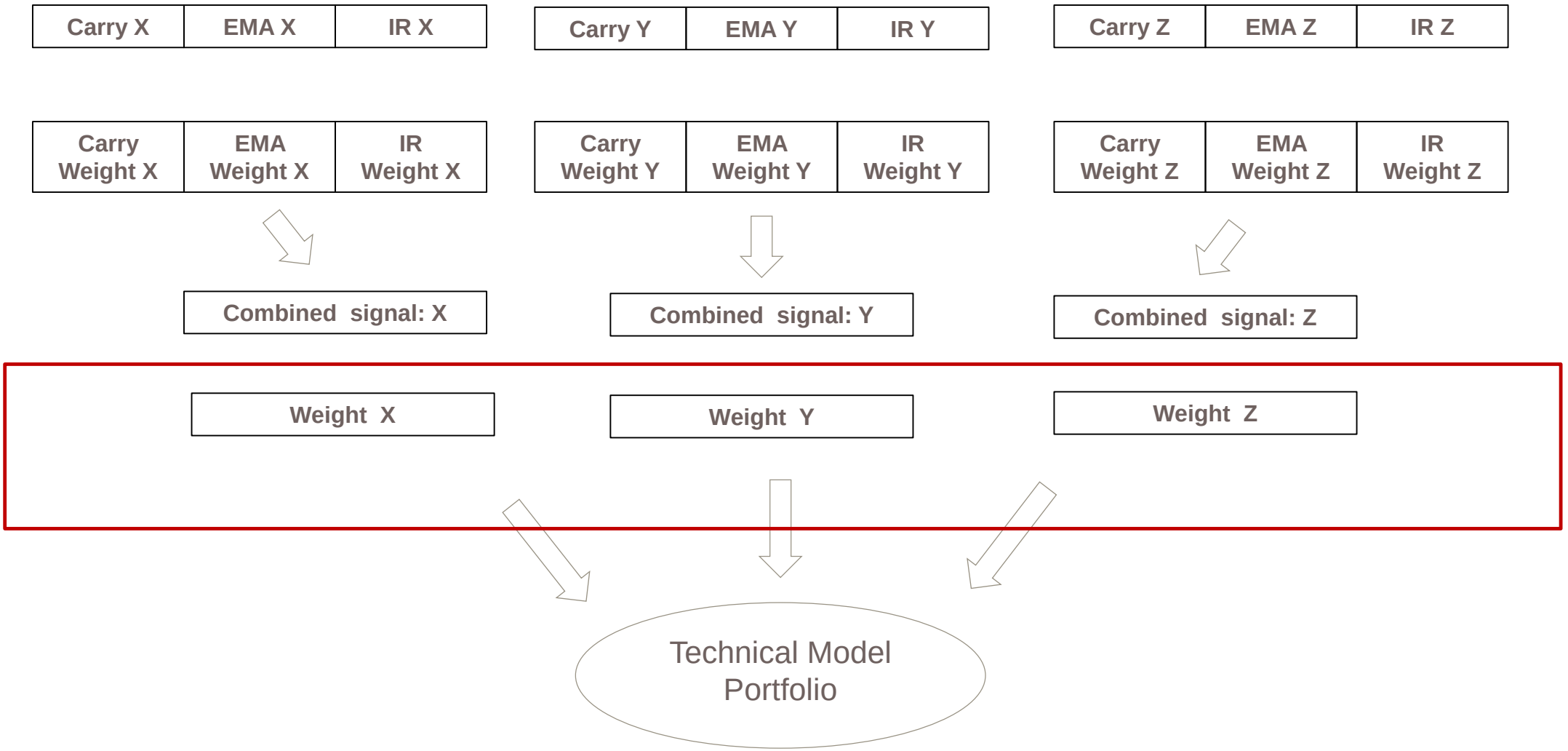
Correlation: Before and After

Correlation between assets are more independent than before.

	US Eq	UK Eq	GER Eq	JP Eq	US Gov	GER Gov	UK Gov	JP Gov
US Eq	1.000	0.539	0.572	0.278	-0.348	-0.340	-0.270	-0.099
UK Eq		1.000	0.845	0.405	-0.334	-0.316	-0.298	-0.079
GER Eq			1.000	0.355	-0.359	-0.406	-0.372	-0.051
JP Eq				1.000	-0.117	-0.052	-0.135	-0.190
US Gov					1.000	0.552	0.550	0.170
GER Gov						1.000	0.706	0.199
UK Gov							1.000	0.166
JP Gov								1.000

After	US Eq	UK Eq	GER Eq	JP Eq	US Gov	GER Gov	UK Gov	JP Gov
US Eq	1.000	0.163	-0.017	-0.008	-0.103	-0.054	-0.053	-0.036
UK Eq		1.000	-0.503	-0.114	-0.075	-0.106	-0.104	-0.020
GER Eq			1.000	0.130	0.093	0.102	0.053	0.004
JP Eq				1.000	-0.002	-0.008	-0.016	0.007
US Gov					1.000	0.445	0.380	0.088
GER Gov						1.000	0.506	0.086
UK Gov							1.000	0.094
JP Gov								1.000

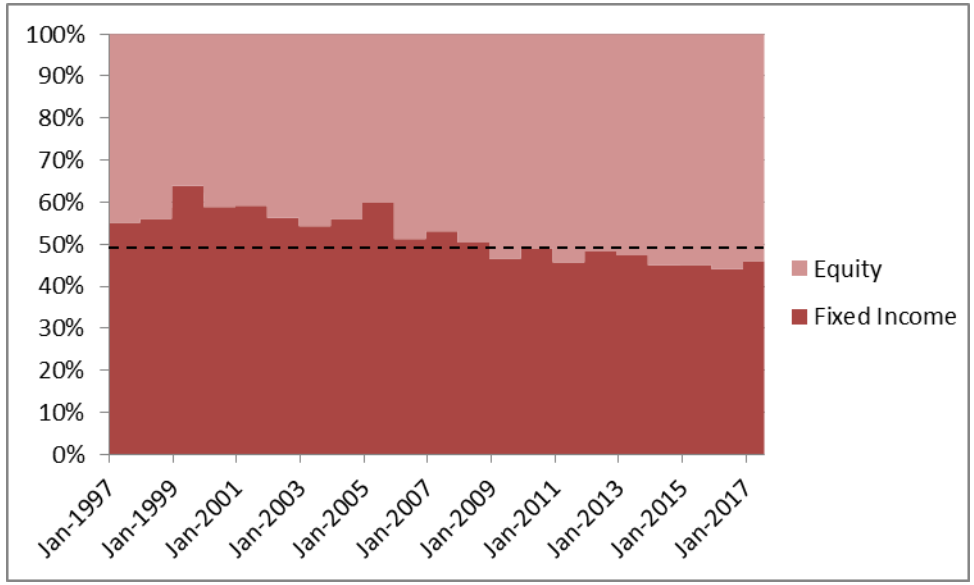
Structure

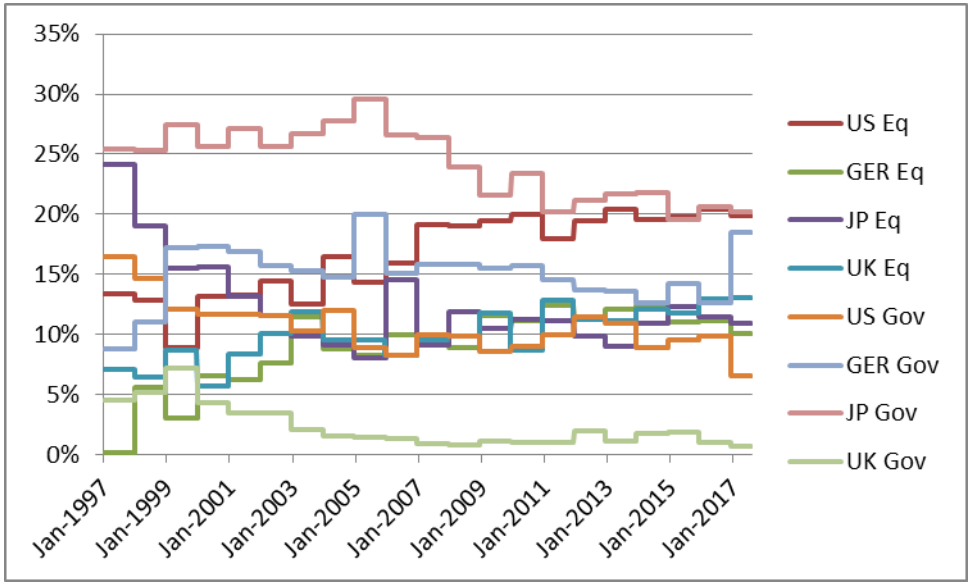

Carry X
EMA X
IR X
Carry Y
EMA Y
IR Y
Carry Z
EMA Z
IR Z
Carry Weight X
EMA Weight X
IR Weight X
Carry Weight Y
EMA Weight Y
IR Weight Y
Carry Weight Z
EMA Weight Z
IR Weight Z
Combined signal: X
Combined signal: Y
Combined signal: Z
Weight X
Weight Y
Weight Z
Technical Model Portfolio

Result - 8 assets model

Estimated weights between Equity and Fixed Income have been switched to more Equity from more Fixed Income. It suggests 50%/50% equal weights, on average, between Equity and Fixed Income.

Given the current optimal weights, US Eq and JP Gov have highest positions of 19.9% and 20.2% respectively.





Result - T model signals as of 20/09/2017

Signal as of 20/09/2017 suggests:

- Sell US Equity; Buy German/Japan/UK Equities
- Buy German/UK Government bonds

Asset Class	Date	Buy/Sell	Overall Signal	Carry	IR	EMA
US Eq	20/09/2017	Sell	-0.9	0.1	-1.5	1.4
GER Eq	20/09/2017	Buy	0.6	0.1	0.8	0.8
JP Eq	20/09/2017	Buy	1.0	0.5	-0.4	1.3
UK Eq	20/09/2017	Buy	0.7	1.6	0.3	0.0
US Gov	20/09/2017	Neutral	0.5	0.6	-0.4	0.3
GER Gov	20/09/2017	Buy	0.7	0.7	0.5	0.7
JP Gov	20/09/2017	Neutral	0.1	-0.3	0.4	0.8
UK Gov	20/09/2017	Buy	0.8	0.9	0.1	0.2

Result – PNL and statistics

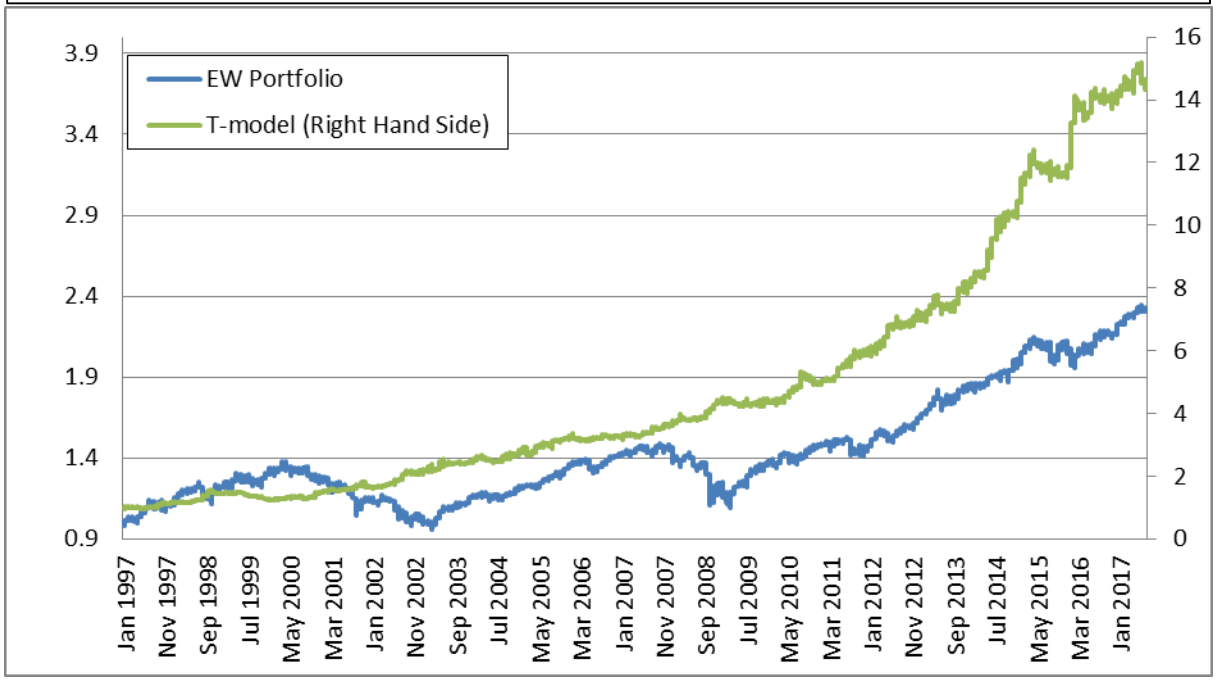
T-model vs E.W portfolio:

- **More than doubled annualised return (APR)**
- **Doubled sharpe ratio (after cost)**
- **Limited drawdown to 20.6%**
- **Maximum weekly loss is -2.13%**
- **Positive skewed**

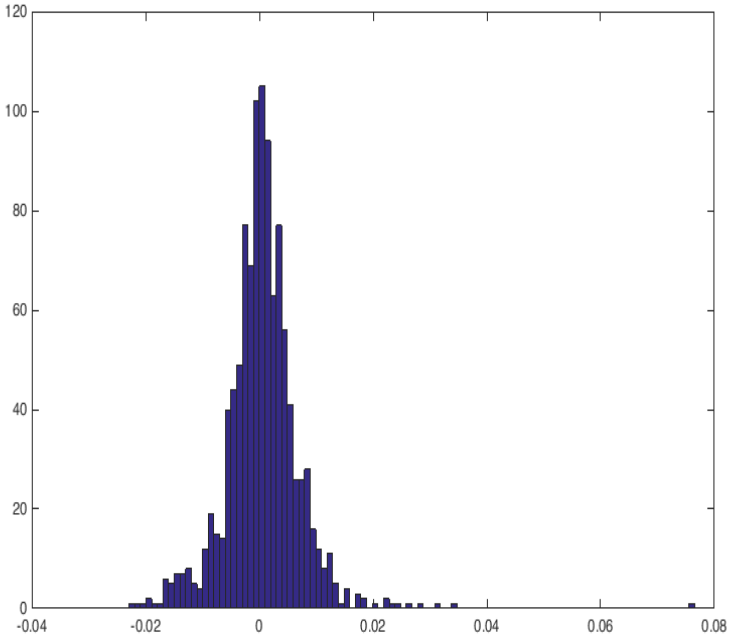
Since 1997	T-model	EW Portfolio
APR	8.8%	4.0%
S.R after cost	1.11	0.55
Max.DD	20.6%	30.6%
Vol.	9.6%	7.6%
Skewness	0.52	-0.21
Kurtosis	10.16	7.04

since 2016	T-model	EW Portfolio
APR	13.0%	7.9%
S.R after cost	1.19	1.33
Max.DD	5.5%	3.9%
Vol.	9.6%	6.3%
Skewness	2.74	-0.50
Kurtosis	16.81	4.18

Total cumulative return since 1997:



Weekly return distribution:



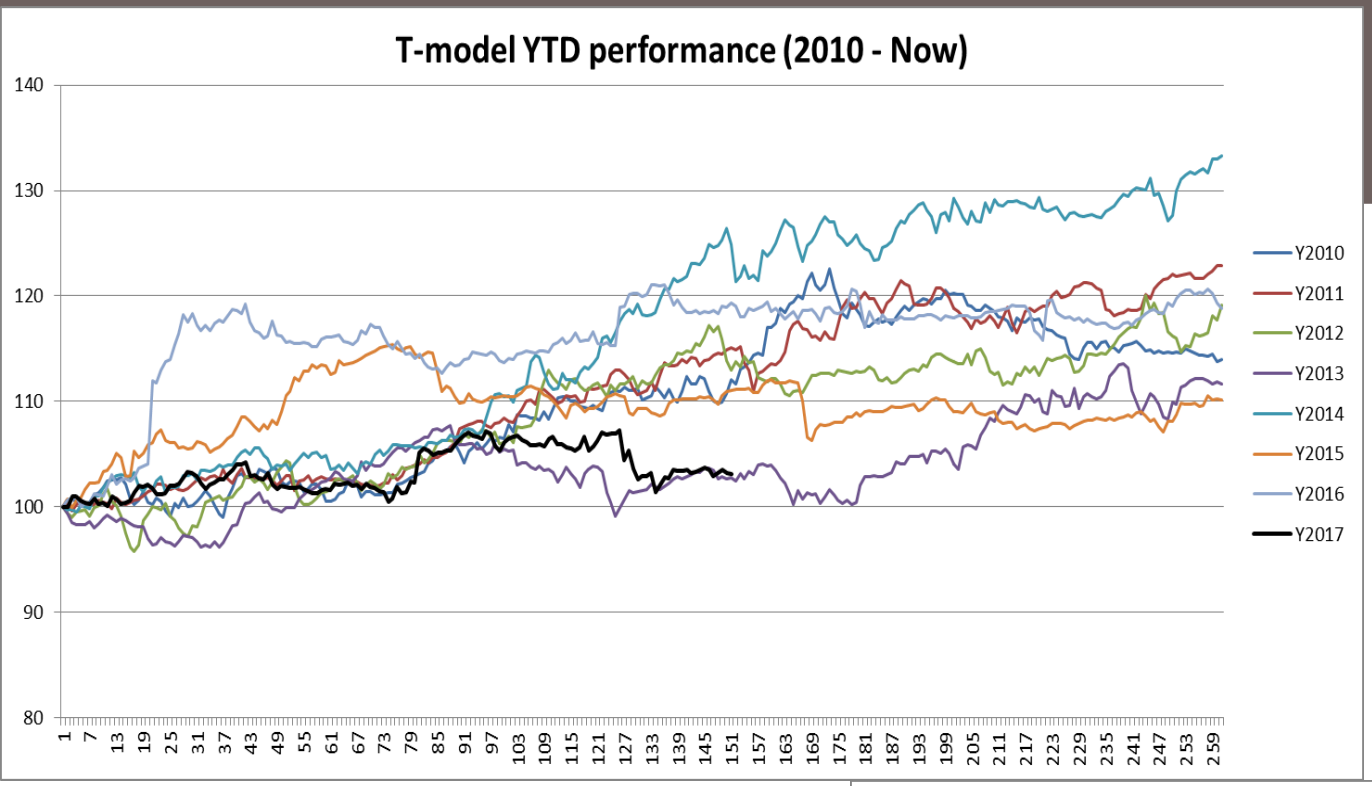
Appendix

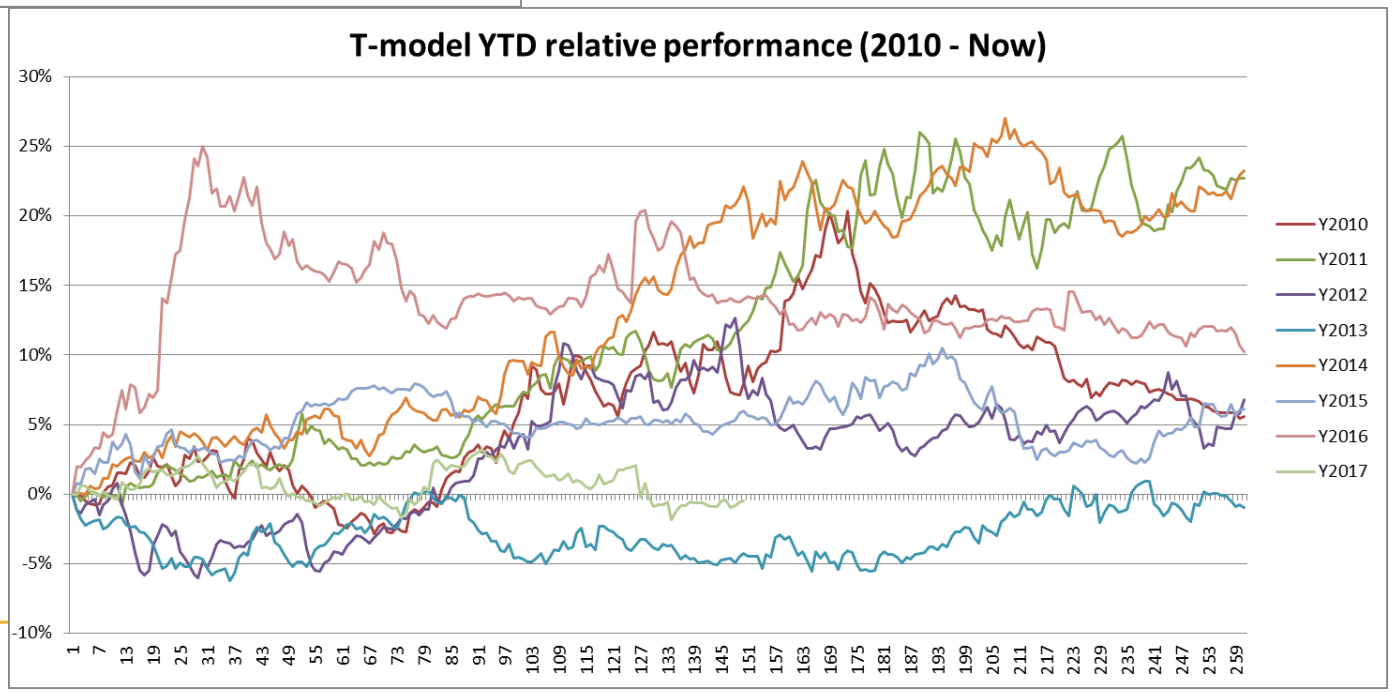
Result – details

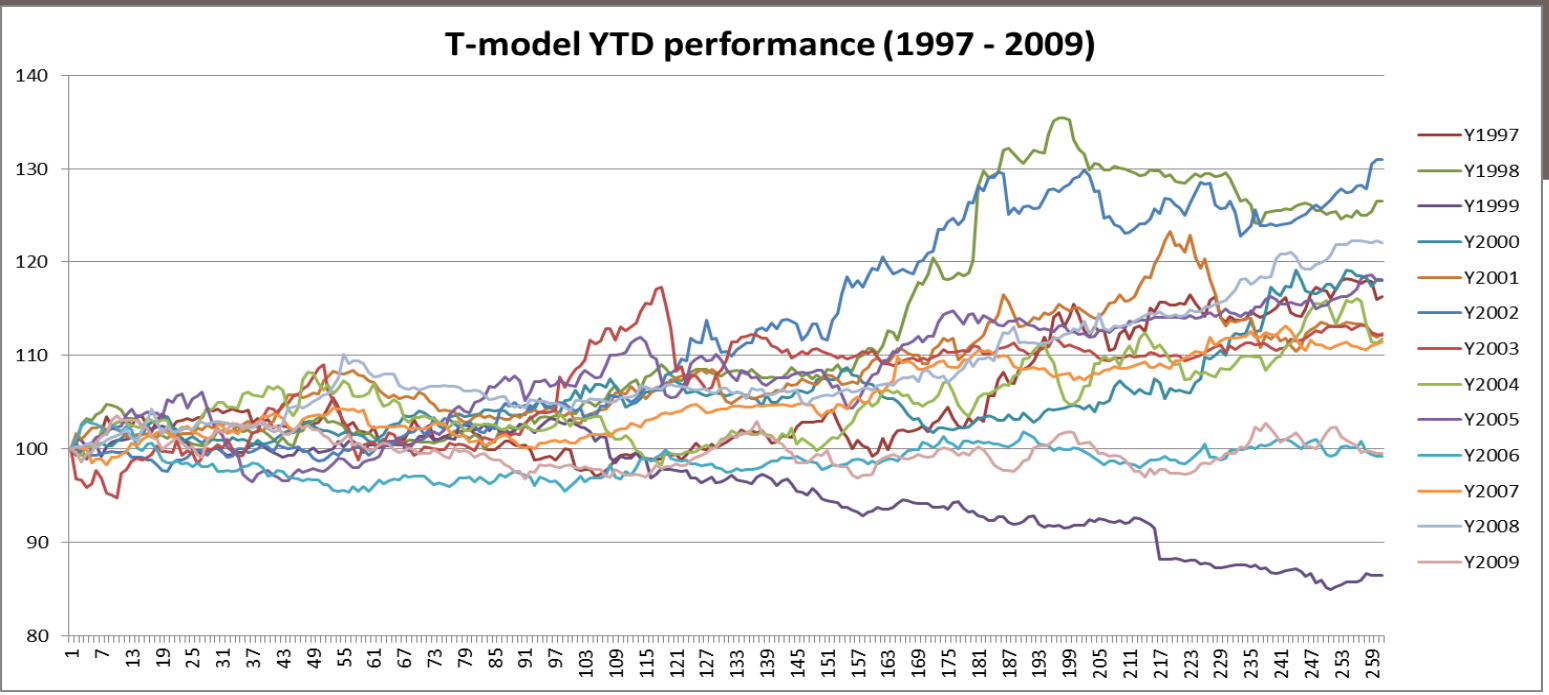
T-model	APR	Sharpe Ratio (after cost)	Max.DD
Y2017 YTD	3.6%	0.70	5.5%
Y2016	18.8%	1.49	5.5%
Y2015	10.2%	1.20	7.9%
Y2014	33.3%	2.80	3.9%
Y2013	11.7%	1.15	8.0%
Y2012	18.7%	1.69	5.9%
Y2011	23.2%	2.55	4.0%
Y2010	14.0%	1.43	7.2%
Y2009	-1.3%	-0.12	6.6%
Y2008	21.5%	2.45	5.5%
Y2007	11.4%	1.58	4.2%
Y2006	-0.7%	-0.06	7.3%
Y2005	18.8%	1.81	9.1%
Y2004	11.9%	1.03	9.1%
Y2003	12.1%	0.97	9.5%
Y2002	30.9%	2.39	5.5%
Y2001	12.3%	1.22	10.4%
Y2000	17.9%	1.81	6.4%
Y1999	-13.5%	-1.73	17.7%
Y1998	26.5%	2.12	8.4%
Y1997	16.3%	1.31	7.9%

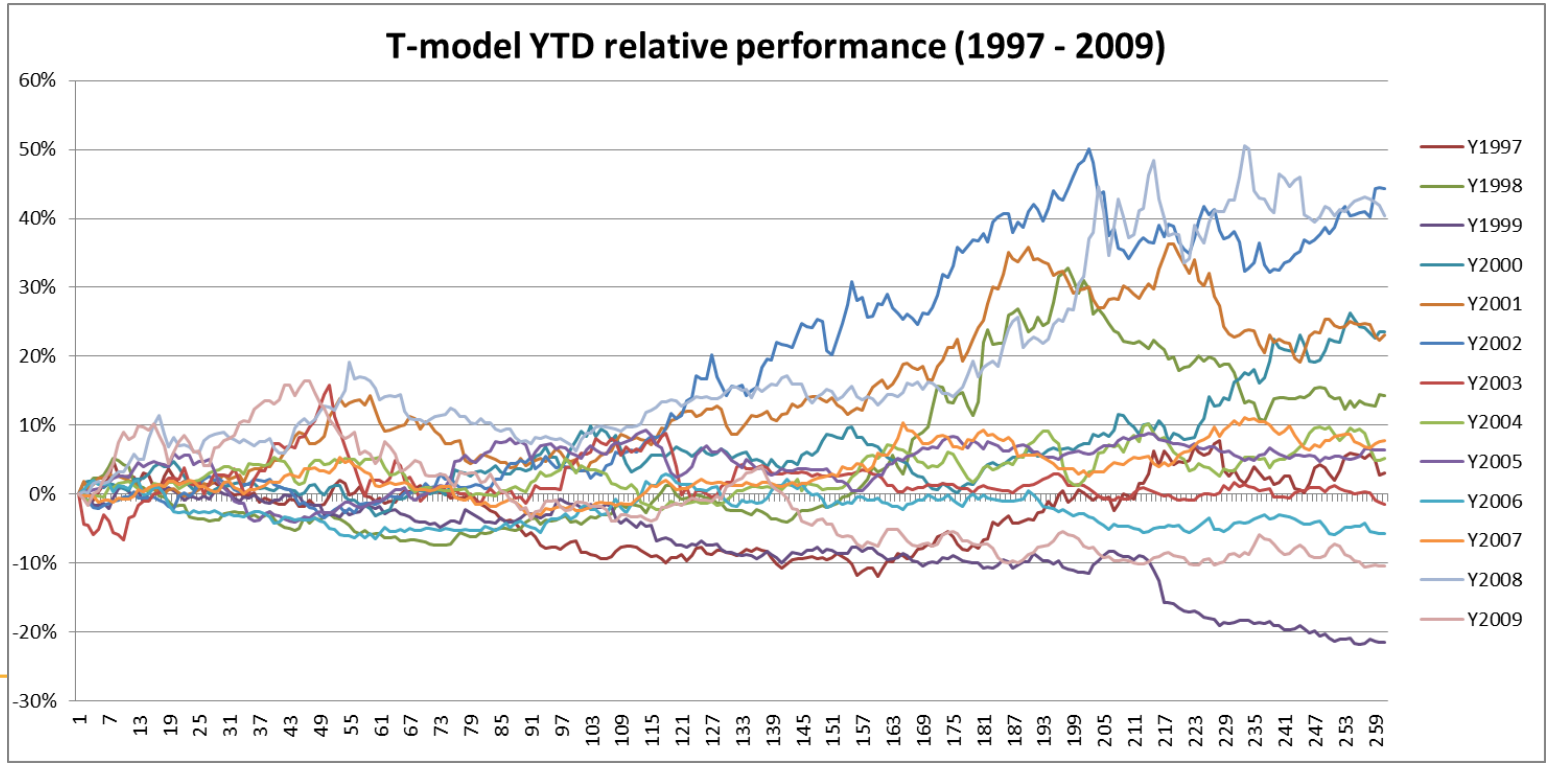
EW Port	APR	Sharpe Ratio (after cost)	Max.DD
Y2017 YTD	3.9%	1.93	1.9%
Y2016	7.2%	1.00	5.7%
Y2015	3.6%	0.52	7.9%
Y2014	8.1%	1.58	3.7%
Y2013	12.7%	2.04	6.9%
Y2012	11.6%	2.17	4.9%
Y2011	-0.3%	0.00	7.8%
Y2010	7.4%	1.13	4.8%
Y2009	10.9%	1.16	12.8%
Y2008	-15.5%	-0.96	24.3%
Y2007	3.0%	0.54	4.3%
Y2006	4.9%	0.91	5.9%
Y2005	10.9%	2.65	2.6%
Y2004	6.1%	1.19	4.6%
Y2003	12.9%	1.62	7.8%
Y2002	-10.5%	-1.03	16.3%
Y2001	-9.6%	-1.11	18.5%
Y2000	-5.8%	-0.69	9.9%
Y1999	9.6%	1.18	6.2%
Y1998	9.5%	1.03	10.7%
Y1997	12.0%	1.35	6.3%

	Relative performance (APR)	Relative performance (S.R)
Y2016	Outperform	Outperform
Y2015	Outperform	Outperform
Y2014	Outperform	Outperform
Y2013	Underperform	Underperform
Y2012	Outperform	Underperform
Y2011	Outperform	Outperform
Y2010	Outperform	Outperform
Y2009	Underperform	Underperform
Y2008	Outperform	Outperform
Y2007	Outperform	Outperform
Y2006	Underperform	Underperform
Y2005	Outperform	Underperform
Y2004	Outperform	Neutral
Y2003	Underperform	Underperform
Y2002	Outperform	Outperform
Y2001	Outperform	Outperform
Y2000	Outperform	Outperform
Y1999	Underperform	Underperform
Y1998	Outperform	Outperform
Y1997	Outperform	Neutral
Hit ratio	15/20	11/20


T-model YTD performance (2010 - Now)
140
130
120
110
100
90
80
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175 181 187 193 199 205 211 217 223 229 235 241 247 253 259
Y2010
Y2011
Y2012
Y2013
Y2014
Y2015
Y2016
Y2017


T-model YTD relative performance (2010 - Now)
30%
25%
20%
15%
10%
5%
0%
-5%
-10%
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175 181 187 193 199 205 211 217 223 229 235 241 247 253 259
Y2010
Y2011
Y2012
Y2013
Y2014
Y2015
Y2016
Y2017


T-model YTD performance (1997 - 2009)
140
130
120
110
100
90
80
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175 181 187 193 199 205 211 217 223 229 235 241 247 253 259
Y1997
Y1998
Y1999
Y2000
Y2001
Y2002
Y2003
Y2004
Y2005
Y2006
Y2007
Y2008
Y2009


T-model YTD relative performance (1997 - 2009)
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151 157 163 169 175 181 187 193 199 205 211 217 223 229 235 241 247 253 259
Y1997
Y1998
Y1999
Y2000
Y2001
Y2002
Y2003
Y2004
Y2005
Y2006
Y2007
Y2008
Y2009