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Equity Research

Using factors with different alpha decay times: The case for non-linear combination

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See Appendix A-1 for analyst certification, important disclosures and the status of non-US analysts.

Any authors named on this report are research analysts unless otherwise indicated.

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PROLOGUE - The future of factor combination: two ways to get to the same answer?

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- **Factors have different information decay times (eg, Value vs Momentum)**
- **We believe that these differences are highly persistent**
- **Most quant models average across signals, thus discarding the information decay differences**
- **Is there a better way to combine factors? Should it be linear?**

- **We (quants) have mined for factors**
- **Harvey, Liu and Zhu (2015)[1] identify 314 factors from academic literature**
- **We conclude: THERE. ARE. NO. NEW. FACTORS. TO. BE. DISCOVERED. (*pace* the possibilities of "big data")**
- **So, instead, maybe we should be looking to find more intelligent ways to combine the factors that we already have.**
- **Let's consider non-linear factor combinations**

[1] . . . and the Cross-Section of Expected Returns. Harvey, Liu and Zhu.
Available at SSRN *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2249314&download=yes*

Introduction

- **Trees for global equity timing**

- **Trees for regional allocation**

- **Non-linear factor combination: rewarding agreement**

Let’s set the bar high to make the point clear

- **At the stock level one can often afford to be lazy.**
- **With 1,000 stocks to choose from, *on average* the stocks that pass the long and short horizon factors do ok**
- **What happens as the number of tradable assets shrinks?**
- **What does one do if there is only one asset: the global equity market?**

Market timing factors have different information decay times: correlation with forward returns

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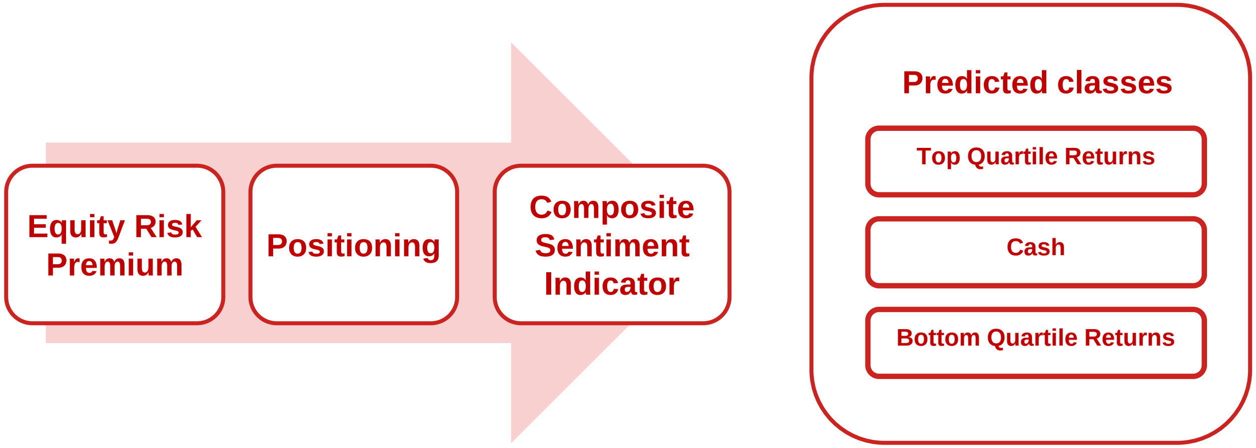
	Shiller PE	Equity Risk Premium	Positioning	Composite Sentiment Indicator
1mth	-0.1	0.1	-0.1	-0.2
3mth	-0.1	-0.1	-0.1	-0.1
6mth	-0.2	0	0.4	-0.2
1yr	-0.4	-0.3	0.5	0.3
2yr	-0.5	0.2	0.5	0.4
5yr	-0.8	0.1	0.3	0.2
10yr	-0.9	0.1	0.3	0.2

Table shows the correlation of indicators with forward market returns over different horizons. Shiller P/E correlation measured since 1980, for other measures since February 1987.

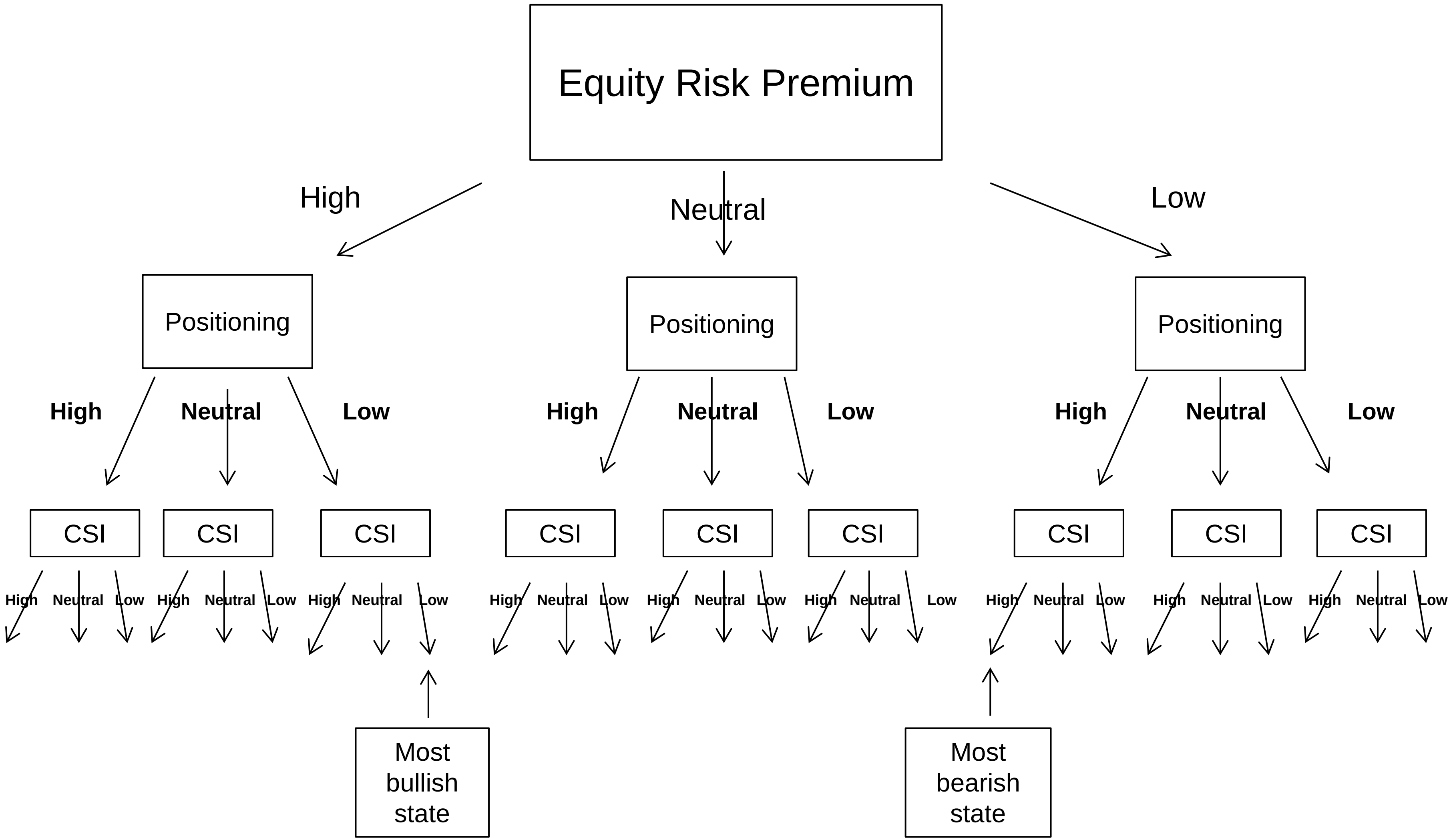
Source: Nomura Quantitative Strategy research

Our framework – a three-level Bayesian tree structure



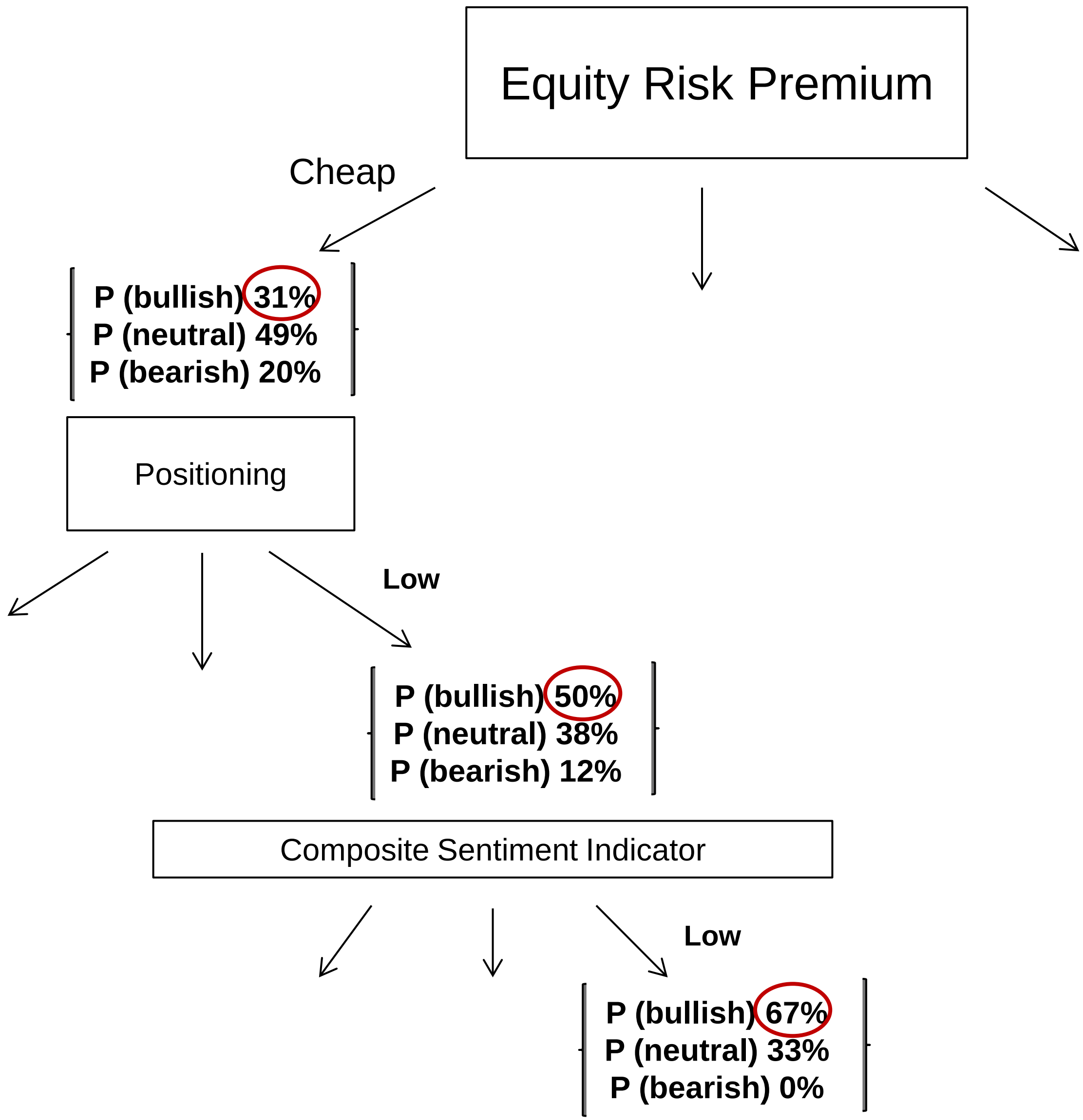
Source: Nomura Quantitative Strategy research

Market Timing: A tree approach



Source: Nomura Strategy research

Populating the tree



Source: Nomura Strategy research

Our three-level probability tree

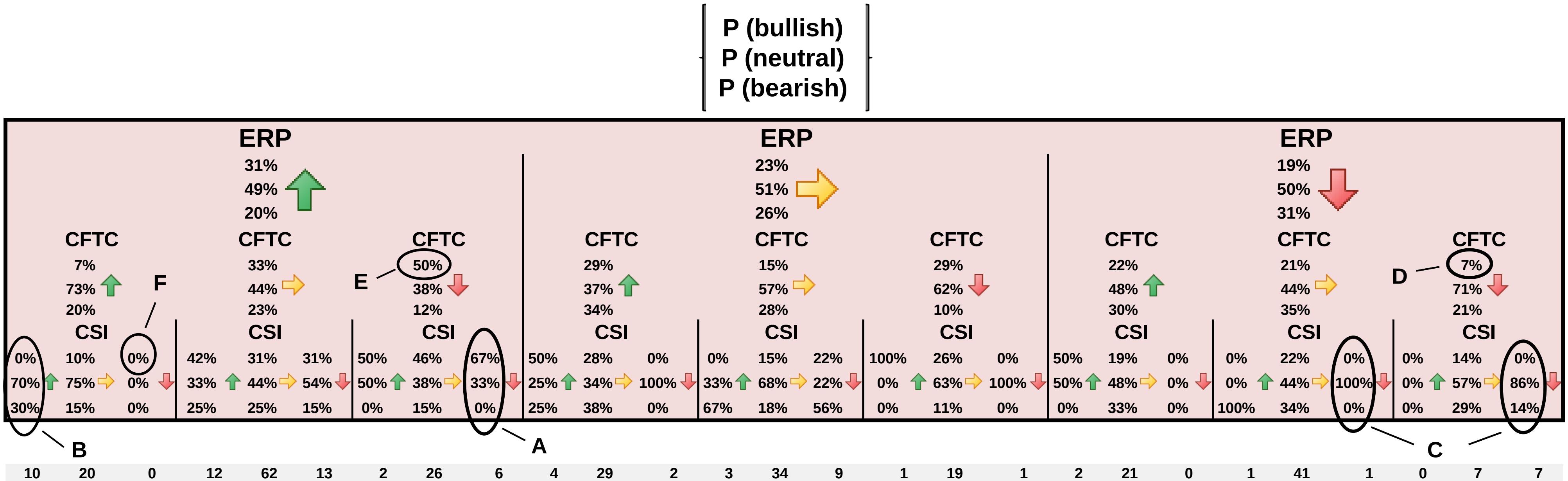


Figure is a graphical representation of the probabilistic mapping between each possible combination of our inputs or predictors (as described by the values ERP, the combinations of the ERP and positioning and, lastly, the combinations of the ERP, positioning and the CSI) and forward equity returns with their associated probabilities. The green, yellow and red arrows refer to 'high', 'neutral' or 'low' values of our predictors while the probabilities refer to the probabilities of one-month forward returns being high (top quartile of historical distribution), low (bottom quartile) or neutral. The probabilities of the various outcomes are estimated using monthly historical returns on the MSCI World, and the monthly historical ERP, CFTC positioning and our Composite Sentiment Indicator series, from February 1987, with a 10-year out-of-sample period starting in October 2004 during which the model learns.

The top 'layer' of the tree is characterised by the level of the ERP, with a high level (a reading in the top quartile) denoted by the green arrow, low by the red arrow and a neutral level by the yellow arrow. The probabilities listed for each ERP 'state' denote, moving down from the top, the probabilities of high (top quartile), neutral or low (bottom quartile) equity returns on a one-month forward view. We can see that using the ERP in isolation tells us that returns are more likely to be high than low when the ERP is high (market is cheap) and vice-versa when the ERP is low, whereas with the neutral reading from the ERP the probability of high and low returns are very similar. As we would expect intuitively, the probability of high returns decreases in a monotonic fashion as we move from high to neutral to low ERP, while the probability of low returns increases monotonically. But, also as we would expect, the ERP alone finds it relatively hard to attach strong probabilities to outcomes on a short-term time horizon, and if we use valuation as the only input, our confidence in discriminating between the worst and best outcomes is low, with the spread between the probabilities attached to returns in the top and bottom range relatively narrow in all cases.

As we move down the decision tree, our information set is enriched, and we are able to discriminate between the likely outcomes with greater confidence. Note that, importantly, the CFTC (positioning) reading and the CSI reading at high levels (and so accompanied by a green arrow) give a negative signal for equity returns and vice-versa, because we use both sentiment indicators in a contrarian manner. As an example, in an environment where the ERP is high (the market is cheap), while both CFTC and the CSI are low (sentiment is depressed), the probability of low market returns over the following month is zero, and there is a nearly 70% likelihood that returns will be 3% or above. (See the circled part denoted 'A', which denotes this state of the world.) In contrast, when sentiment is extended, ie, both positioning and sentiment as measured by the CSI are at high levels, then despite the fact that the market is cheap, the probability of high returns is very low (see the part of the tree denoted by 'B' on the diagram). When equities are expensive relative to bonds (the ERP is low), depressed sentiment does not help the return expectation and the probability of one-month forward returns exceeding 3% is low or zero across most scenarios (eg, node C).

Looking at different 'layers' of the diagram, we can see how the impact of positioning on forward returns varies depending on the valuation background and how the impact of the CSI is, in turn, dependent on the environment in which we find ourselves as determined by valuation and positioning. For example, low positioning implies very different likely market outcomes if the market is expensive (7% probability of high returns, circled and marked 'D' on the diagram) and if the market is cheap (50% probability of high returns, marked 'E' on the diagram). Similarly, looking at the next level down, CSI at extreme lows is associated with a zero probability of a bullish outcome when positioning is high (circled and marked 'F') and almost 70% when positioning is low (node A) even against the same valuation background. Being able to capture these interdependencies and the fact that the same reading from each input can act as a very different signal in different environments – ie, signals are conditional on the other variables – is a crucial advantage of this framework. Source: Nomura Quantitative Strategy research

Performance of the model since 1987

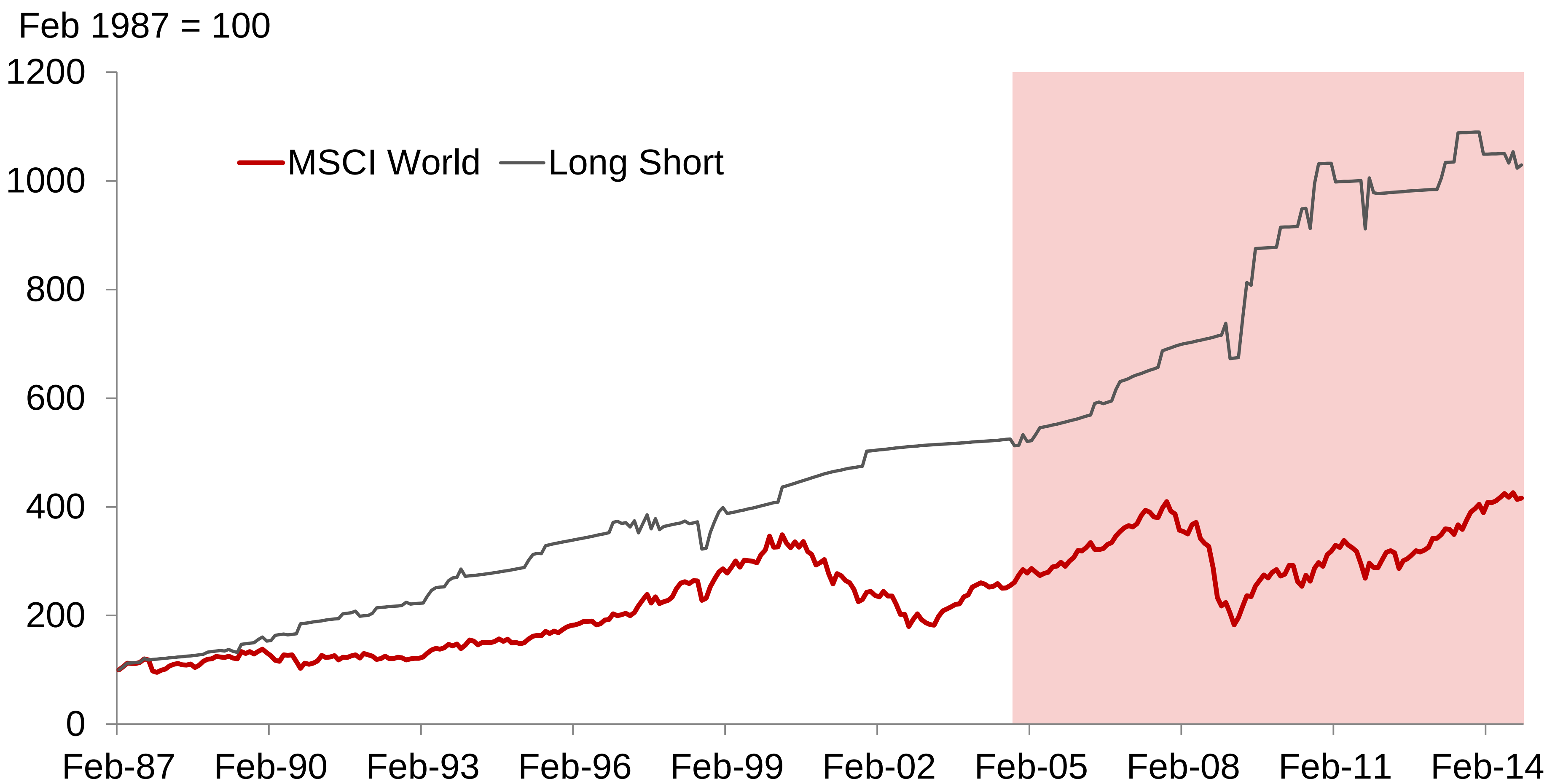


Chart shows the performance of the strategy based on going long equities when the model predicts 'high' one-month forward equity returns (top quartile of the historical range), going short equities when the model predicts 'low' ret urns, and holding cash when the model gives a neutral signal. The index is MSCI World. The model uses the Equity Risk Premium, the CFTC positioning data and our Composite Sentiment Indicator as performance signals. An out-of-sample period of 10 years (starting October 2004) is used.

Source: Nomura Quantitative Strategy research

Performance of the model and the standalone performance of individual components

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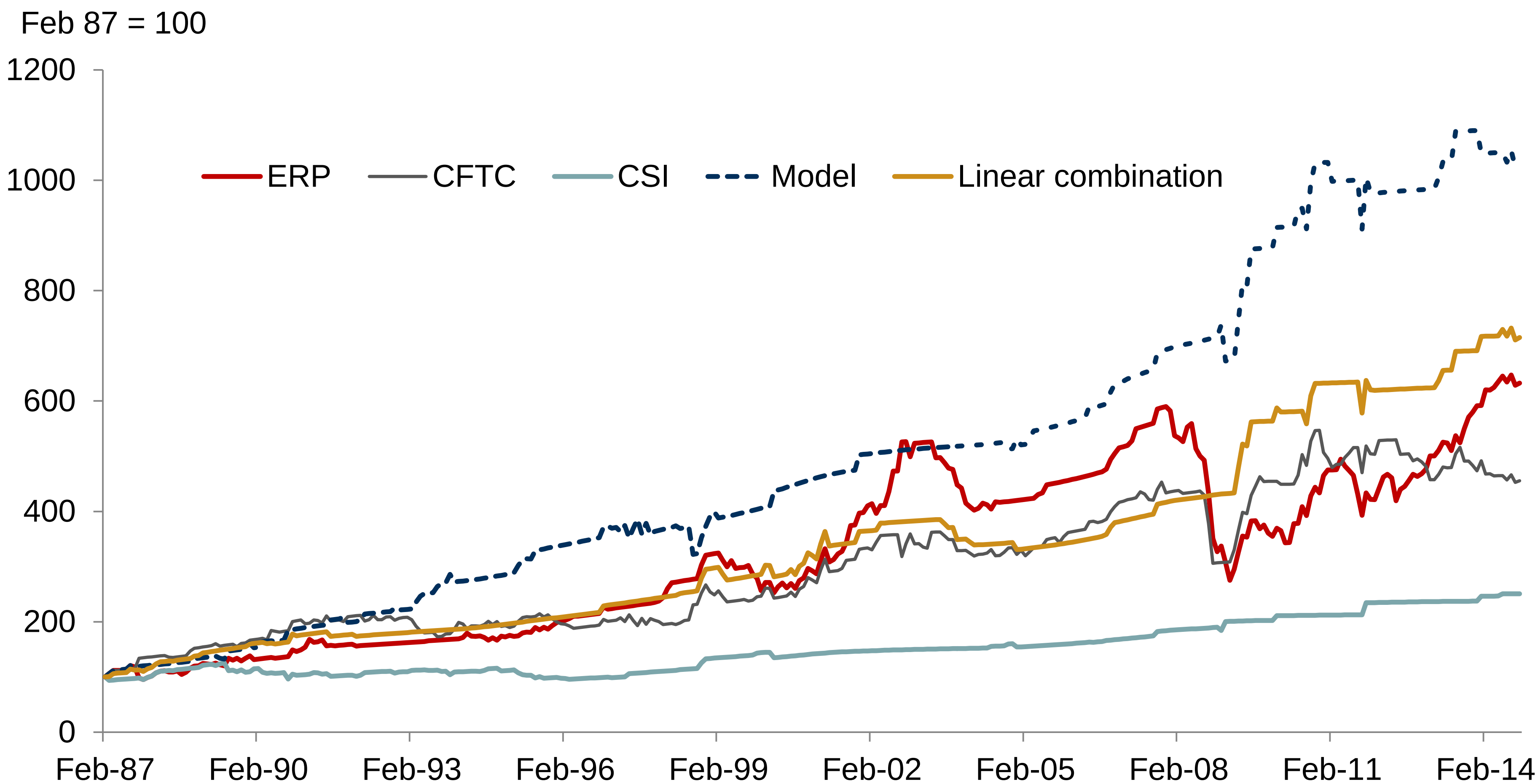


Chart shows the performance of a long short strategy based on the monthly generated by our Market Timing model and compares it with performance of the model's individual components. For consistency of comparison, the performance shown here is the long short performance of each variable with one month holding period; the same 10 year out-of-sample period is used throughout.

Source: Nomura Quantitative strategy research

The performance of the model with and without learning

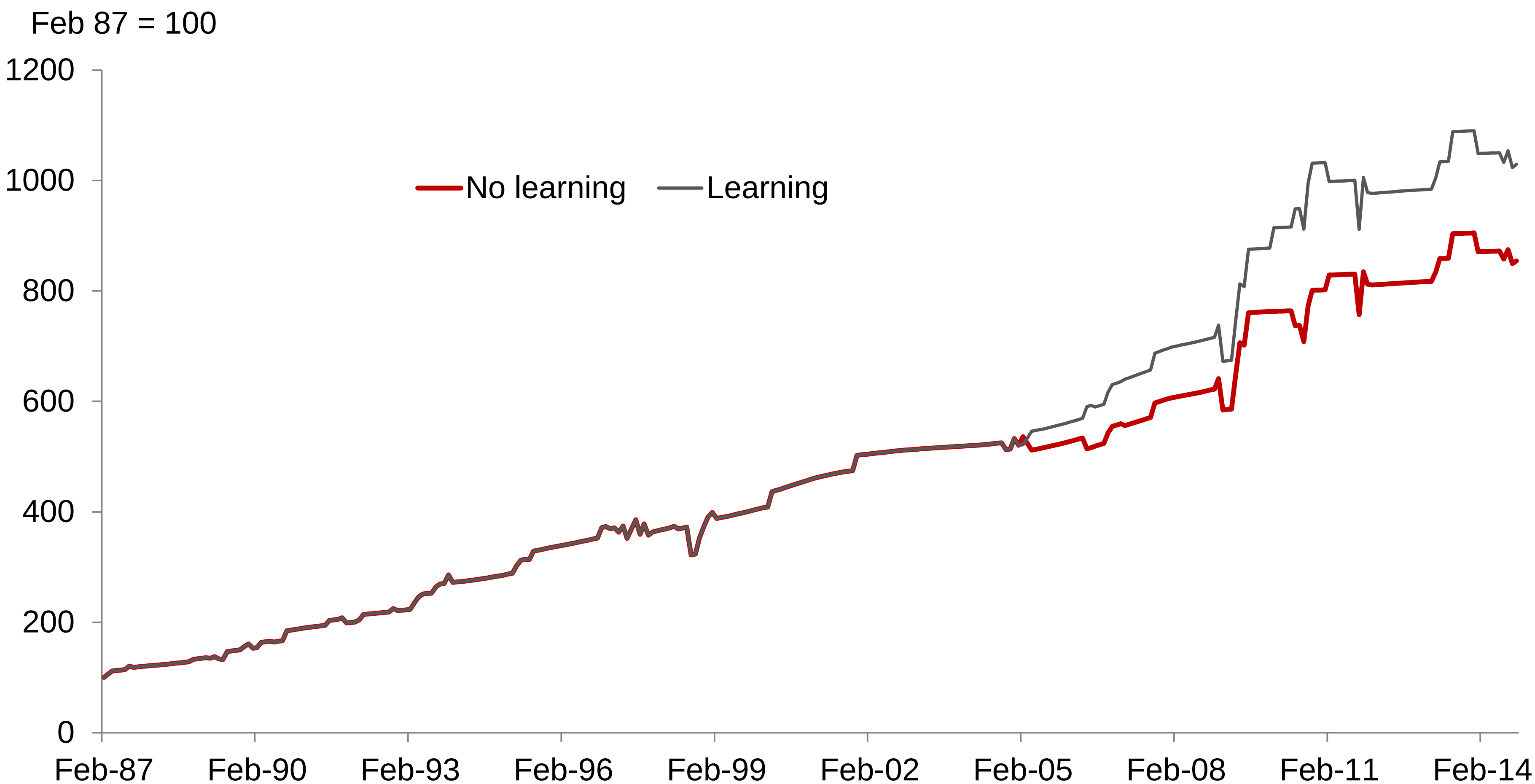


Chart compares the performance of our Market Timing model with learning during the out-of-sample period and without learning, ie with the parameters fixed at the end of the in sample 'training' in October 2004.
Source: Nomura Quantitative Strategy research

We can scale views given our confidence

Our confidence measure, which we use to size the positions prescribed by the model, consists of three components:

1. The diversity of predictions: How much does the model discriminate between outcomes?

2. Leaf error: What is the likelihood of getting it wrong?

3. Leaf frequency: How often have we observed this state before?

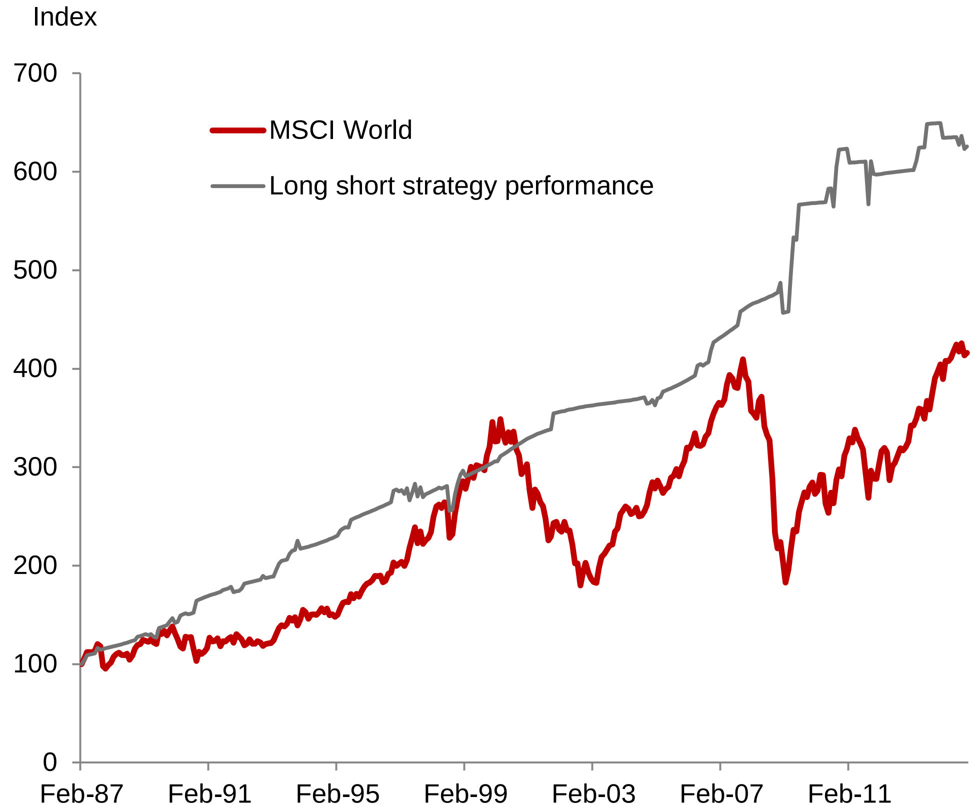
We combine the three measures of confidence in one overall measure, attaching a 50% weight to leaf frequency and 25% each to the Gini Diversity measure and leaf error, reflecting a more distinct function performed by the former measure than by the latter two. The greater the value of the overall Confidence Measure, which ranges from 0 to 100%, the greater our confidence in the signal and the bigger the size of the position we take.

We can scale views given our confidence

Performance of the MSCI World model with confidence scaling

	Strategy	Benchmark	OS strategy	Benchmark
Average	6.87	5.30	8.80	4.32
Vol	6.22	15.30	6.77	16.06
R/R	**1.11**	**0.35**	**1.30**	**0.27**
Max Drawdown	**-9.70**	**-55.37**	**-7.70**	**-55.37**
Calmar ratio	70.89	9.58	114.35	7.80
Omega ratio	3.57	1.37	3.93	1.30

Performance of the MSCI World model with confidence scaling



Source: Nomura Quantitative Strategy research

Using the tree for regional selection

S&P

Topix

Eurostoxx

Equity Risk Premium

↓

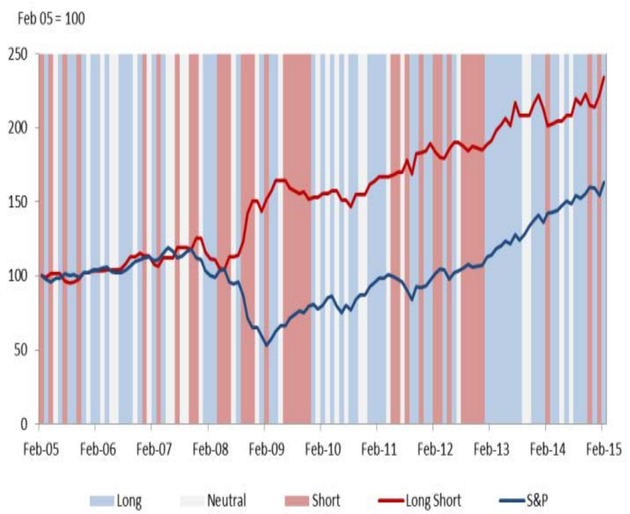
Regional Flows

↓

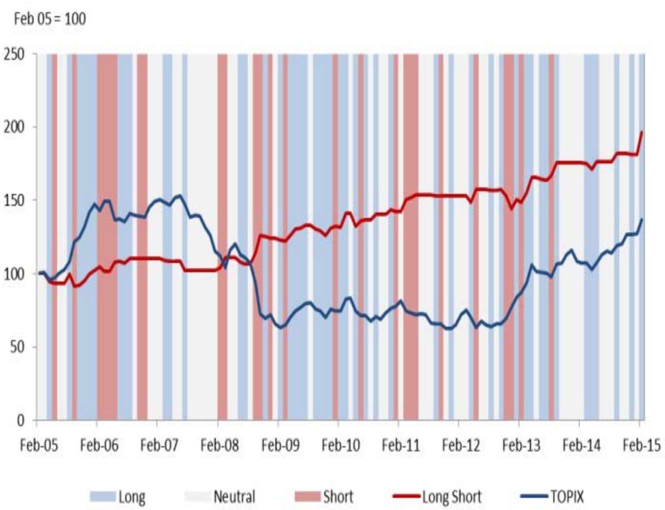
Composite Sentiment Indicator

Using the tree for regional selection

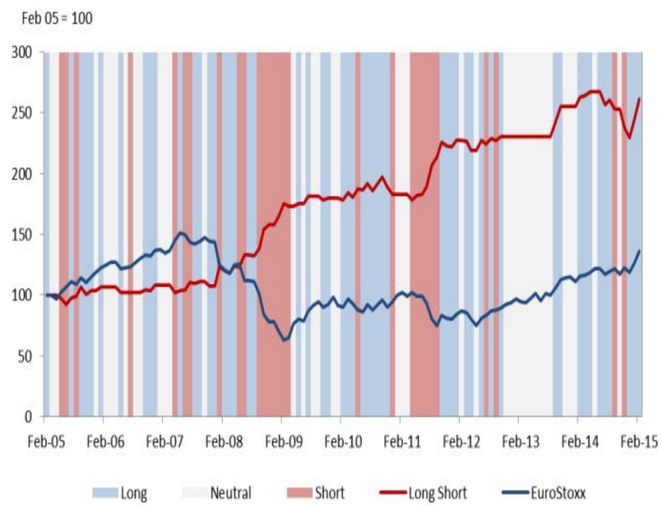
Performance of the S&P model – out of sample



Performance of the Topix model – out of sample



Performance of the Eurostoxx model – out of sample



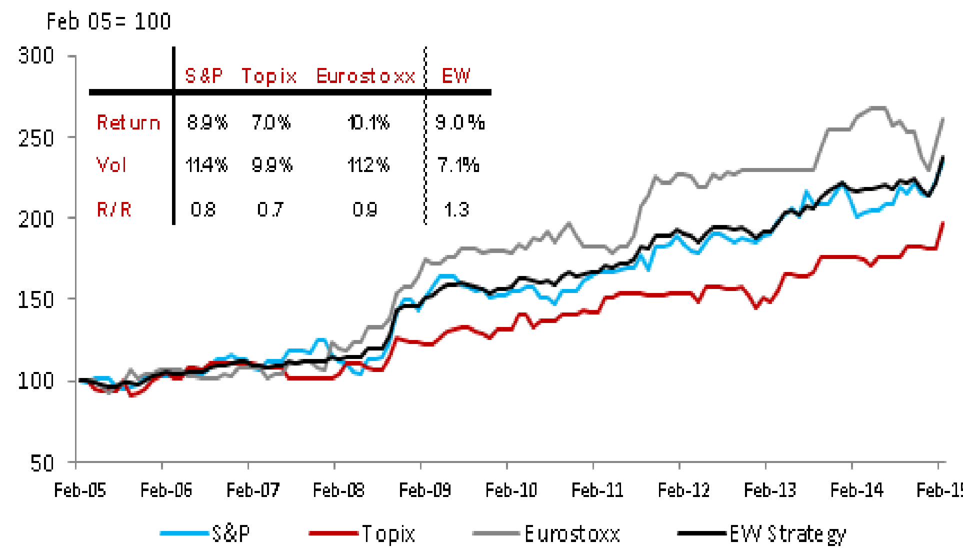
Source: Nomura Quantitative research

Bringing together the regions

Correlation matrix of the regional model performance

	Whole sample		Avg PC: 0.1	Out of sample		Avg PC: 0.1
	S&P	Topix	Eurostoxx	S&P	Topix	Eurostoxx
S&P	1	0.2	0.2	1	0.2	0.2
Topix	0.2	1	0.0	0.2	1	0.0
Eurostoxx	0.2	0.0	1	0.2	0.0	1

Performance of the equal-weighted strategy – out of sample



Source: Nomura Quantitative research

Non-linear global multifactor model

We use a non-linear ‘cross-term’ factor that models the interaction of factors

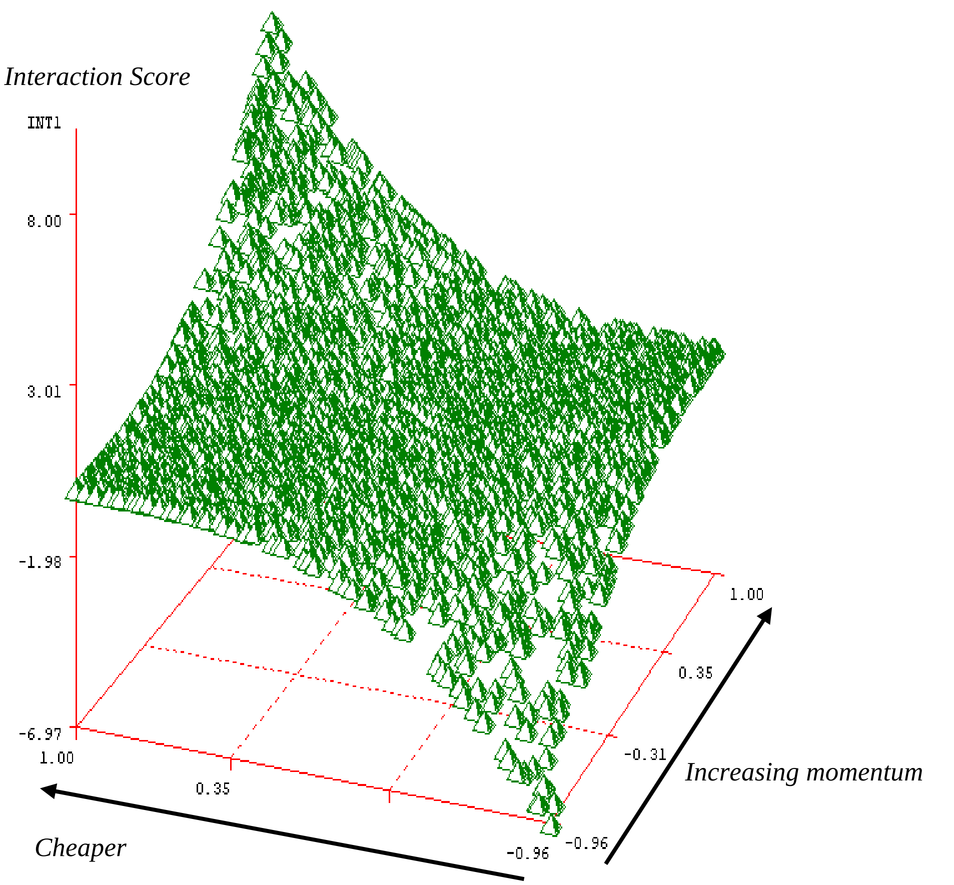
- The functional form of our multifactor model:

$$r_{i,t:t+\delta} = \alpha + \beta_1 . V_{i,t} + \beta_2 . M_{i,t} + \gamma . \Im(V_{i,t} \cdot M_{i,t})$$

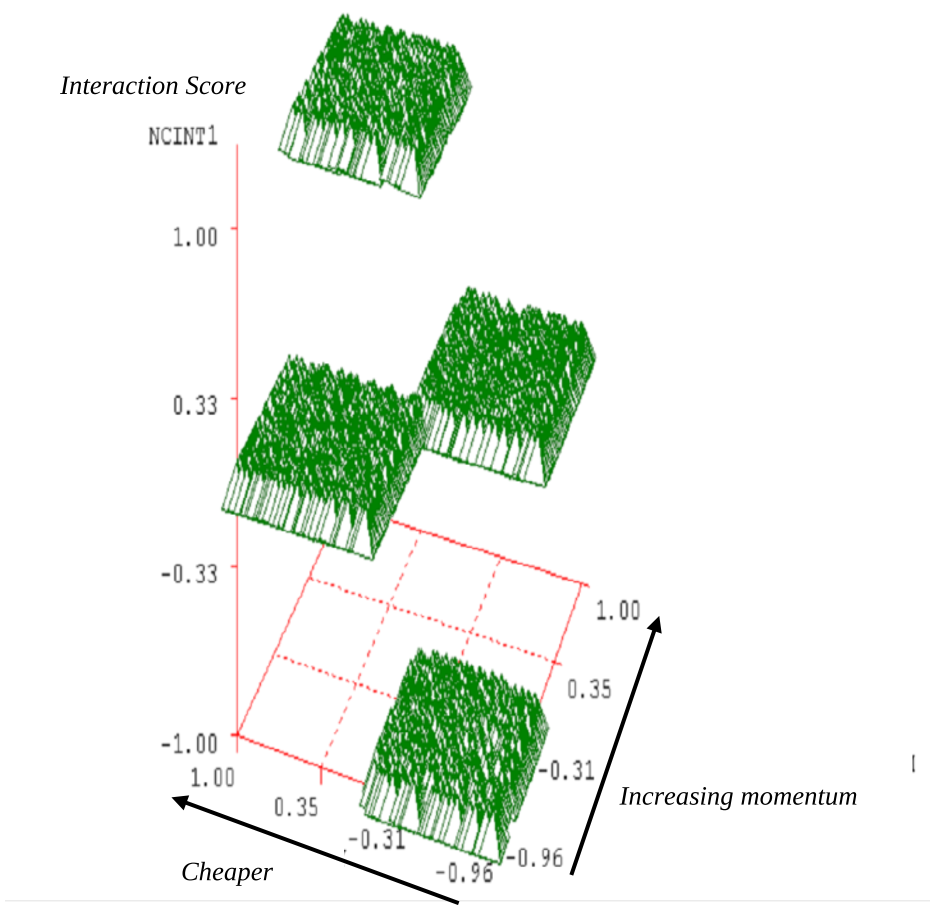
- Certain non-linear interaction functions can have the **economic interpretation of measuring agreement**.
- Extra complexity should be added only with good reason, but we can show an empirical benefit to such a term.
- To defend against a charge of data mining, we impose an *a priori* functional form that we believe is defendable.
- Non-linear interaction terms also have the benefit of lessening the impact of crowding if it brings together factors in ways that are not usually practiced.
- Model has been published and hence live since July 2009, based on an initial European version first published Sep 2008.

Non-linear global multifactor model

We use a cubic interaction factor as our favoured approach



Alternative is a discontinuous interaction screen



Source: Nomura Strategy research

Non-linear global multifactor model: % weights of factors by sector. Result of a learning process

		Basic Industries	Consumer Cyclicals	Capital Goods	Consumer Staples	Energy	Healthcare	Media	Tech	Telecoms	Utilities	Financials
Value	Price/book		5									
	EV/EBITDA	20					10				20	
	PE (forward)									35		
	PE (trailing)			20								
	FCF Yield				25	25		30				
	Div Yld (b'back adjusted)			10			20		20	25	10	20
Growth	Internal Growth	25	20		25			35	10		15	
	Growth FY0-FY3	20			15		25					20
	Long-Term Growth					30			35			
	Sales Growth (historical)						10					
Quality	Interest Cover	5										
	Debt/EBITDA							-15			-15	
	Change in Shares		-25	-20							-10	
	EBITDA Margin		25									
	ROE					20	10					25
	ROCE			15						10		
	Accruals						-5					
Momentum	1m Price Momentum	-15			-20				-15		-5	-20
	9m Price Momentum		15	25								
	12m Price Momentum						20					
	Normalised 12m P Mtm										25	
	6m Earnings Momentum									20		
Interaction	$(V+M)^3$	15	10	10	15	25		20	20	10		15

Source: Nomura Strategy research

Global multifactor model

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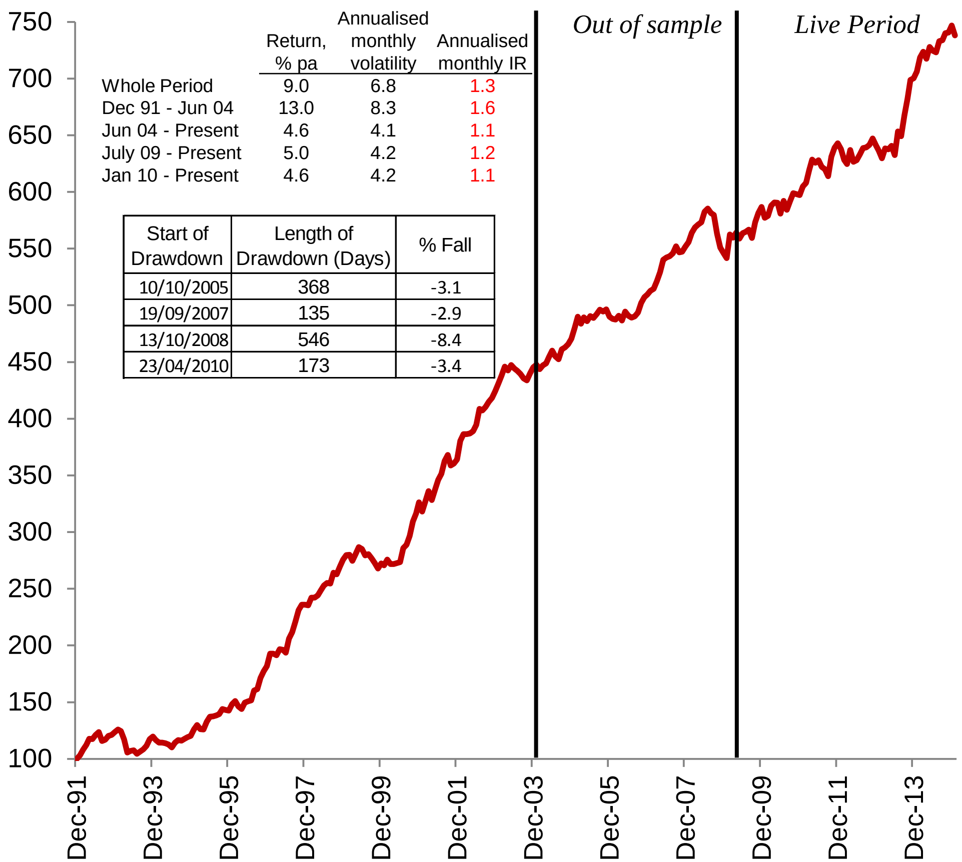
Performance of Nomura global multifactor model

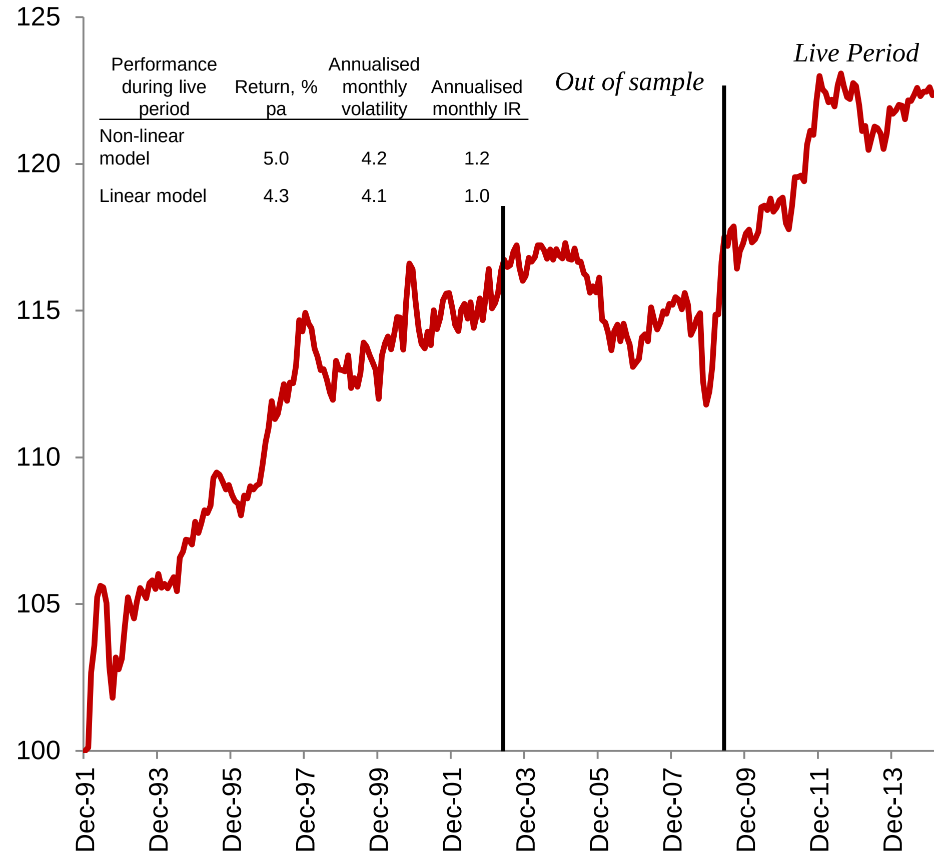


	Return, % pa	Annualised monthly volatility	Annualised monthly IR
Whole Period	9.0	6.8	1.3
Dec 91 - Jun 04	13.0	8.3	1.6
Jun 04 - Present	4.6	4.1	1.1
July 09 - Present	5.0	4.2	1.2
Jan 10 - Present	4.6	4.2	1.1

Start of Drawdown	Length of Drawdown (Days)	% Fall
10/10/2005	368	-3.1
19/09/2007	135	-2.9
13/10/2008	546	-8.4
23/04/2010	173	-3.4

Source: Nomura Strategy research

Value added from non-linearity

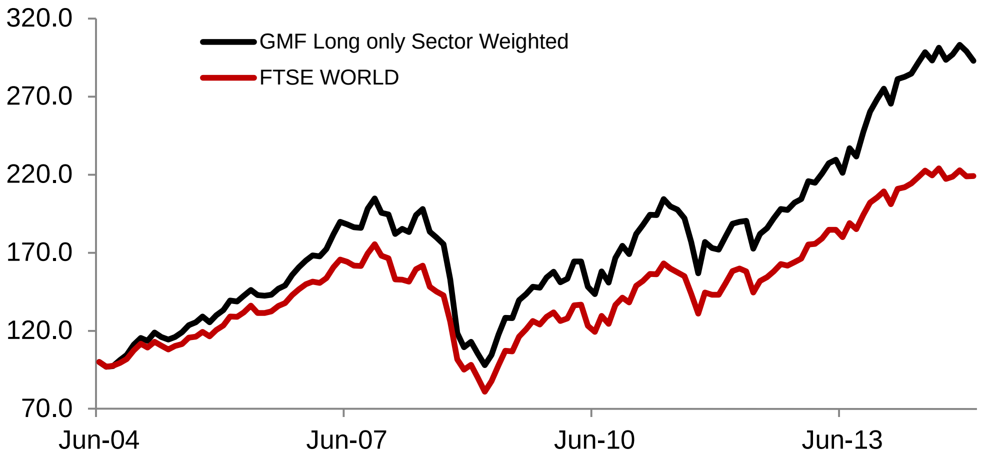


Performance during live period	Return, % pa	Annualised monthly volatility	Annualised monthly IR
Non-linear model	5.0	4.2	1.2
Linear model	4.3	4.1	1.0

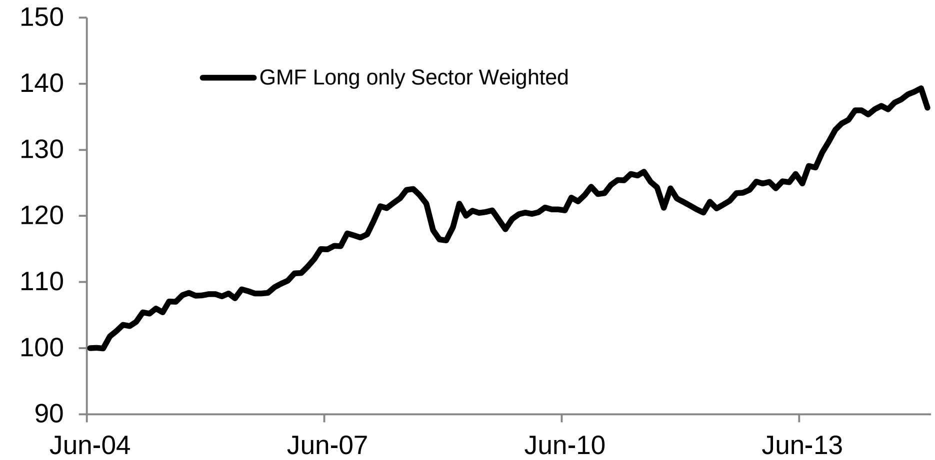
Relative performance of non-linear and linear versions of our global multifactor model.
Source: Nomura Strategy research

Global multifactor (long-only version)

Absolute return performance (out-of-sample period)



Relative returns performance (out-of-sample period)



Absolute return statistics

	Return, % pa	Benchmark
1 yr	10.3	8.8
3 yr	17.5	13.3
5 yr	14.1	11.6
Out of sample Period	10.7	7.7

Relative return statistics

	Return, % pa	Annualised monthly volatility	Annualised monthly IR
1 yr	1.4	2.9	0.5
3 yr	3.9	3.0	1.3
5 yr	2.5	3.2	0.8
Out of sample Period	3.0	3.2	0.9

Source: Datastream, IBES, Nomura Strategy research

Conclusion

- To combine factors with different information decay times into a common signal, we think there are better approaches than simple linear combinations
- Trees can be used with the information decay time determining the factor order in the tree
- If there are indeed no new accounting factors to be discovered, then we should look for new ways to combine the factors that we have
- There is a case for using non-linear factor combinations in stock selection as well

Appendix A-1

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Explanation of Nomura's equity research rating system in Japan and Asia ex-Japan prior to 21 October 2013

STOCKS

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