



UBS Investment Research

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Stock selection using random forests

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Machine learning

- Artificial intelligence
- This is everywhere, already
 - Email spam filters
 - Internet search results
 - Customised product suggestions
 - Self-driving cars
- Random forests
 - Very modern
 - Hugely popular in commercial/academic settings

Cutting edge performance

Simple to understand

Robust to over-fitting

The wisdom of crowds

- Surowiecki (2005)
- Popularised "crowd-sourced" decision making to achieve better outcomes
- E.g. jellybean guessing contest

The collective wisdom of a diverse and independent group has more information than any single expert

The wisdom of crowds

- Diversity matters – statistically!
 - Information value of breadth
- Corollary – the danger of groupthink
 - History abounds with mistakes
- Intuitive, but often taken for granted
 - CEO + board of directors
 - Analysts covering a stock

Bias and Variance

- Bias is a systematic error component
- Variance is the dispersion of this error

High bias, low variance

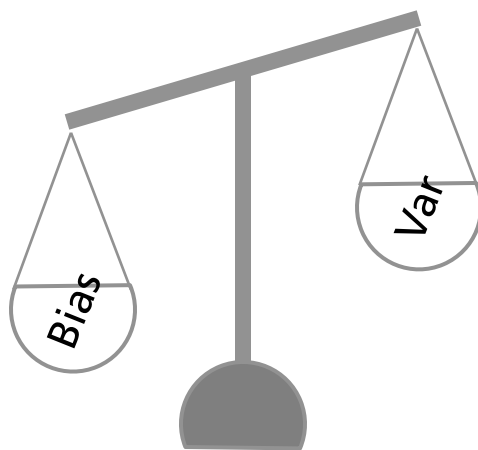


Low bias, high variance



Bias and Variance

- Ideally, low bias & low variance
- Fundamentally opposing objectives



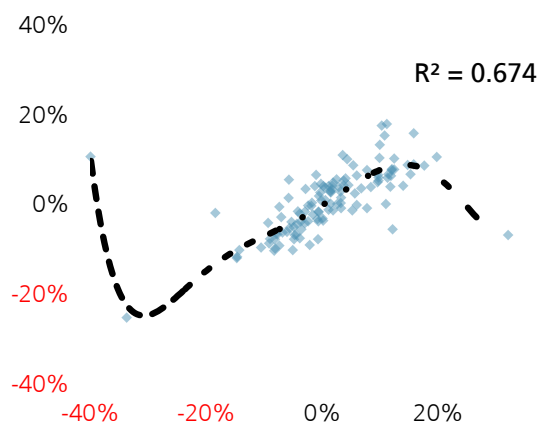
- This trade-off underpins all machine learning techniques
 - Directly impacts decisions and outcomes

Bias and Variance

- Model error (MSE), $\Sigma(\text{forecast} - \text{actual})^2$

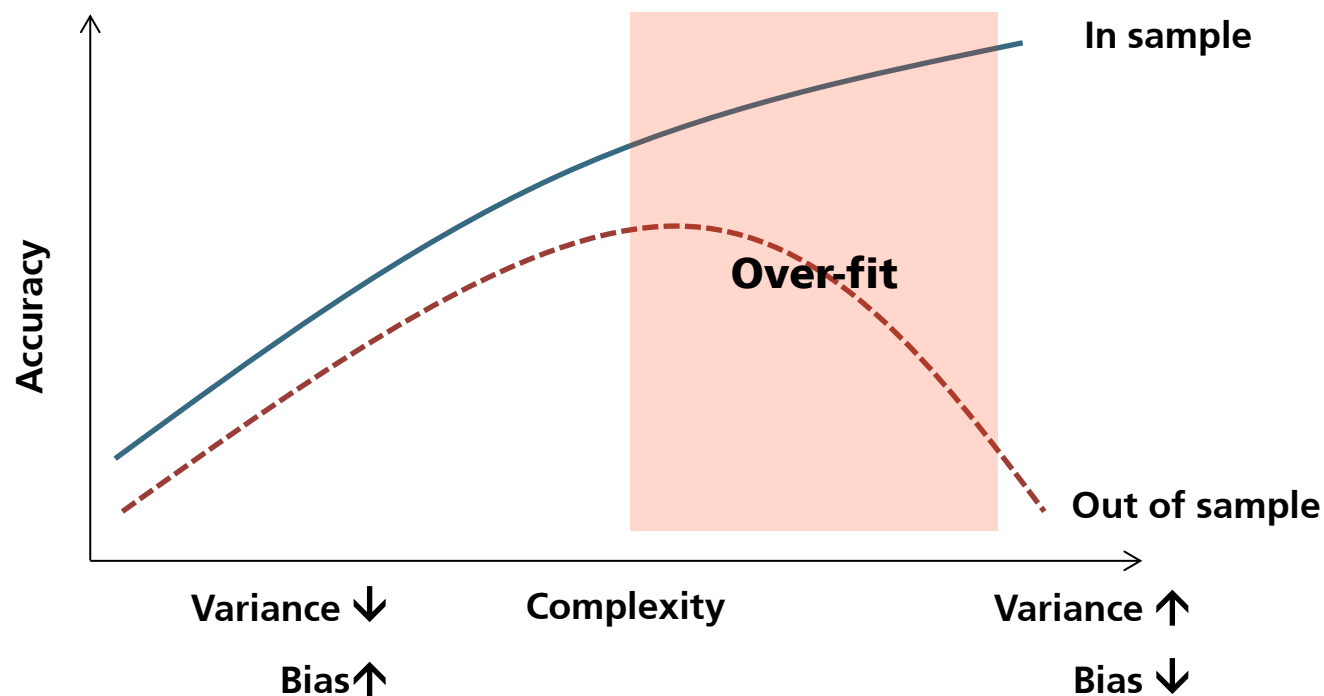
$$MSE = \text{Bias}^2 + \text{Variance} + \sigma^2$$

- Framework for model selection
- 100% hit rate, 99% R^2 , 3.5 Sharpe? Probably not...
- Overfitted model "memorises" training data, rather than generalising



Source: UBS

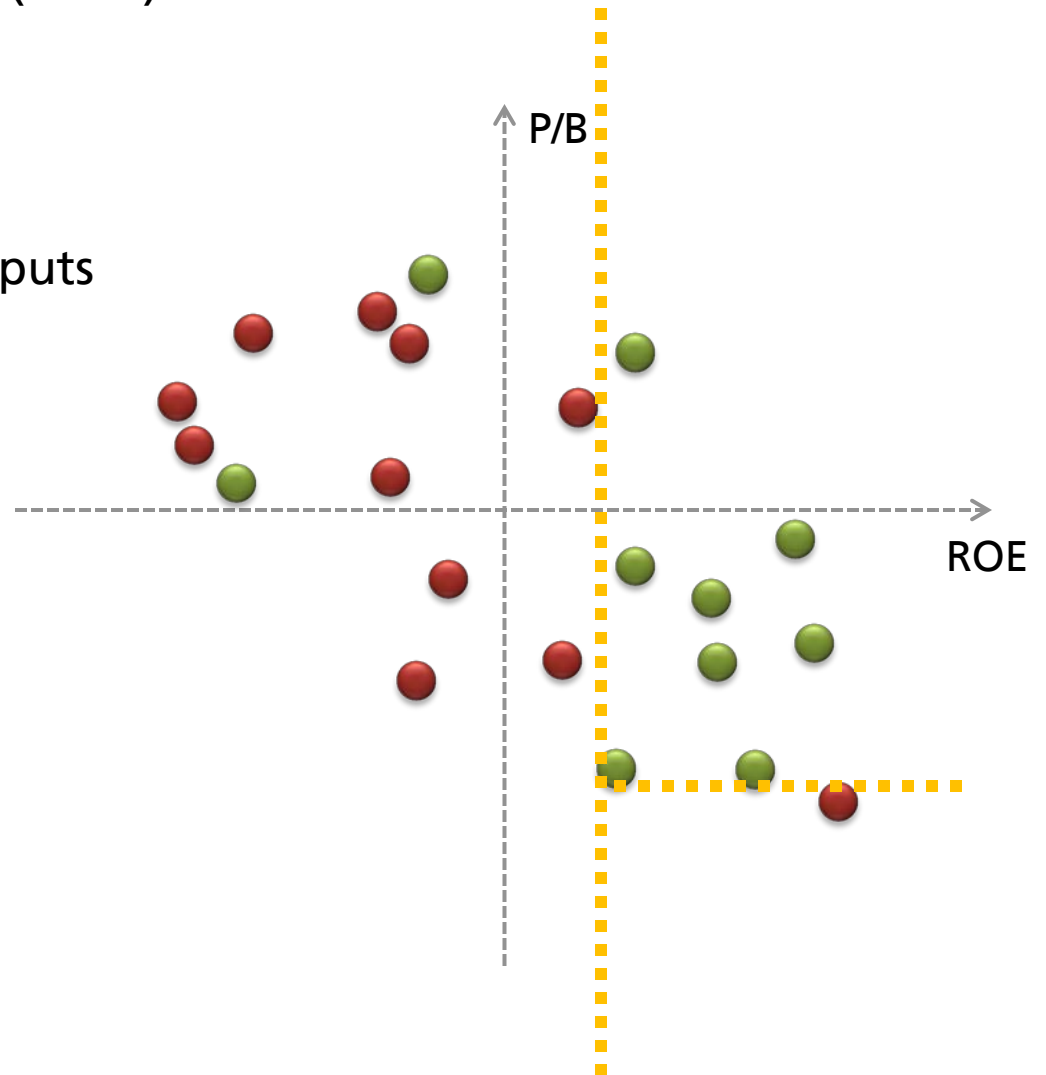
Bias and Variance



- Random forests perform cross-validation internally!
- Practically, there are no parameters to tweak
 - **Cutting edge performance with no tuning required, cross validated results**

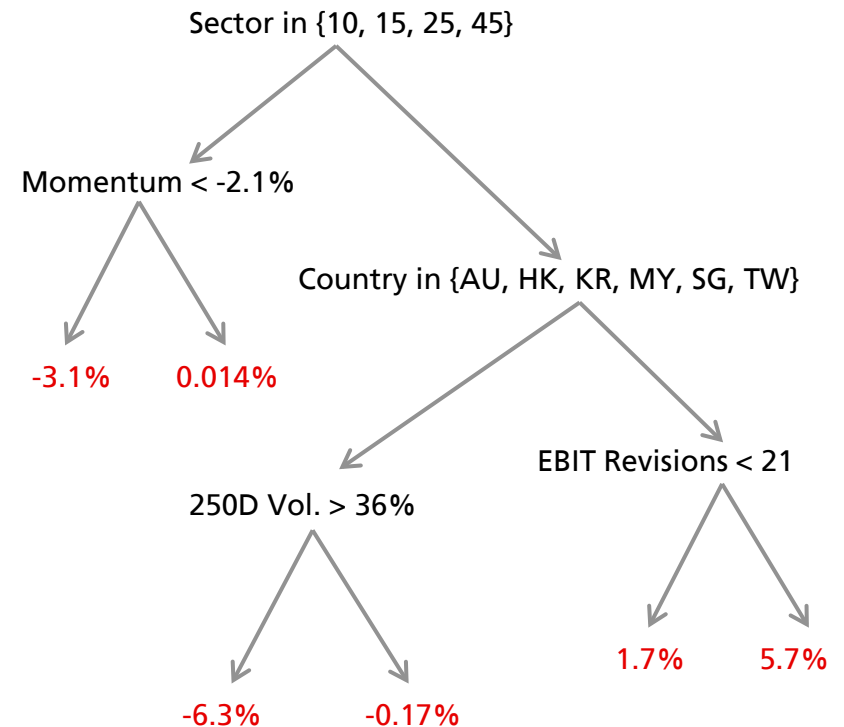
Seeds to trees

- Classification and Regression Trees (CART)
- Breiman, 1984
- Very popular technique
- Splits inputs by similar-looking outputs



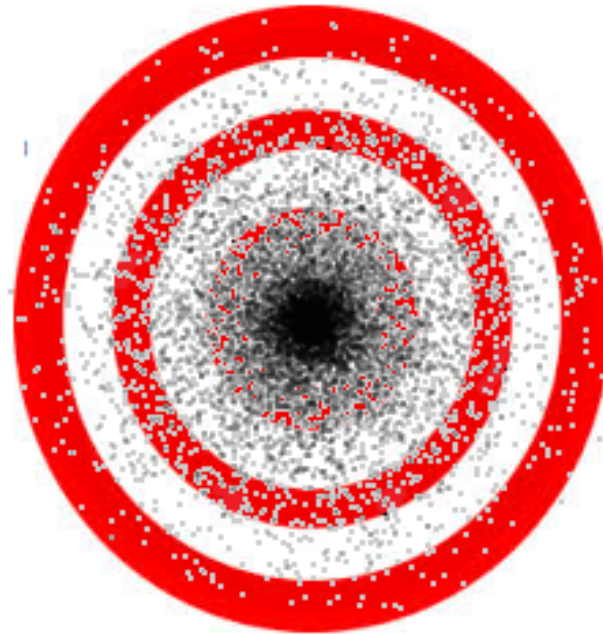
Seeds to trees

- This process continues...
- Very similar for regression
- Pros
 - No assumptions on underlying data structure
 - Easy to interpret and visualise
 - Handle categorical and numerical data easily
 - Robust to real-world data
 - Computationally efficient
- Cons
 - They over-fit
 - Pruning helps to an extent
 - Still not competitive with modern techniques



Trees to forests

- Combine thousands of independent low bias, high variance predictors (trees)
- Which produces a low bias, low variance result



- Successor to CART (Brieman 2001)

Trees to forests

- The layperson explanation
- Independence is key!
- Introduce 2 sources of randomness:
 - Randomly select factors
 - Randomly select data (OOB)

- Reduction in variance from bagging

$$\text{Var}(f) = \rho\sigma^2 + \frac{1-\rho}{B} \cdot \sigma^2$$

- Currently no analytic expressions for RF

Trees to forests

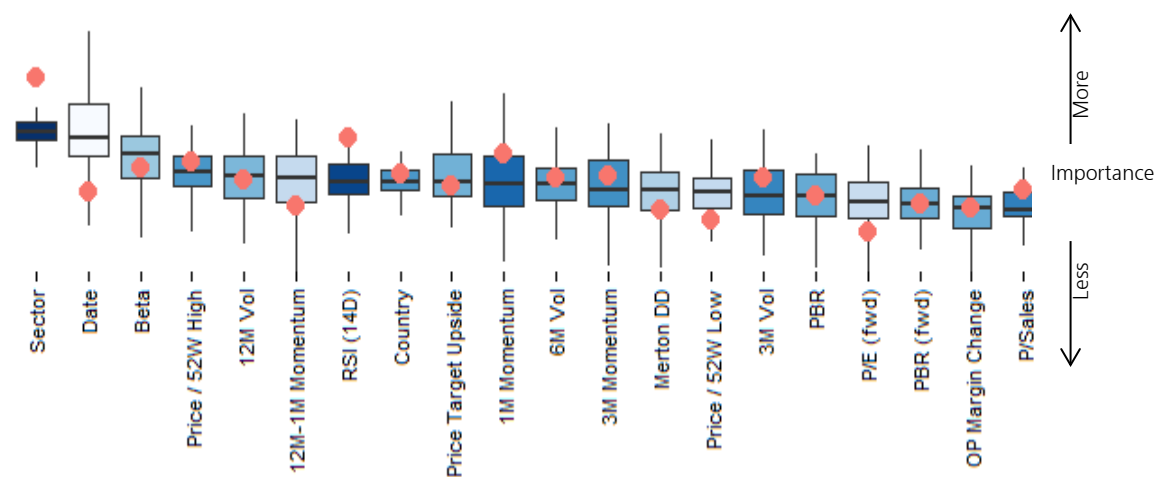
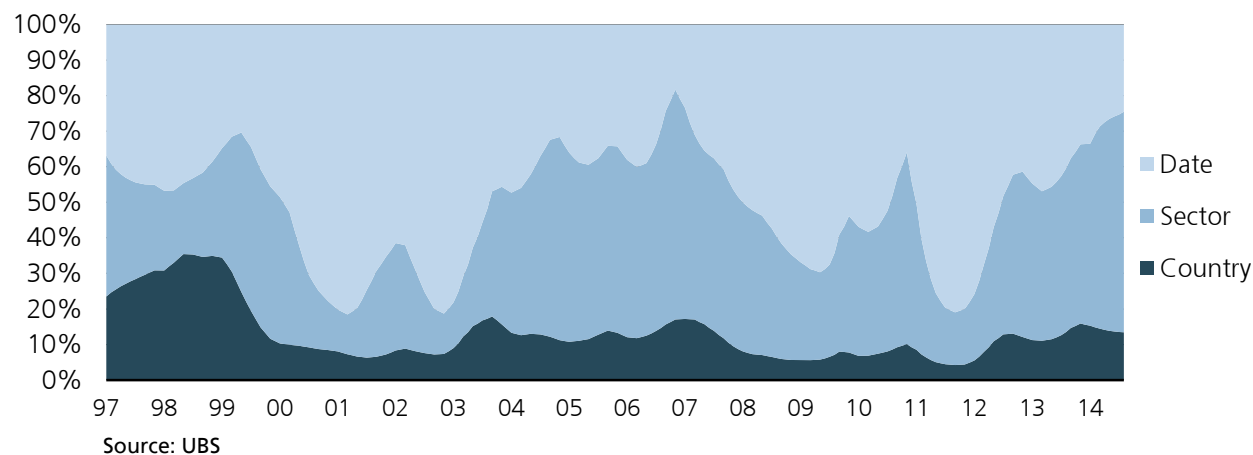
- Two useful by-products from OOB

- Proximities

- Effective imputation

- Variable importance

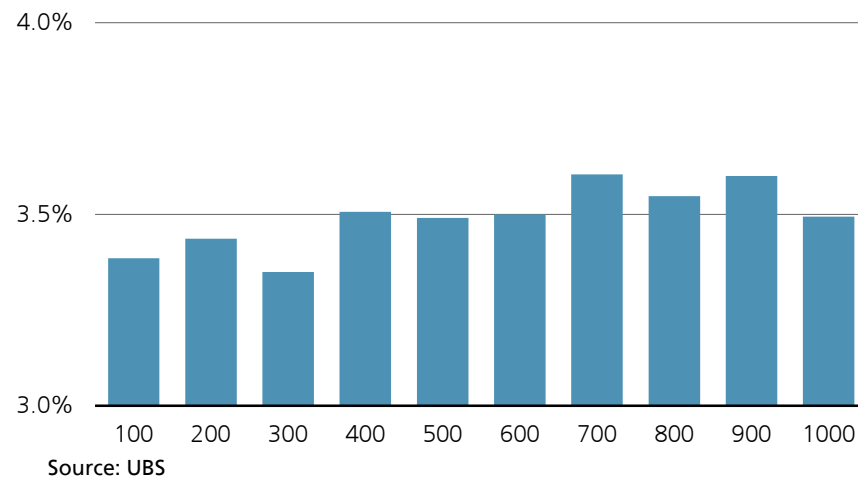
- Frequency
- Impurity
- Permutation



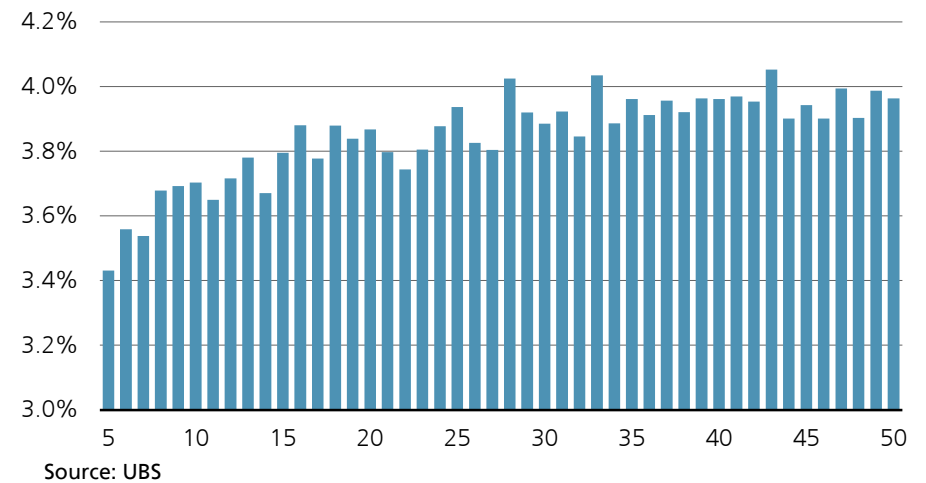
Trees to forests

- Minimal model parameters
 - #trees in forest
 - #splitting vars

Rank IC vs number of trees

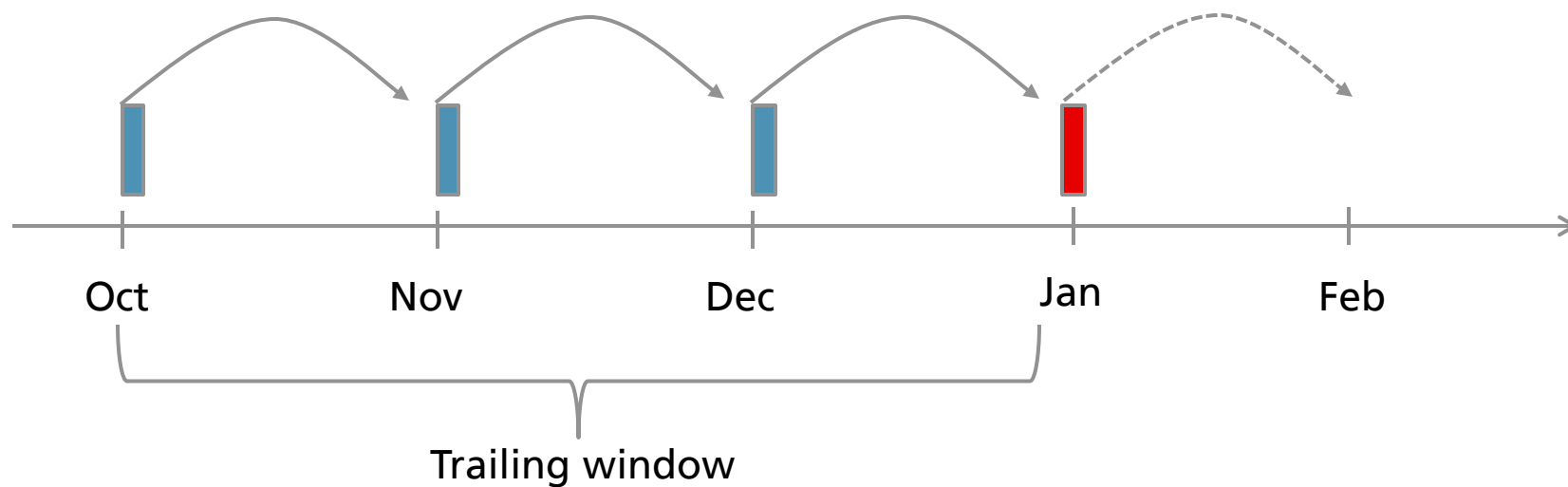


Rank IC vs splitting variables



- Trees typically grown to full depth

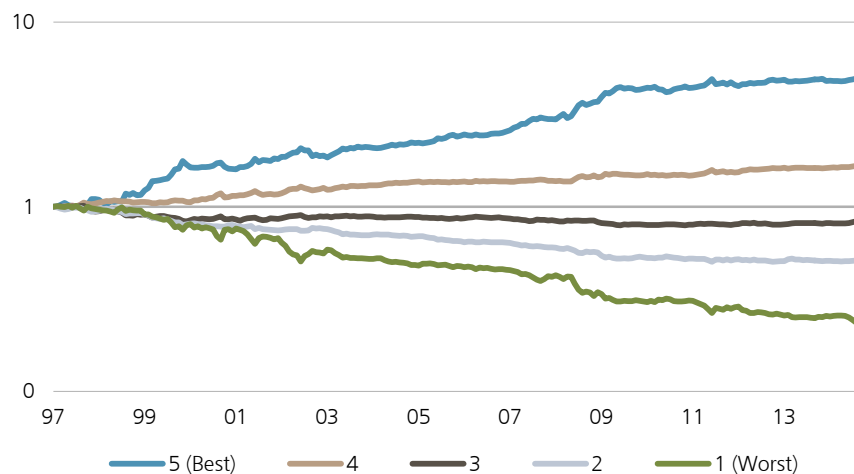
Putting it together



- Build forest using short trailing window
 - Response variable is the forward return
 - Predict using the latest available factors
- A regression problem
 - Not all out/underperformers are equal
 - Discrete response is not practical

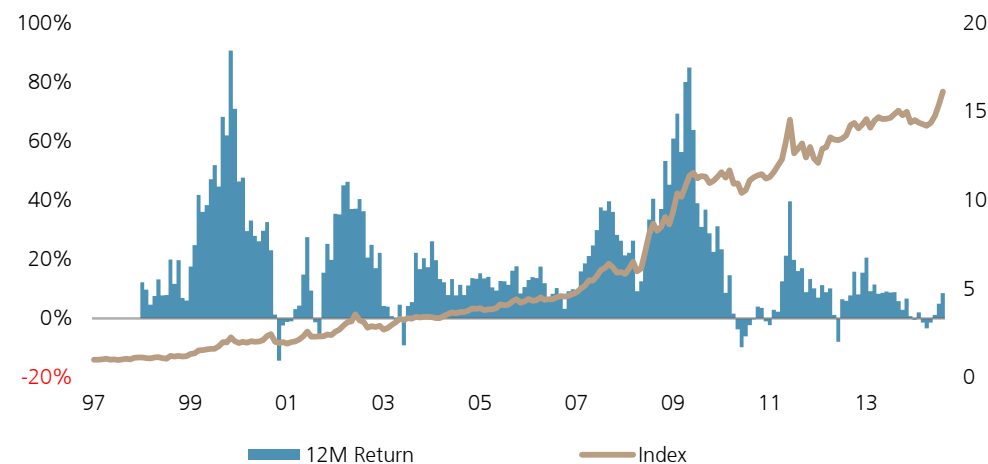
Performance

MSCI AC World excess return fractiles



Source: UBS

MSCI AC World Long-Short



Source: UBS

Index	Return	Sharpe	Max Drawdown	Hit Rate
MSCI AC World	17.1	1.1	-24.4	66.8
Developed	14.5	0.8	-35.2	64.9
Emerging	15.9	1.0	-28.3	68.7
MSCI AC Asia Pacific ex Japan	17.3	0.9	-39.4	64.9
Developed	15.8	0.8	-40.8	63.0
Emerging	9.1	0.6	-52.9	58.8
S&P/ASX 300	25.0	1.1	-35.7	68.7
MSCI Japan	6.2	0.4	-58.7	57.3
MSCI AC Europe	14.1	0.9	-37.1	66.4
Developed	13.2	0.7	-47.2	63.0
Emerging	7.8	0.5	-38.3	55.9
MSCI North America	9.7	0.5	-30.8	57.8

Source: UBS

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Buy	FSR is > 6% above the MRA.	47%	37%
Neutral	FSR is between -6% and 6% of the MRA.	42%	32%
Sell	FSR is > 6% below the MRA.	11%	21%
Short-Term Rating	Definition	Coverage ³	IB Services ⁴
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	less than 1%	less than 1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	less than 1%	less than 1%

Source: UBS. Rating allocations are as of 31 December 2014.

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