Back to basics

Quantitative Equity Research

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Section 1

Introduction

Introduction to quantitative investment – an outline

- What do we mean by quantitative investment?
- What are the different parts of a quantitative process?
  - Finding factors
  - Combining factors
  - Turning factors into portfolios
- Where to start from – alternative benchmarks
- What can go wrong?

Let's start at the very beginning, which is a very good place to start …

What do we mean by calling someone a "quant"?

- There are various types of "quants"
- Derivative pricing – figuring out how to price and hedge sophisticated derivative structures. Part theory, part writing efficient computer code to calculate prices quickly
- Algorithmic trading quants – designing and implementing methods for computers to trade for you
- "Investment" quants – we'll discuss the definition of this below
- Equity Quantitative Investing is often broken down into:
  - Statistical arbitrage ("stat arb") – high volume trading using (generally) short term relationships between stock prices. "Black box" strategies. Holding periods in terms of hours or days
  - Slightly longer term strategies using well researched strategies. (Market Neutral and Long Short Equity)
- High frequency trading – market making, of sorts

What is quantitative investment?

- Quantitative Investing is highly systematic approach to investing.

  There are four core steps

  1. Data management
  2. Alpha discovery (Strategy development)
  3. Alpha capture (Portfolio Construction and Trading)
  4. Feedback loop.

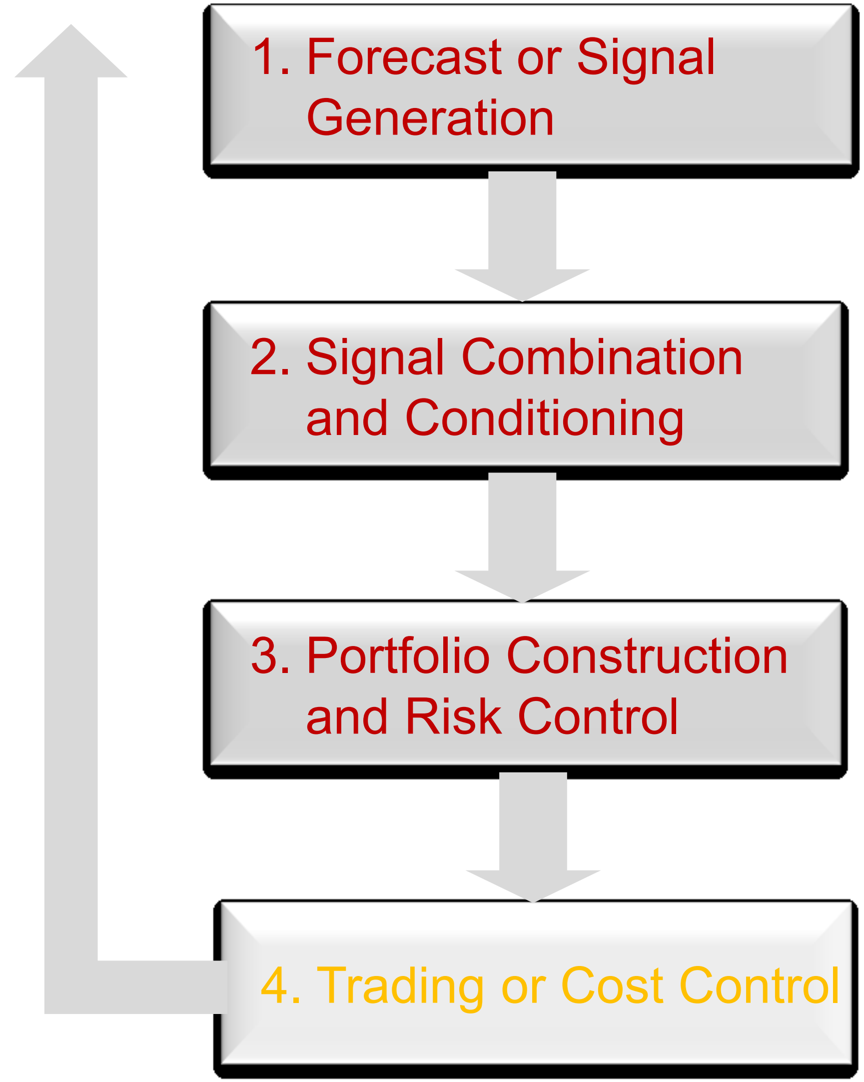
- But what makes a portfolio a “quant” portfolio?
  - Formal process – rule based
  - Often driven by academic research
  - Very heavy usage of data and databases
  - Buying factors / portfolios, not individual stocks
- Can judgement come into it?

Active investment process

- The process can be broken down into 4 stages. Successful outcomes requires careful design at all stages.
- The potential performance is derived from both

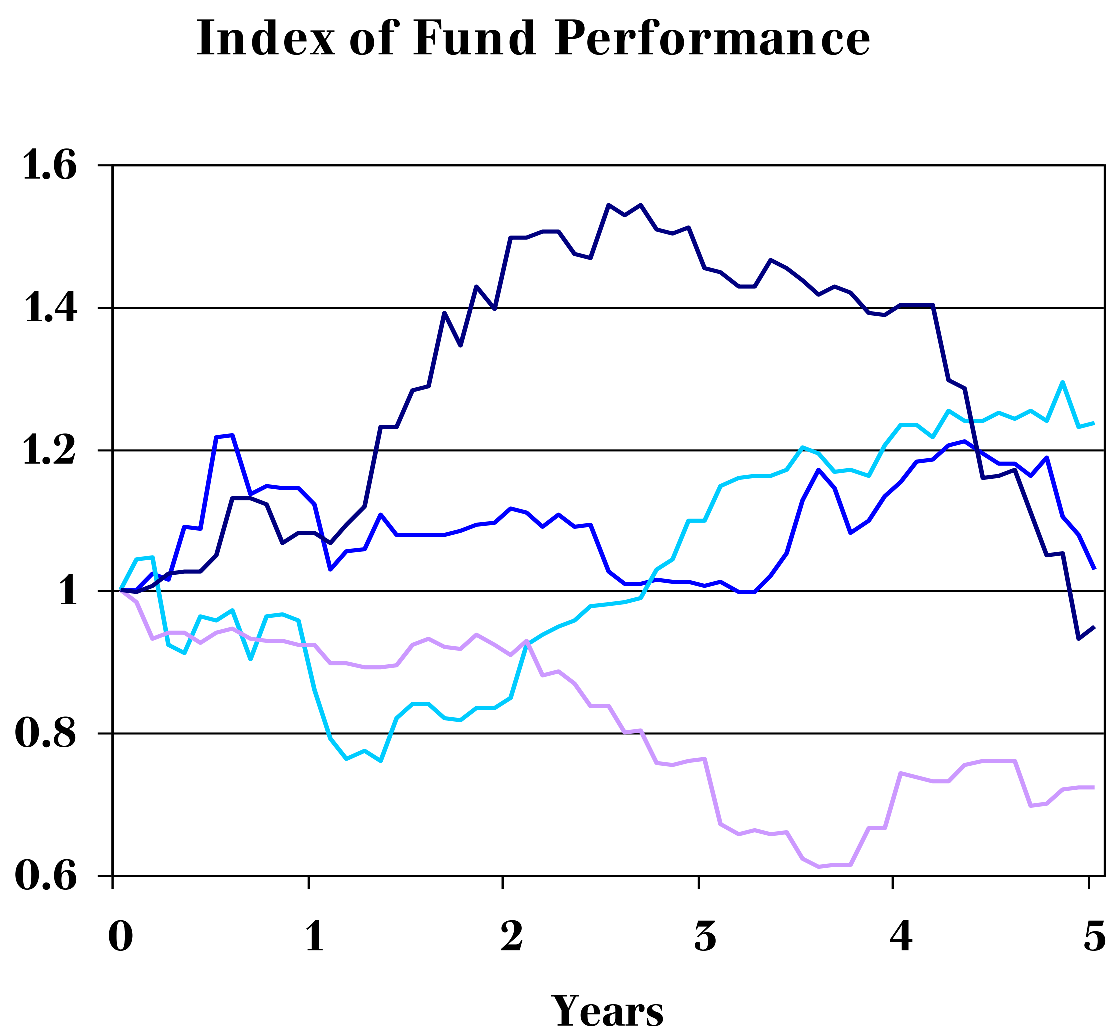
1. Quality of the signals
2. Number of signals

This is the **Fundamental Law of Active Management**



Fundamental Law of Active Management

- Imagine a single Style Strategy Fund e.g. Value/Growth Fund
- Assume the manager has above average skill. Measure this skill, or IC, by the correlation of his forecasts with actual outcomes.
- For an IC=0.15, generate a possible history of fund performance.
- Even given 5 years, many funds will have lost money.



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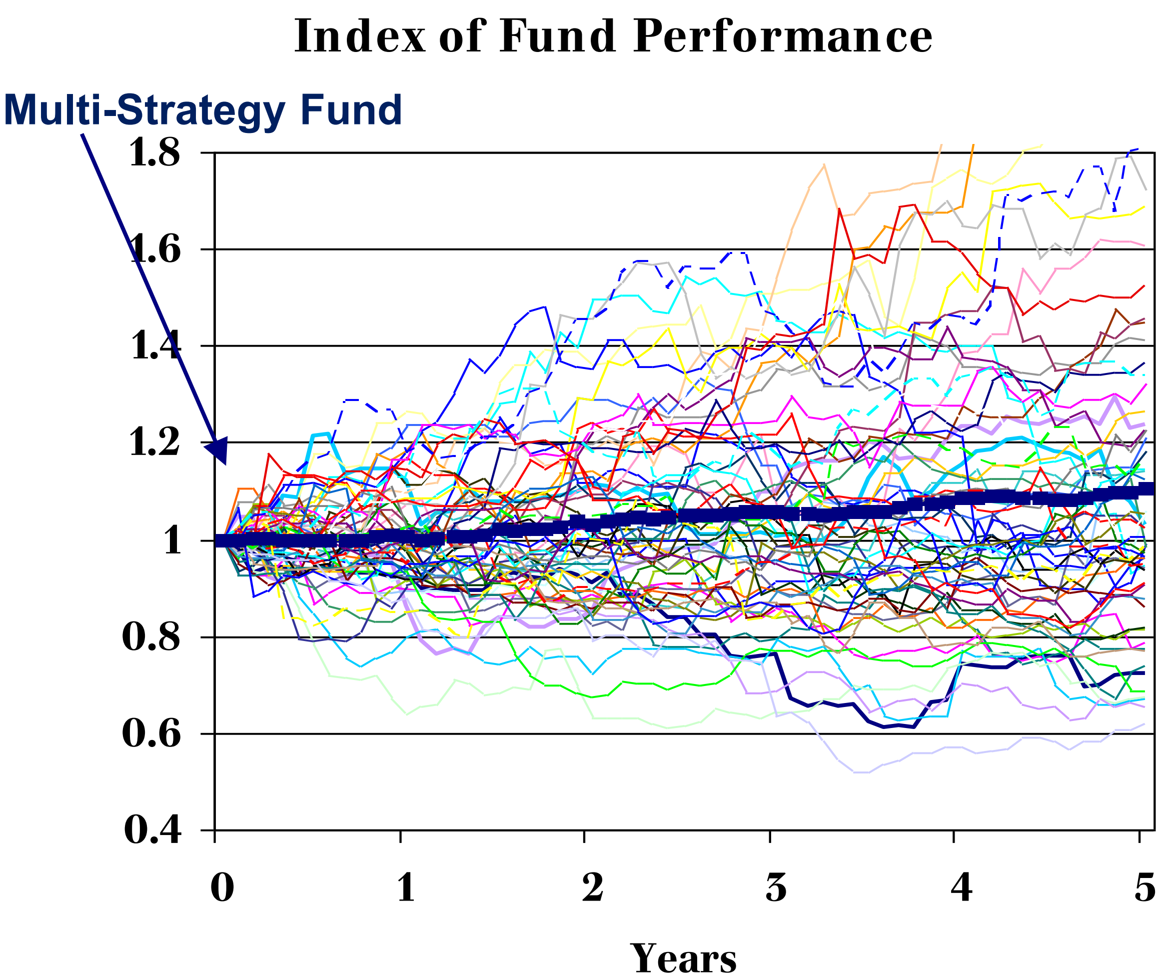
Fundamental Law of Active Management

- However, imagine a multi-strategy fund that combines 60 such ideas in a single portfolio.
- Its performance, or Information Ratio, is no longer 0.15 but 1.2 = $0.15\sqrt{60}$
- The Fundamental Law of Active Management:

$$IR = IC\sqrt{Breadth}$$



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"Aye, there's the rub"

- For the *'Fundamental Law'* to apply the signals must be independent.

- Analyst Forecasts or individual stock forecasts have the potential to be uncorrelated *but*
  - Forecasts based on rising demands or falling costs are likely to correlated across companies with industries and even across industries.

- Value forecasts maybe picking up mis-valuation at an individual stock level
  - Our research ("Understanding value") suggests that value is a combination of mispricing and exposure to risk
  - But it is more likely they are picking a common signal such as a rise in short term earnings versus long term earnings

Example Signals

Valuation	Growth	Quality	Sentiment
• Dividend Yield • Cash Flow to Price • Earnings Yield • Book Yield	• Analyst Forecasts • Analyst Revisions • Historical Growth	• Return on Equity • Accruals • Asset Growth	• Momentum • Equity Dilution • Short Interest • Directors' Dealings • Volatility

Trading Costs

- Quantitative funds typically have a much higher turnover than qualitative funds (some turnover their portfolio every 1 to 2 months)
- It is possible that the difference between success and failure is the control of trading costs.
- As we will discuss, costs, or at least an awareness of costs, should be built into every stage of the process

Section 2

Data and databases

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What do we want our database to be able to do?

- There are a few basic needs we have of a quant database
- Avoiding survivorship bias
  - The database must contain all the companies that existed at a certain time in the past, even if they don't exist now
- Avoiding look ahead bias
  - We should be able to test our strategy only using the information we would have had at that time in the past.
  - The relatively recent development of point-in-time data is a great move in the right direction
- Accurately link together disparate sources of data
  - Different data vendors use different codes as the primary key in a database. Linking these together accurately through time is a challenge
- Calculate total returns for a strategy accurately
  - This means tracking any corporate action for a stock, or its forebears, accurately. This can be challenging as different data sources can deal with the same corporate action in different ways

Challenges of data

- Once we have the database set up and everything linked together there are still other things to consider. These include:
- Are accounting items comparable?
  - This is a question to ask cross-sectionally (i.e. can we compare different companies from the same database), and over time (can we calculate a growth rate from a historic database to a forecast database)?
- Should we use the last reported or last 12 months or forecast data?
- Which exchange rates to use – spot or average?
  - And which source of exchange rates? (Note that this can make a big difference on any single day – however the error will not compound over time)

Where is data going?

- There are two ways to find new signals
  - Process your existing data in a new way, which includes finding a novel way to link together data from separate databases
  - Find a new data source
- It is this latter approach that people are spending time on. Examples of these new data sources include
  - Satellite imagery – tracking number of cars in shopping mall car parks
  - Supplier / client information
  - Internet – “text mining” for sentiment
  - Surveys – can be proprietary
  - Option volatility data
  - Tick data – problems here of data storage and processing ability

Data mining

- One definition of “data mining” is
  - The automatic extraction of useful, often previously unknown information from large databases or data sets
- In our case we’re using it to mean “over extracting” of data.
- If you run twenty tests on something random then you would expect one of them to look significant (as the definition of significance is often a p-value of less than 0.05, i.e. the probability of seeing a result is less than 1 in 20. But if you’ve got 20 samples …)
- One way to avoid data mining is to approach the data with a prior view – start from what you expect to find and then look for it. Sometimes you’ll be surprised, which is the whole point, but often you won’t.
- The other problem is how to know if you have just been lucky.

Section 3

Finding and measuring sources of outperformance

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What do we mean by “a style” or “a factor”?

- A style is defined by a group of companies sharing some common characteristic, usually derived from fundamental (accounting) data
- Such a data intensive approach to building characteristic portfolios is problematic if the underlying data items are not constructed in such a manner as to be globally comparable
- Style, in our opinion, should not just be another way of defining industries but rather should span multiple industries
- Styles are generally considered to be potential drivers of return and not just risk factors - we are completely agnostic on this issue

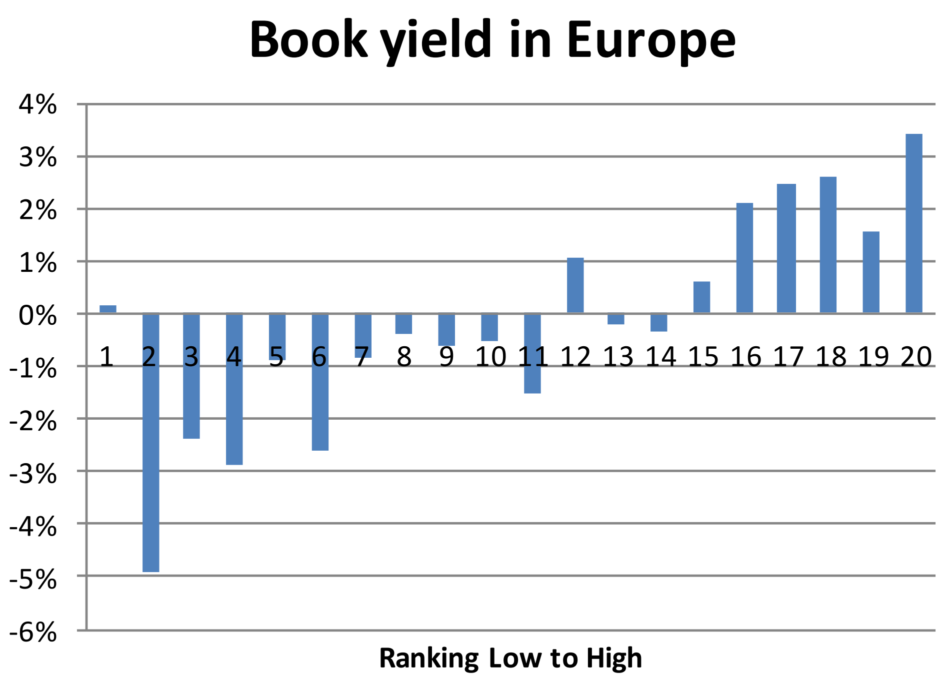
What makes a style a good candidate?

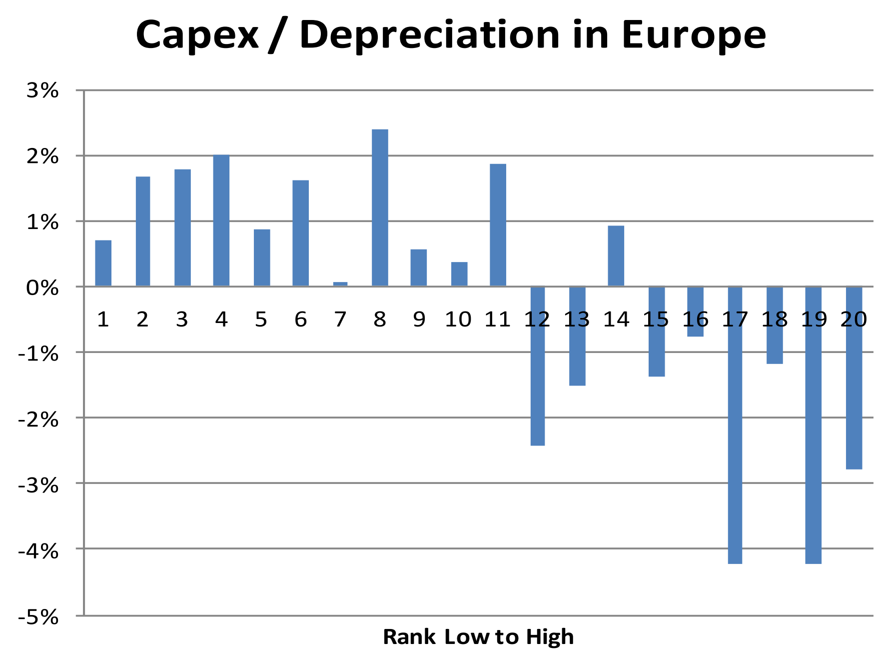
How do we measure "good" when considering whether we should use a style in our investment process?

- Positive return over time
  - N.B. this may not be completely obvious as we have to take transaction costs into account.
  - Also, if the new strategy has an average return of zero, but is uncorrelated with an existing strategy it is possible that the sum of the two strategies has a good return but with lower turnover.
- Low correlation with existing strategies
- Good hit rate both in cross section and over time.
  - Better a strategy that wins small most of the time than one that wins big but only occasionally.
- There seems to be some "investment case" behind the style's return

Where is the performance coming from?

- Looking at the factor's performance in detail helps to understand this. This includes looking where in the distribution the returns are created. For book yield this is fairly uniform from low to high whereas for capex / depreciation more of the performance is coming from the negative performance for the high values





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How should we build portfolios?

There are many questions to consider:

- Neutrality - sector neutral or size neutral or region neutral or not?
- How many names?
- Weighting scheme
- Rebalancing frequency (and timing)
- Should we neutralise to other factors?
- Turnover control

Other issues include

- Currency
- Ranking or z-scores
- Robustness

Weighting schemes

There are many ways that a factor portfolio can be constructed just in terms of the weighting methodology. These include:

- Equal weighted
  - Sector neutrality can be maintained in a long short portfolio by investing in the top & bottom n (or top & bottom third say) in each sector.
- Cap weighted
- Risk weighted
  - Weights here are proportional to 1 / variance. Harder to use in a long / short framework. It also tilts the portfolio towards low volatility so introduces a correlation to this factor.
- Rank weighted
  - Rank the stocks from –n to n (where there are 2n or 2n+1 stocks) and make the weights proportional to this
- Z-score
  - Similar to ranking but using the normalised scores rather than the ranks
- Optimisation

Neutralising a factor

- As we stressed earlier, the ideal situation is that we create uncorrelated signals.
- Unfortunately simply ranking on a signal is likely to give us various biases to sectors and countries which are likely to introduce correlations between the signals.
- The table below shows the sector weights of European book yield and capex / depreciation portfolios.

	Book yield			Capex / depreciation		
Group Weights (%)	**Longs**	**Shorts**	**Net**	**Longs**	**Shorts**	**Net**
Energy	3.7	-7.4	-3.7	2.8	-12.9	-10.1
Materials	12.3	-6.7	5.6	8.1	-15.1	-7.0
Industrials	8.4	-25.3	-16.9	21.8	-13.5	8.3
Consumer Discretionary	6.7	-17.1	-10.4	13.4	-8.6	4.8
Consumer Staples	3.0	-13.6	-10.6	6.6	-10.0	-3.4
Health Care	1.7	-12.0	-10.2	13.8	-1.7	12.1
Financials	51.2	-3.1	48.1	13.1	-25.2	-12.1
Information Technology	1.8	-5.5	-3.8	6.0	-1.9	4.1
Telecommunication Services	3.5	-7.8	-4.3	9.1	-2.1	7.0
Utilities	7.9	-1.7	6.2	5.4	-9.0	-3.5

Source UBS Quant, for illustrative purposes only

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Neutralising a factor

- And if we look further at the capex / depreciation portfolio we find a large tilt on free cash flow yield.

Net Long Styles		**Net Short Styles**	
Low Capex/ Depn <Q>	87.6	High Capex/ Depn <Q>	-84.6
High Free Cash-flow Yield <V>	42.8	Low Free Cash-flow Yield <G>	-41.0
High Dividend Growth <G>	12.3	Large Cap <S>	-12.0
Mid Cap <S>	11.1	Low Short Term Price Momentum <	-10.1
Low Debt to EV <Q>	11.0	Low ROIC <V>	-8.5
Low Volatility <Q>	9.8	Low Forecast PE <V>	-7.7
Low PEG <Q>	7.8	Low Medium Term Price Momentur	-7.4
High ROIC <G>	7.5	High Dividend Cover <Q>	-6.9
High Forecast EPS Growth <G>	7.0	Low Earnings Momentum <M>	-6.6
Low Book / Price <G>	6.2	High Beta <M>	-6.4

Source UBS Quant, for illustrative purposes only

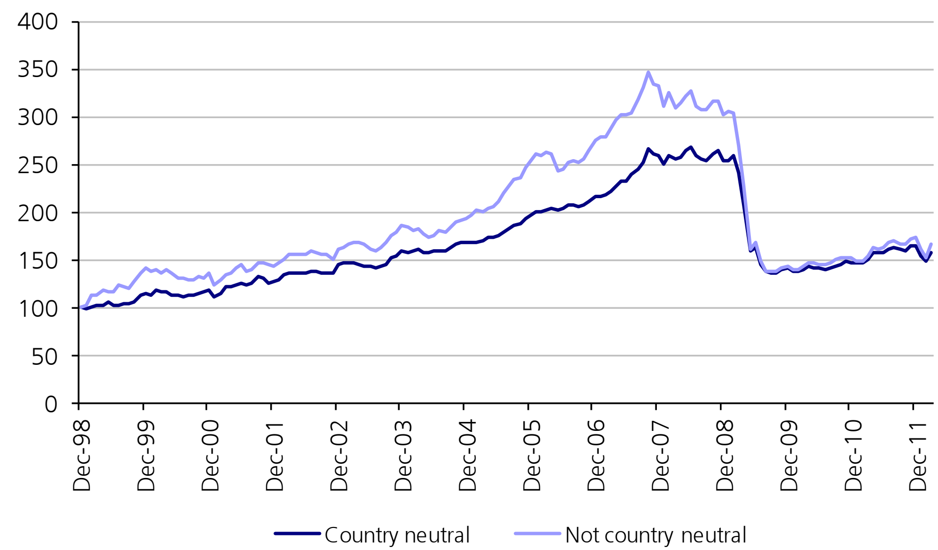
Neutralising a factor

- So how do we go about neutralising a factor?
- In our view it depends whether your two styles are attempting to capture the same underlying factor (so two different value measures for example) or if they are from different style categories.
- In the first case we tend to suggest creating a composite factor which will be a more robust way of measuring our exposure to the underlying (but unobservable) factor.
- In the second case there is a continuum of approaches from making the factors sector neutral (or country neutral or both) to creating an optimised portfolio which is neutral to all the other factors.

Neutralising a factor

- There can be other advantages to making our style neutral to the other factors, one of which is it controls the risk of the style return and hence improves the risk adjusted returns to the factor.
- For example if we consider emerging market price momentum then we have shown in the past ("Emerging market momentum") that at least in the past there was a large country component to this.
- However even in this case although the not-country neutral strategy has a higher return the risk adjusted return for the country neutral strategy is better.

		Not Country Neutral	Country Neutral
Full period	**Return**	4.0%	3.5%
	Risk	14.9%	11.3%
	Return / Risk	0.27	0.31
To Dec 07	**Return**	14.2%	11.2%
	Risk	10.4%	7.1%
	Return / Risk	1.38	1.58



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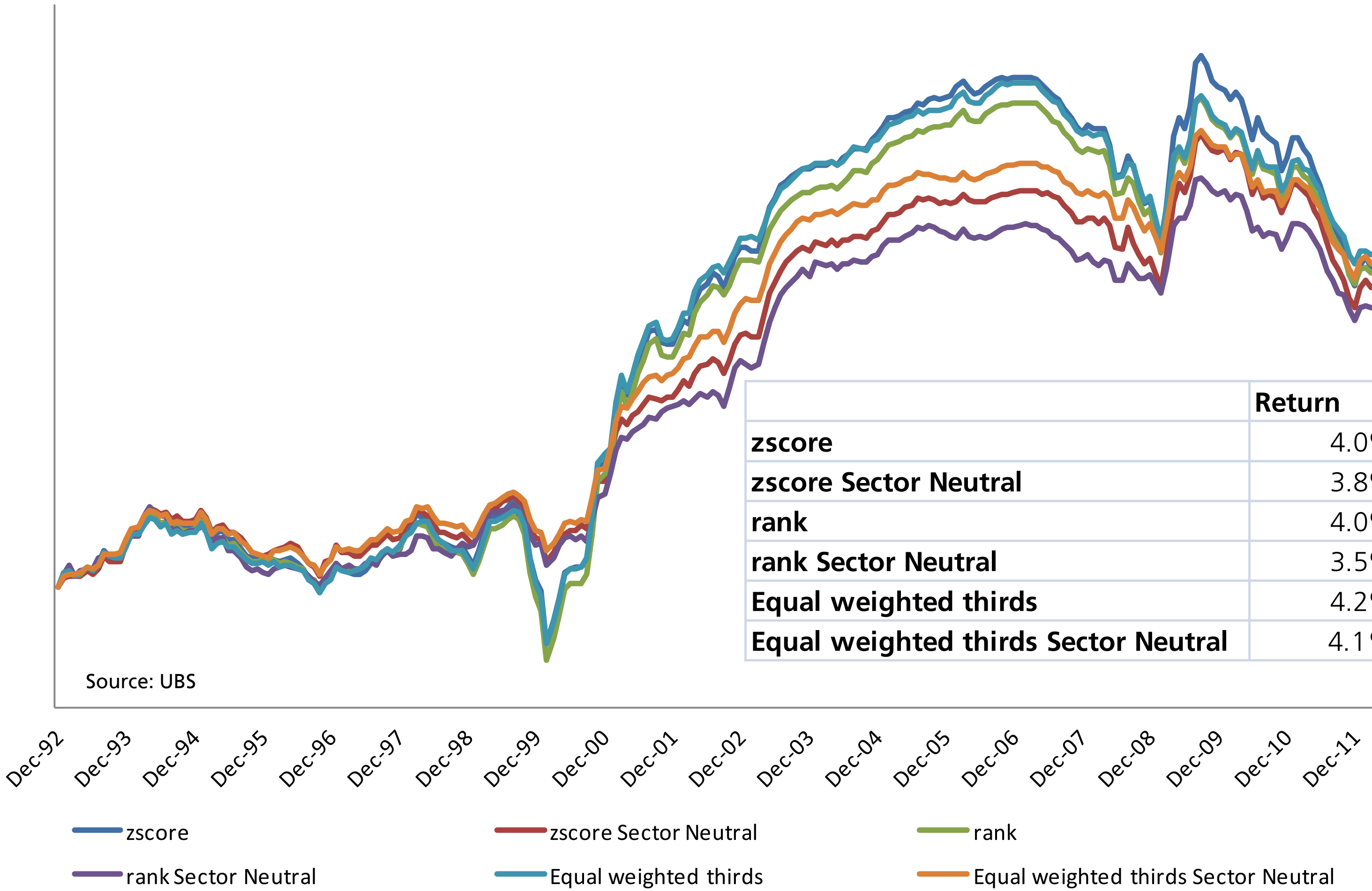
Example

- This shows the European book yield factor calculated using various of the approaches we have discussed.

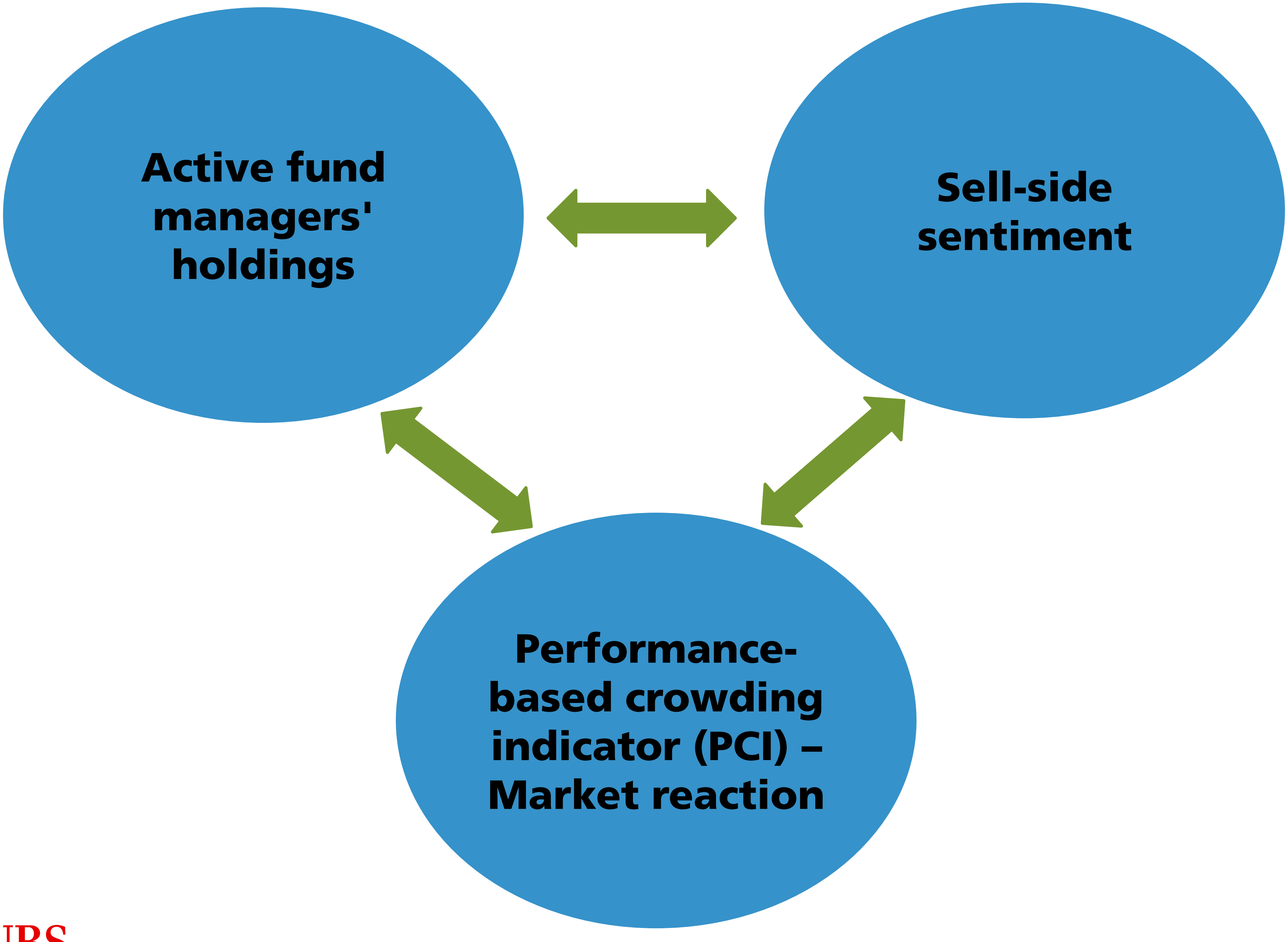


	Return	Risk	Risk / Return
zscore	4.0%	11.6%	0.348
zscore Sector Neutral	3.8%	8.4%	0.446
rank	4.0%	10.6%	0.374
rank Sector Neutral	3.5%	7.3%	0.482
Equal weighted thirds	4.2%	10.3%	0.406
Equal weighted thirds Sector Neutral	4.1%	7.3%	0.559

Section 4

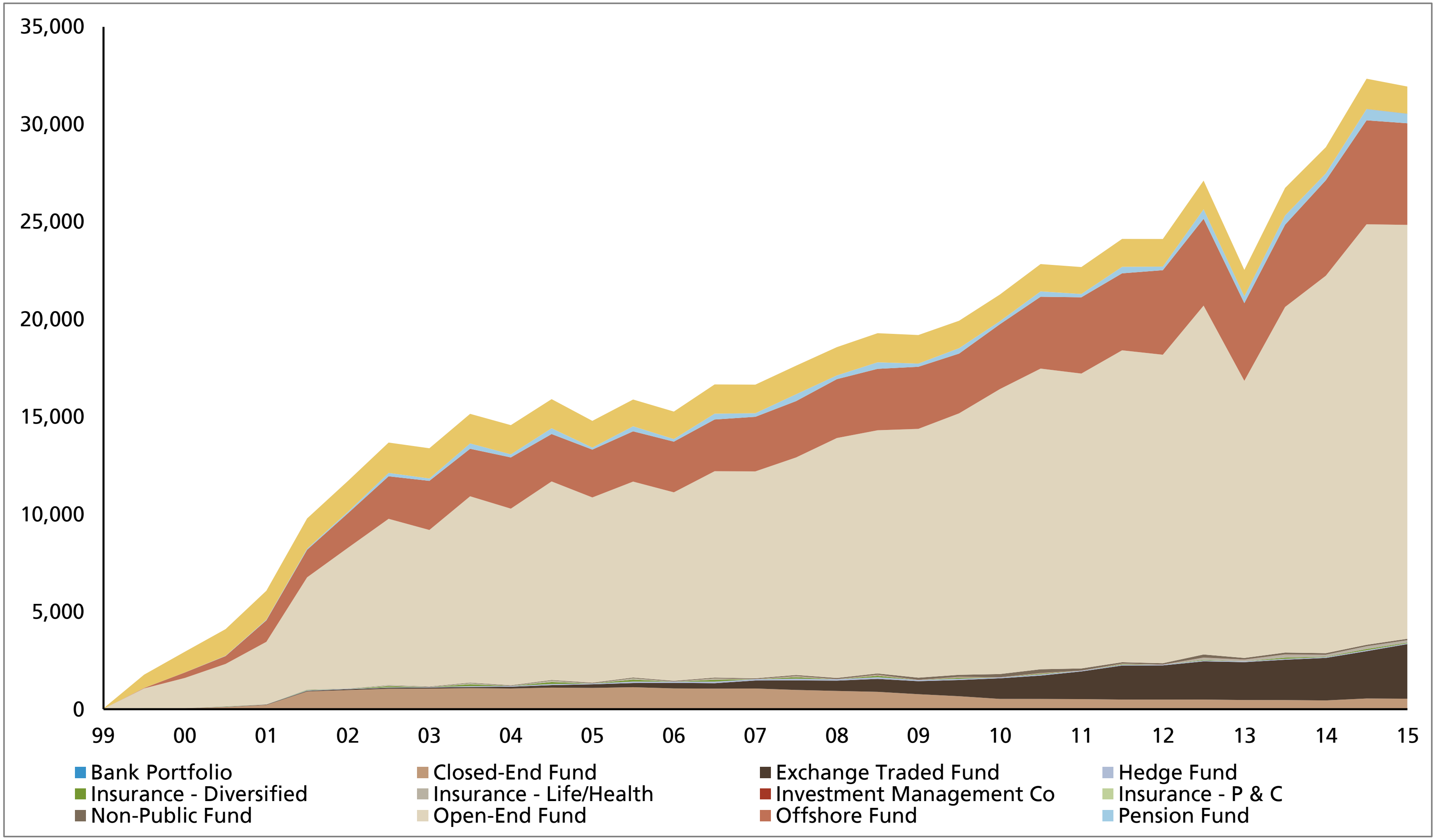
Crowding

Three angles



Active fund managers' holdings

- FactSet ownership database



Source: FactSet, UBS Quantitative Research

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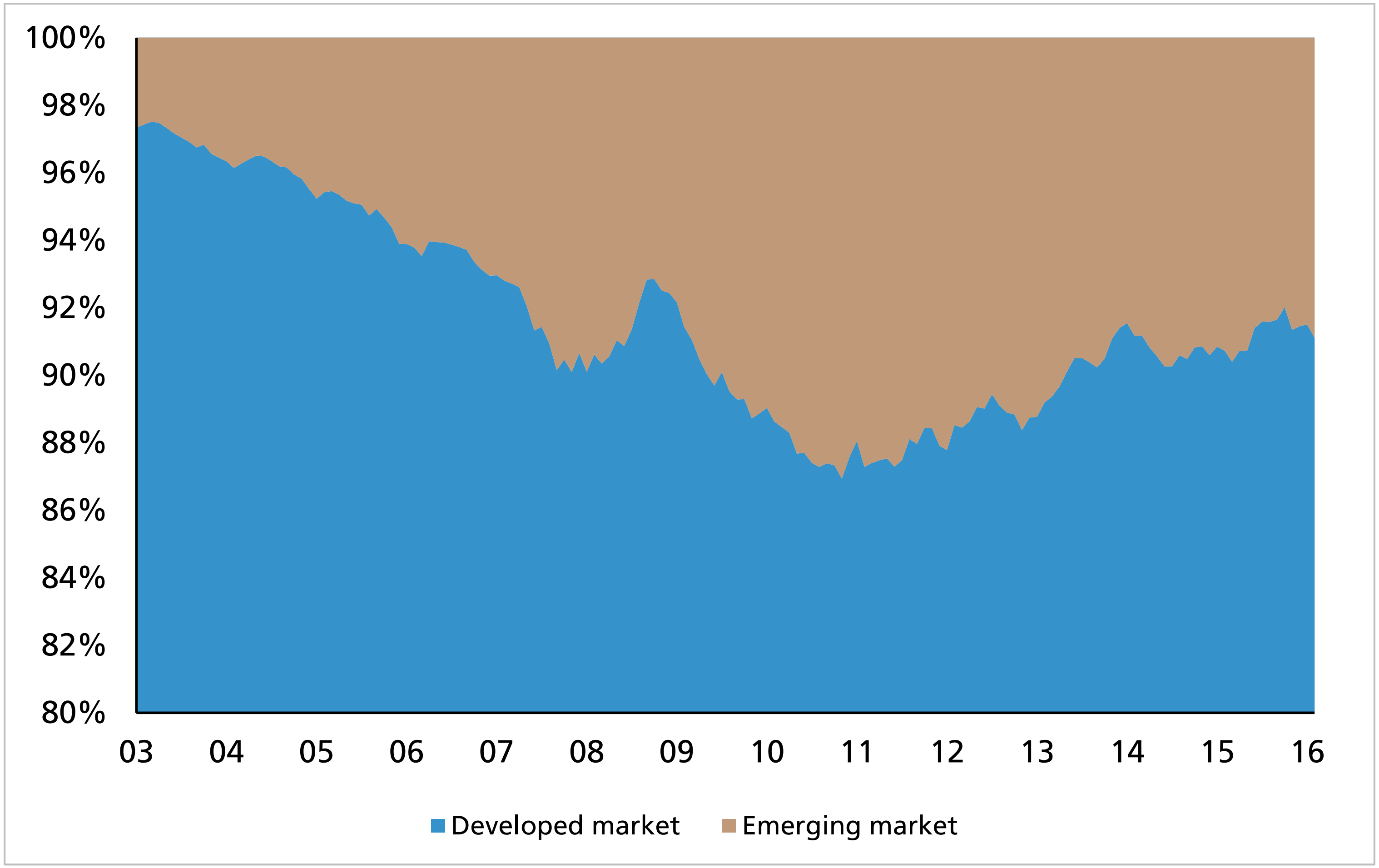
Absolute weight and Relative weight

- Aggregate holdings from global active managers' portfolios to form an **active trading portfolio** every month
- Calculate the weight of each stock in this portfolio – **absolute weight**
- Compare weights in the active trading portfolio against benchmark (e.g. MSCI AC World) – **relative weight**
- Aggregate stock level absolute/relative weights to countries, sectors, styles, etc.

Active fund managers' holdings – example

Absolute weights – Developed market v.s. Emerging market



Note: Data as of 31 March 2016

Source: FactSet, MSCI, UBS Quantitative Research

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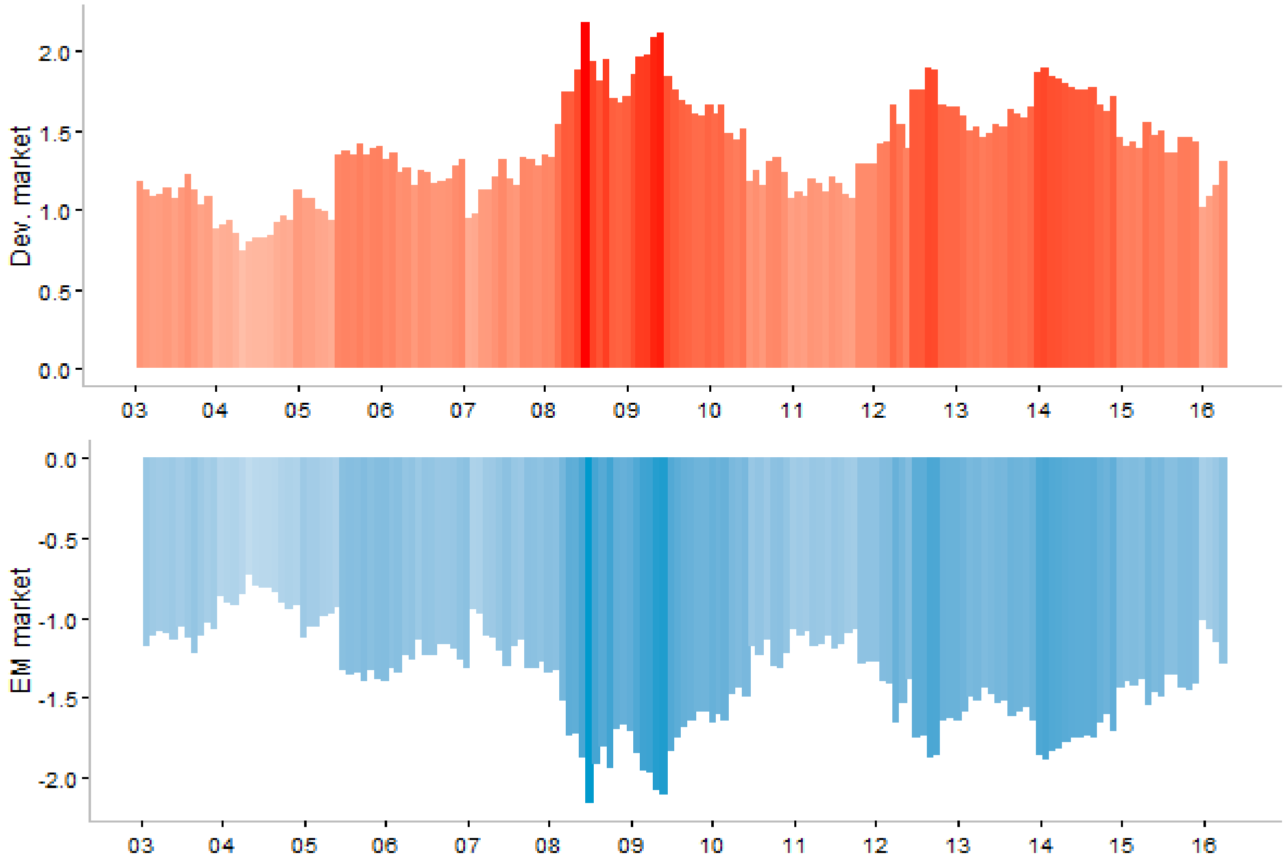
Active fund managers' holdings – example

Relative weights – Developed market v.s. Emerging market



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Source: FactSet, MSCI, UBS Quantitative Research

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Sell-side sentiment

- **Coverage-weighted aggregate ratings from sell-side analysts**

$$R_t = \frac{n_{ti} * r_{ti}}{\sum_i (n_{ti} * r_{ti})}$$

where r_{ti} is the consensus rating for stock i in month t; n_{ti} is the number of analysts contributing to the consensus rating for stock i in month t.

- **Contrarian indicator**

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Performance-based Crowding Indicator (PCI)

Our method builds on the ideas in "Comomentum: Inferring arbitrage activity from return correlations", Dong Luo and Christopher Polk, 2013.

As investors crowd into an investment theme, stock peers exposed to this theme will tend to track together

↓

Stock return comovement

↓

Pairwise correlation

Source: UBS Quantitative Research

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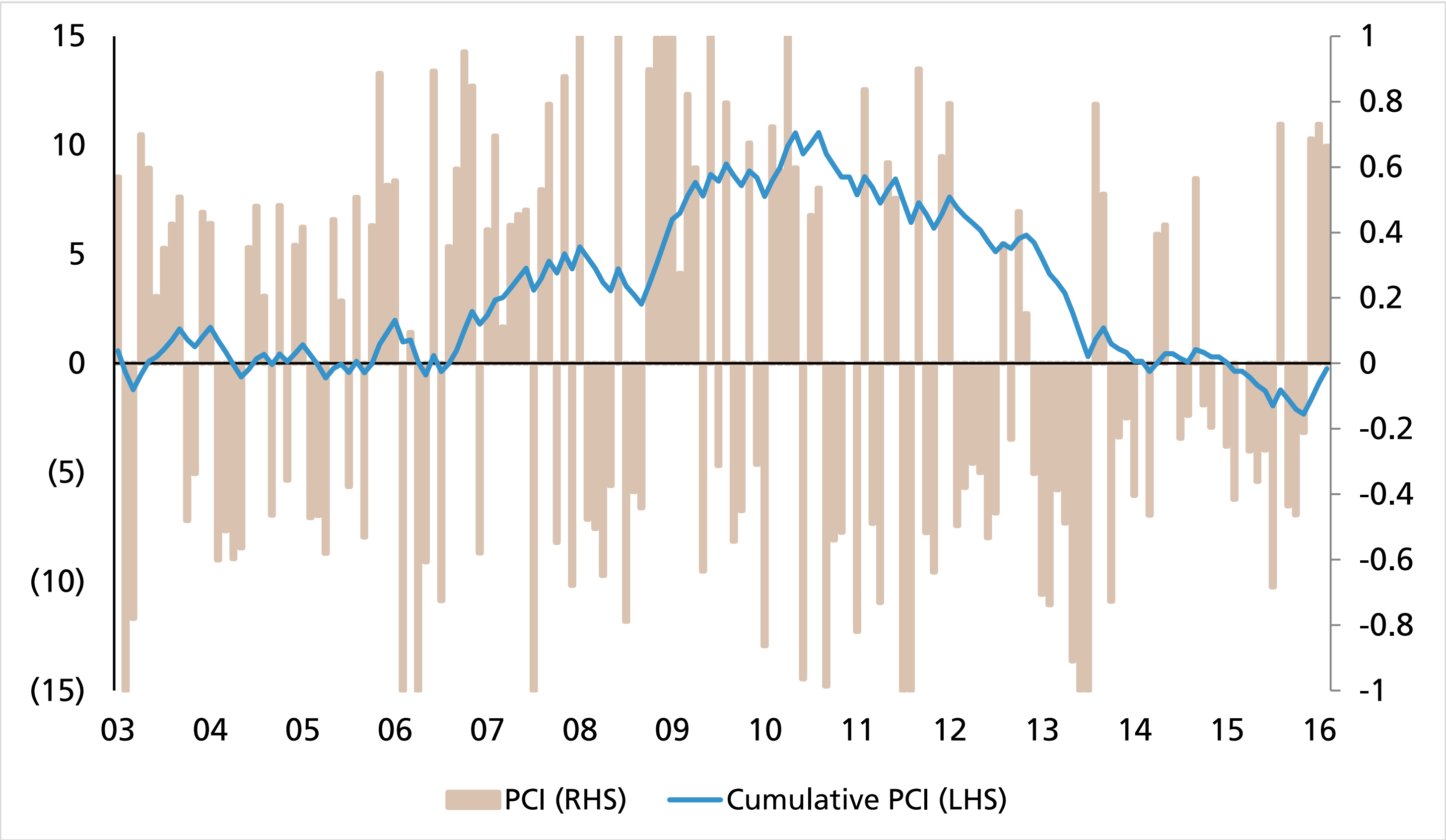
PCI - methodology

Pairwise correlation → Fisher transformation → $\frac{Mean}{SD}$ → Standardise by market portfolios → Framed in historical context → Use hit rate to define the sign

Source: UBS Quantitative Research

PCI – example

Emerging market PCI and Cumulative PCI



Note: Data of 31 March 2016

Source: MSCI, UBS Quantitative Research

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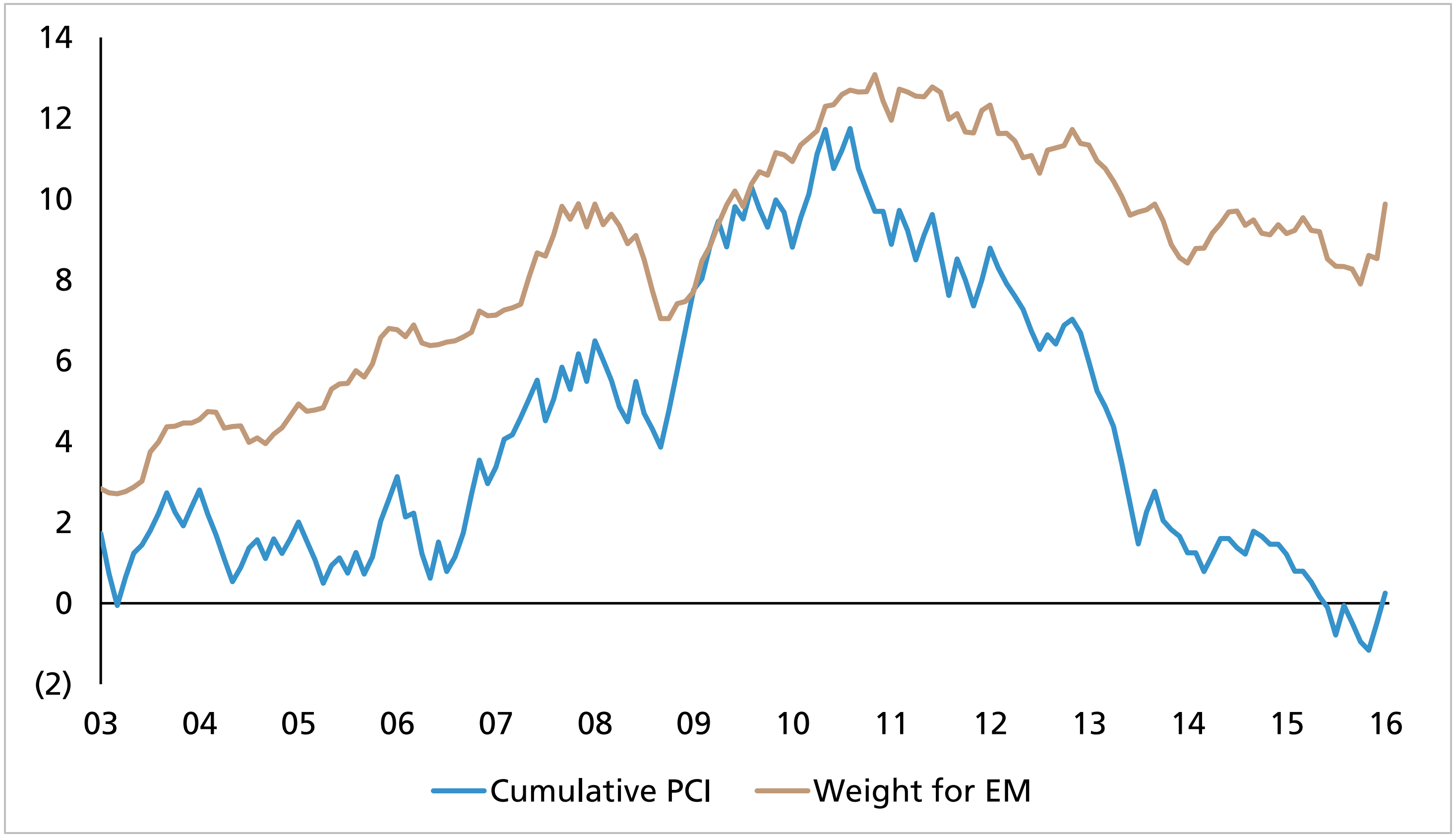
PCI – a supplementary indicator to fund holding data

- Limitations on holding data: delay, incomprehensiveness

- High correlation between cumulative PCI and weighting

Emerging market cumulative PCI vs weight in active trading portfolio



Note: Data of 31 March 2016

Source: FactSet, MSCI, UBS Quantitative Research

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Section 5

Turnover reduction

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Turnover

- High turnover means higher costs and lower capacity.

Incorporate turnover in each step of the process:

- Signal construction
  - slow moving signals are lower turnover
  - look at IC over longer time horizons
- Portfolio construction
  - Risk weighted or cap weighted portfolios are lower turnover, equal weighting higher

- Direct measures include:
  - Lower rebalancing frequencies
  - Buffers so that you only trade a stock if its signal has changed "significantly"
  - Optimisation to find minimal trading that keeps your TE to your ideal portfolio below a threshold.

Section 6

Optimisation

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Mean-Variance Optimisation

- Markowitz's mean-variance model of portfolio construction was one of the first major contributions to modern finance.
- Yet as a practical tool, it languished for decades.

Why?

- Optimisers appeared opaque – it was often difficult to explain the final portfolio in terms of the original forecasts.
  - There was no audit trail
- The optimal portfolio weights appeared unstable. A small change in the forecasts could cause a large change in the weights.
  - Michaud (1988) called this the "error maximisation problem".
- Optimisers over-promised and under-delivered.
  - They appeared over-engineered.

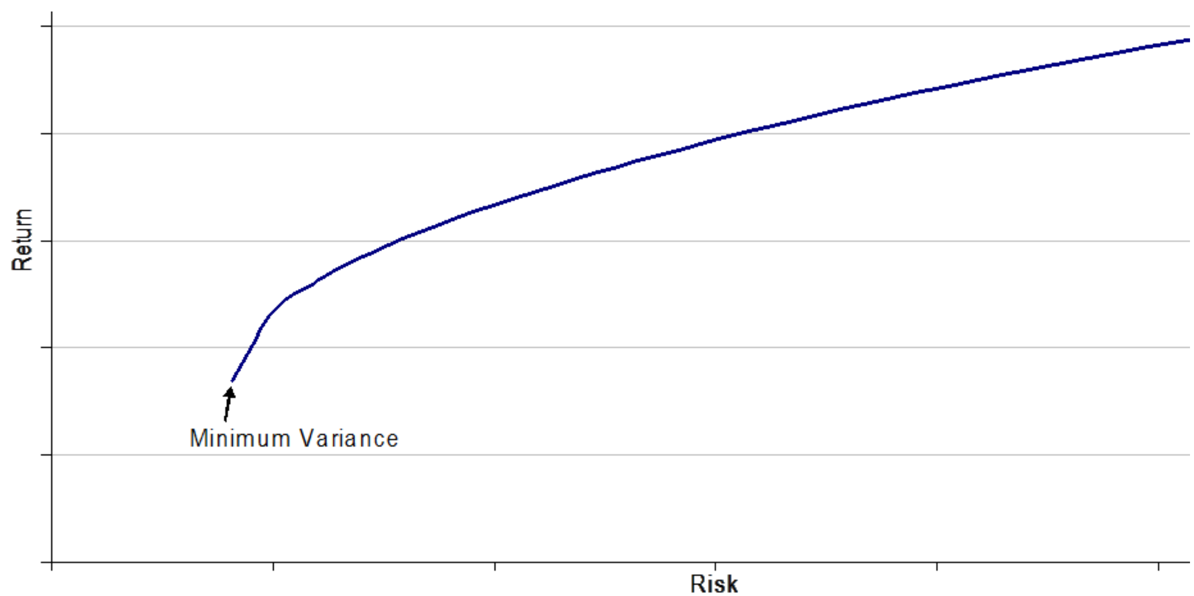
Mean-Variance Optimisation - Problem Definition

- A mean variance efficient portfolio, *w*, is a portfolio that solves

$$\mathbf{w}^{mv} = \arg\max_{w} \mu^{\mathbf{T}}\mathbf{w}$$
$$s.t. \quad \sqrt{\mathbf{w}^{\mathbf{T}}\mathbf{V}\mathbf{w}} \le \sigma_W$$

where μ is expected returns of the assets (and is a function of our scores s), V is the covariance matrix of returns,, σ_W is the maximum portfolio volatility.

- The efficient frontier plots the locus of achievable returns, $\mu^T w$, as the risk constraint, σ_W is relaxed.



Source: UBS Quants. For illustrative purposes only

Implications of Error Maximisation

There are two critical implications of error maximisation

1. Instability of the optimal portfolio weights (Jobson & Korkie 1981, Britten-Jones 1999)

   This is the principal concern for practitioners

2. Bias in estimated performance - promises far more than it delivers (Broadie 1983, Hillier and Satchell 2003, Kan, Smith 2007)

   This has been the focus for academics

Instability of Weights

- Optimisation looks for portfolios that are low risk
- These low risk portfolios will have low betas to all the systematic risk factors
  - This removes all systematic risk
- These low risk portfolios will tend to be well diversified
  - This removes or diversifies away most of the idiosyncratic risk

- Hence the optimiser is more likely to find a low risk portfolios
  - greater the number of assets in the universe
  - The larger the sampling or estimation error

- Once the optimiser finds these low risk portfolios – which will have a high Sharpe ratio just because they are so low risk – it will leverage up.

An Example

- To illustrate with a 5 asset example:
  - Assume 2 cases that differ only in respect to a small change in return to asset 5

Risk Matrix V

Volatility on diagonals, Correlations off diagonals

	A	B	C	D	E
A	**48%**	0.59	0.67	0.75	0.82
B		**70%**	0.57	0.58	0.54
C			**47%**	0.66	0.70
D				**45%**	0.40
E					**45%**

Returns μ

Case 1	Case 2
5%	5%
5%	5%
2%	2%
3%	3%
4%	**3%**

- Optimise in both cases so as to achieve a return of 4%
  - Case 1: Short the two highest returning assets - unintuitive looking portfolio
  - Case 2: More intuitive or "reasonable looking" portfolio

Optimal Portfolio, w

	A	B	C	D	E
Case 1	-36%	-8%	-71%	98%	117%
Case 2	30%	7%	-27%	49%	42%

Achieved Performance

Return	Volatility
4%	37%
4%	42%

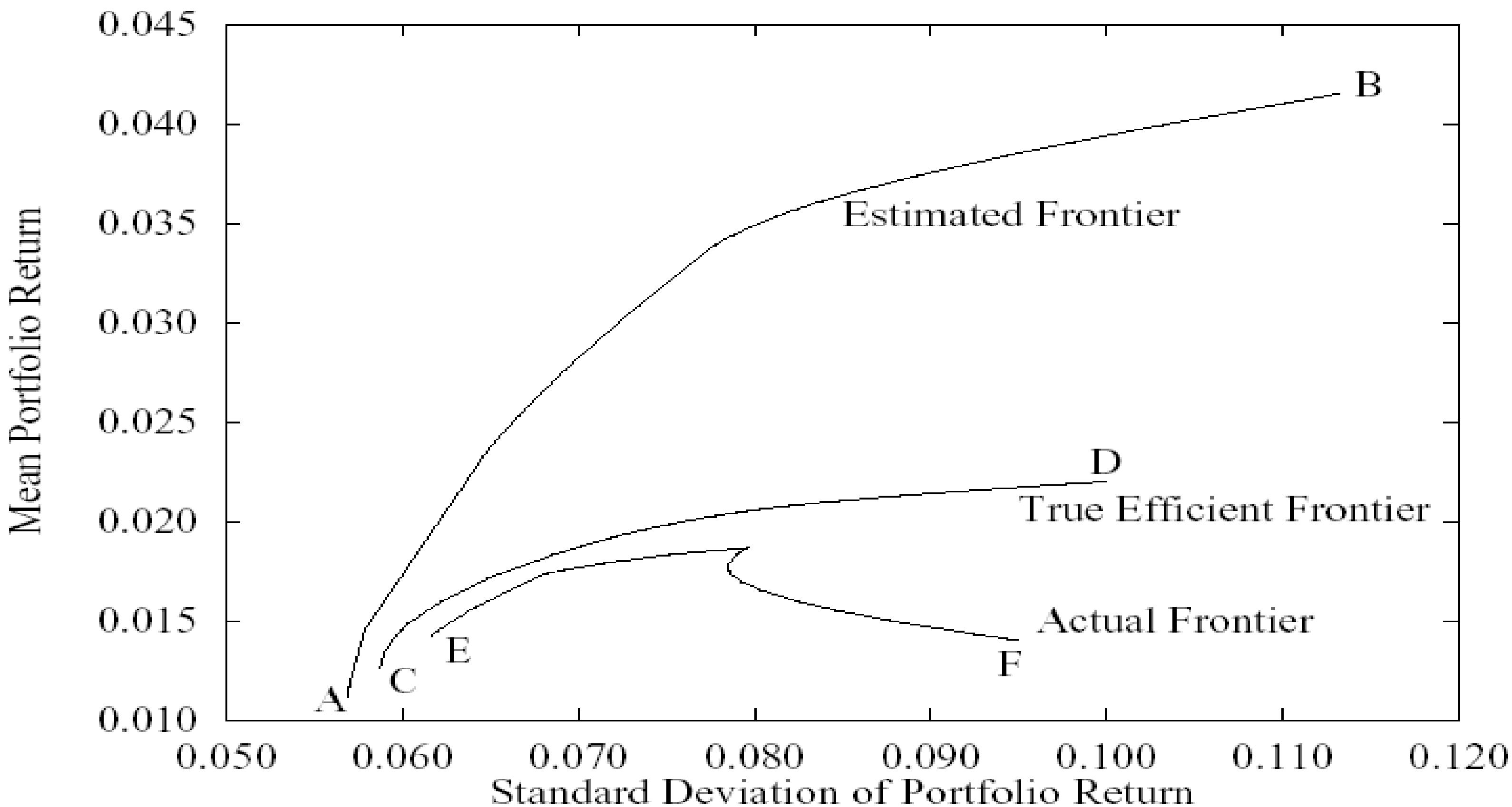
Source: UBS Quants. For illustrative purposes only

One approach to solving the Instability problem

- Our example illustrated the problem with only 5 assets. Problem is amplified many times in 1000 asset portfolio!
- Kritzman (2006) suggested instability not a problem as portfolios have similar performance even though very different.
  - True, but assumes trading is costless! If not, portfolio instability can lead to excess trading in dynamic problem.
- Some Practitioners solve the problem by constraining the solution portfolio, Jagannathan and Ma (2003), so the weights are:
  - Long only
  - Sector Neutral
  - No more than +/- 2% market weight
- By then why optimise?

Bias in estimated performance: Illustration from Broadie (1993)

- Assume a normal distribution for 5 assets. Generate 24 months of return data.
  - True Efficient Frontier – the frontier of the assumed model
  - Estimated Frontier – the frontier estimated from sample data
  - Actual Frontier – the achieved performance from the estimated portfolios (or out of sample)



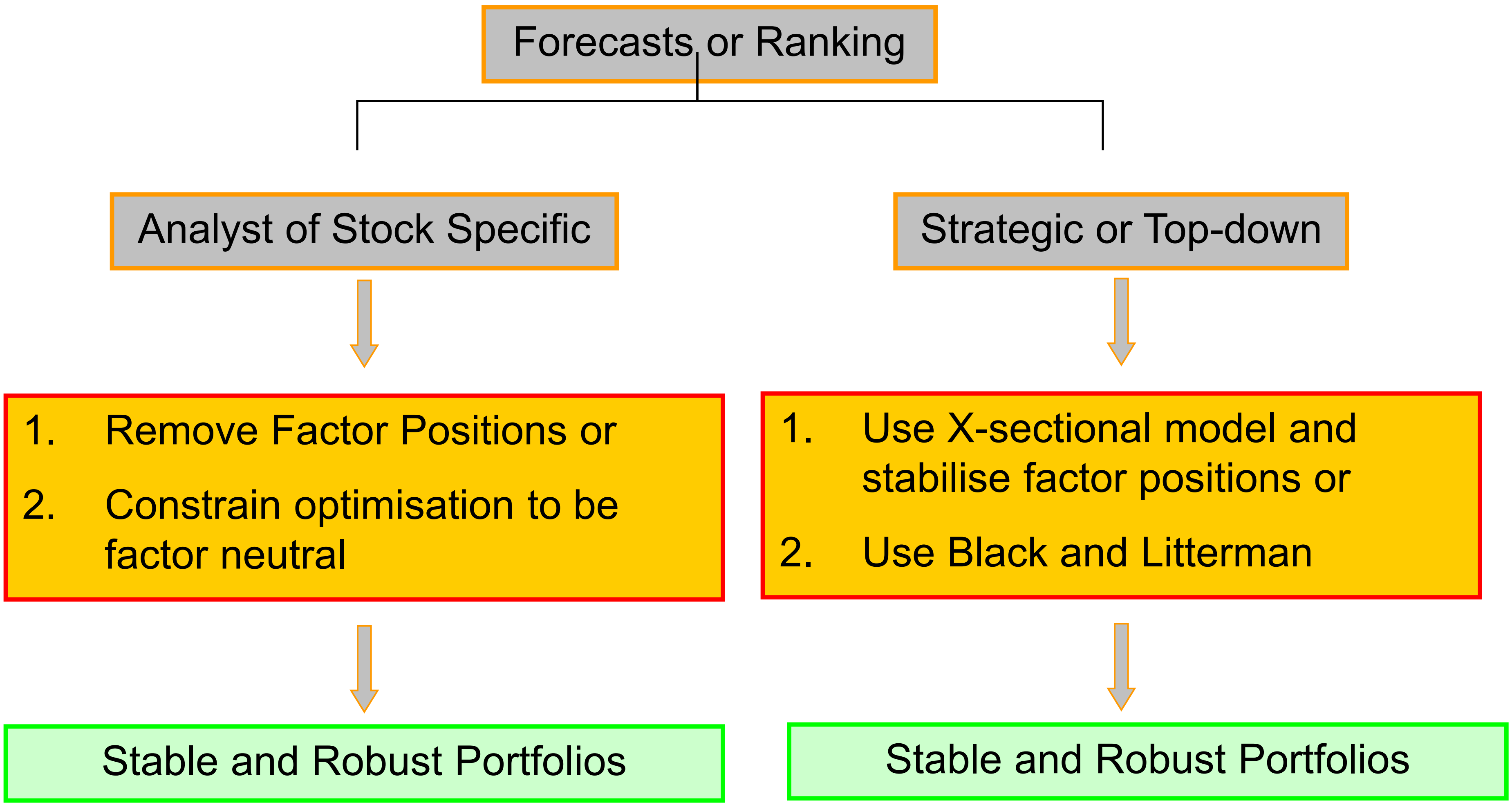
Source: reproduced with permission from Mark Broadie (1993), Annals of Operations Research

Practitioners have converged on a solution

- A stock selection quant manager removes (or neutralises) any factor or systematic positions from his alphas.
  - Removes most of covariance in expected returns
  - Implies the associated risk matrix is diagonal
  - Therefore optimisation procedure is very stable.

- A manager taking strategic or top-down positions uses some form of Black and Litterman or Bayesian conditioning
  - Aligns strategic positions with systematic factors in the risk matrix.

What are you good at?



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12-Month Rating	Definition	Coverage[1]	IB Services[2]
Buy	FSR is > 6% above the MRA.	45%	26%
Neutral	FSR is between -6% and 6% of the MRA.	39%	23%
Sell	FSR is > 6% below the MRA.	16%	11%
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.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 30 September 2017.
1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
3:Percentage of companies under coverage globally within the Short-Term rating category.
4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

KEY DEFINITIONS:Forecast Stock Return (FSR) is defined as expected percentage price appreciation plus gross dividend yield over the next 12 months. **Market Return Assumption (MRA)** is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium). **Under Review (UR)** Stocks may be flagged as UR by the analyst, indicating that the stock's price target and/or rating are subject to possible change in the near term, usually in response to an event that may affect the investment case or valuation. **Short-Term Ratings** reflect the expected near-term (up to three months) performance of the stock and do not reflect any change in the fundamental view or investment case. **Equity Price Targets** have an investment horizon of 12 months.

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UBS Limited: David Jessop, Claire Jones, Josie Gerken, Desi Ivanova

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