SYSTEMATIC

~~ALGORITHMIC~~ TRADING. MTH9894

Lecture 2
Quantitative Investment Framework

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This lecture is partially based on the presentation of

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given by him to 2013 MTH9894 class

Reading Material

Course Projects: Study one of these. Implement. Suggest Improvements

- The Little Book That Still Beats the Market by Joel Greenblatt
- The Handbook of Equity Market Anomalies, by Leonard Zacks (editor)
- Quantitative Equity Portfolio Management, by E. Qian, R. Hua, E. Sorensen

- Momentum: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=299107
  By Narasimhan Jegadeesh, Sheridan Titman
- Value and momentum everywhere by AQR (Asness, Moskowitz, and Pedersen) (posted on Forum)
- What is Dividend Premium: Laura Liu (posted on Forum)
- Generating Excess Returns through Global Industry Rotation: John Okunev
  http://papers.ssrn.com/sol3/papers.cfm?abstract_id=904106
- Multifactor Evaluation of Style Rotation: Kevin Q. Wang
  http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1339671

ANOMALIES: REAL VS NOT

- If you found a person among 1 billion people who threw 30 heads out of 30 coin tosses, what is the chance that next time his hit rate is >50%

  Tells nothing about the future

- http://www.wallstreethorizon.com/upload/IsThereNewsLatestJan2015.pdf

"It shows that when firms advance their earnings announcements at least four days prior to expectations, the earnings surprises in those quarters tend to be positive and the abnormal returns from two days after the earnings release date was announced through one day after earnings are actually announced are positive and significant. The converse is true for firms that delay their earnings announcement at least four days relative to prior expectations. "

- So we are delaying telling the bad news…. Does it seem like a common, recurring behavioral pattern?

UNDERSTANDING MARKET ANOMALIES

not normaly: 异常 something that deviates from what is standard, normal, or expected

1. **Is anomaly real?**
2. **Risk mis-measurement:**
   - Factor is subsumed by known risk factors
   - E.g. only shows ER in univariate regression or CAPM, but not in Fama-French model (1993) – any decent economic paper tests for FF3,4,5.
3. **Statistical reliability**
   - Type I error: null hypothesis of zero abnormal returns is falsely rejected
4. **Data-snooping**
   - Finding accidental pattern in the data vs. accidentally finding a real pattern
   - Real factors typically has economic rationale or theory, such that a series of tests can be designed to validate it (e.g. validate behavioral patterns, not returns directly).

THEORIES OF FINANCIAL ANOMALIES

- **Behavioral = investor irrationality**

- **Rational structural uncertainty = investor uncertainly about economic environment**
  - Having incomplete information
    - Short History
    - Small caps
    - Relaxed accounting standards
  - New “disruptive” technologies
    - No frame of reference
    - Uncertainly about valuations parameters

...difficult to separate these categories. Overconfidence belong to both…

IS ANOMALY EXPLOITABLE?

Anomaly is not showing with showable objects

- **Limits to Arbitrage**
  - Transaction Costs
  - Short Sale Constraints
    - Always calculate ER for long- and short- portfolios
    - Check for hard to borrow names

ER: excess return

- **Arbitrageur presence**
  - Absence of Close Substitutes
  - Unsalable opportunity

Outline

1. Quants and quantitative investments
2. A little about history
3. What fills a day at a quant fund
4. New areas of growth

Quants and Quantitative Investments

Quants: anyone who toys with numbers

- Inside one's brain – heuristics
- With a ruler – chartists
- With a calculator – fundamental
- With a super computer – canonical quants

Heuristics, Experience, Guts or by any other names

- **Heuristics: simple, efficient, learned rules**
  - "Sell in May, go away": some evidence to support that: June through August average return 4.3% p.a., other months 11.5% p.a.
  - "January effect" – rally in January that follows December selloff (create tax losses to offset capital gains)
  - Invest in companies people "like". Brand recognition among retail investors.
  - Opposite: "popular" stocks underperform. ("Dimensions of Popularity" by Ibbotson & Idzorek)
  - Financial Firms are riskier than others: seems to be supported by 2008/2009 crises
  - "Cheap Companies Ultimately Outperform": survivorship bias.
- **Innate vs. sum of experiences**
  - Some we are born with
  - Some we acquire
  - Hearsays
  - Mental accounting: we are all secret "frequentists"

Biases: a case against intuition

KAHNEMAN, TVERSKY "PROSPECT THEORY: DECISION MAKING UNDER RISK", 1979 ALSO 1984, 1986
KAHNEMAN, RIEPE 1998

Heuristic simplification

- Problem solving is simplified to a rules-of-thumb (narrow framing, mental accounting, loss aversion, representativeness heuristics)
- Confirmation Bias: consciously or unconsciously seeking evidence to confirm one's heuristics ("My success must imply I have done something right, and let me enumerate...")
- Anchoring: our tendency to attach our thinking to a reference point (Chart reading: arbitrary support/ resistance levels)
- Opposite: "Superforecasting: The Art and Science of Prediction" by Tetlock, Gardner

  …superforecasters do have a healthy appetite for information, a willingness to revisit their predictions in light of new data, and the ability to synthesize material from sources with very different outlooks on the world. They think in fine gradations (probabilities)….

Self-deception

- Overconfidence (humans are poor judges of probability)
- Optimism (underestimation of likelihood of bad outcomes over which they have no control)
- Self-attribution (attribute success to skill and failure to bad luck)

Emotions and self-control

- Emotions overpower reason (people in good mood are more optimistic in their choices)

Biases: a case against intuition (cont'd)

- **Survivorship Bias: we acknowledge what survive and ignore those that didn't;**
  - Value investing: it does work however people underestimates the risk involved;
- **Substitution: we answer questions easier than the ones being asked**
- **Herd Behavior: agree *and* do what your brethren do, by shared euphoria or pessimism**
  - Tech Bubble: 1997 – 2003
  - Housing Bubble: 2003 – 2007
  - Safety Bubble: 2010-2013
- **Instinctive response usually are the best starting point of an analysis**
- **Instincts are the best to deals with fast change in circumstance**

Invest with a ruler: technical analysis

- **Core Beliefs:**
  - Price Discovery incorporate all information: truism "market knows better"
  - Past trading pattern repeats

- **Typical stuff: there really are only two strategies out there**
  - Trend Following: channels, breakouts, MACD
  - Mean-reversion: stochastic oscillators, "head and shoulders", "double top"

Invest with a ruler: criticism, criticism of criticism

- **Criticism:**
  - Efficient Market Hypothesis (weak form)
    - *all past prices of a stock are reflected in today's stock price (prices follow random walk). Therefore, technical analysis cannot be used to predict and beat a market. (fundamental strategies may still outperform)*
  - Arbitrariness: more an aesthetic differences

- **Criticism of criticism**
  - Efficiency in the eyes of beholder: short-term inefficiencies
  - Flow and liquidity do matter in the short to medium term in price discovery: pattern as indicators
  - Evidence: turtle traders (trend followers) 1980s, $250K -$2 MM each to $175 MM profit within 5 years
  - Simple rule-based momentum strategy (6+1+6) continues to work

Invest with a calculator: fundamental analysis

- **Core beliefs:**
  - Fundamentals read tables (as opposed to technical analysts reading charts)
  - Financial statements contain accurate and sufficient information about a firm
  - Such information is predictive of stock price movements

- **Typical stuff: there really are only two strategies out there**
  - Trend Following: momentum, sentiments
  - Mean-reversion: valuation (P/E, P/S, P/Cash Flows)

Invest with a calculator: criticism, criticism of criticism

- **Criticism:**
  - Efficient Market Hypothesis (strong form)

    all information in a market, whether public or private, is accounted for in a stock price. Not even insider information could give an investor the advantage.
  - Herding in analysts' opinions: followers vs. leader
  - Financial Statement Manipulations

- **Criticism of criticism**
  - Efficiency in the eyes of beholder: intellectually appealing but impractical
  - Near equilibrium: behavior biases, macro overhang
  - Evidence: "Value Investing" Graham and Dodd; Franklin Templeton Value Fund

Invest with a super computer: quants

- **Core beliefs:**
  - "Quant understands risk better"
  - Statistics based: against human biases
  - Broader reach, higher efficiency

- **Typical stuff: there really are only two strategies out there**
  - Trend Following: momentum, sentiments
  - Mean-reversion: valuation (P/E, P/S, P/Cash Flows)

Invest with a super computer: criticism, criticism of criticism

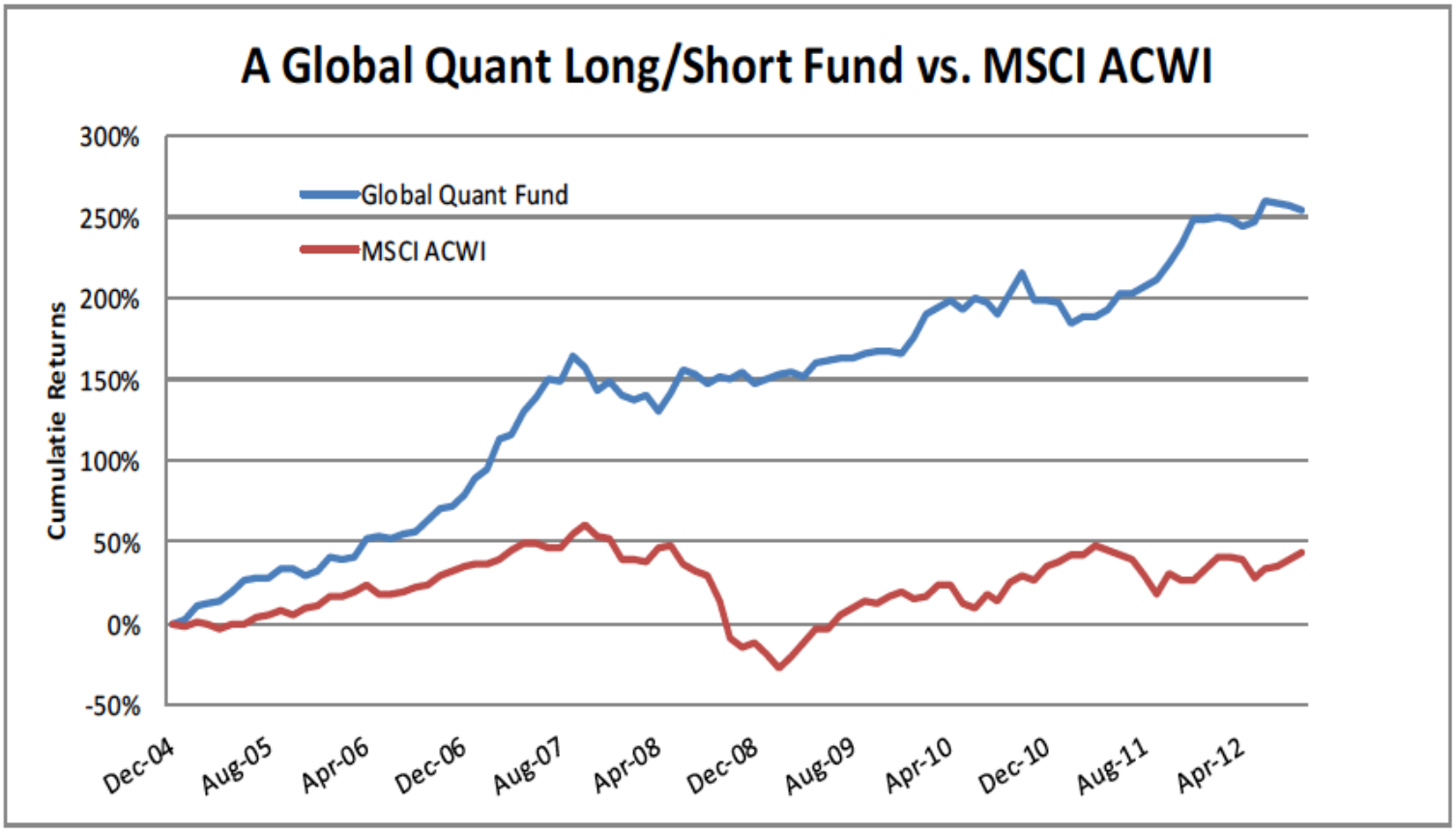
Criticism

- Efficient Market Hypothesis (strong form)
- Biases or blind spots of quants: pretend things outside models do no harm;
- Model selection: a model that have described the history is the only one I care
- Confusing correlation with causality: ignoring underlying dynamics;
- Statistics vs. Dynamics: does statistics ever tell you anything you don't know?
- Quants herd too! (Quant crises of 2007)

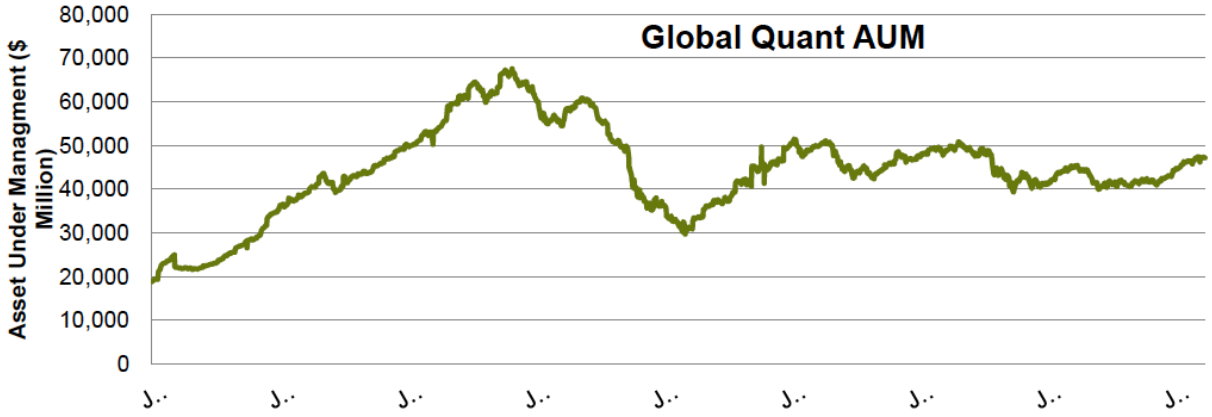
Criticism of criticism

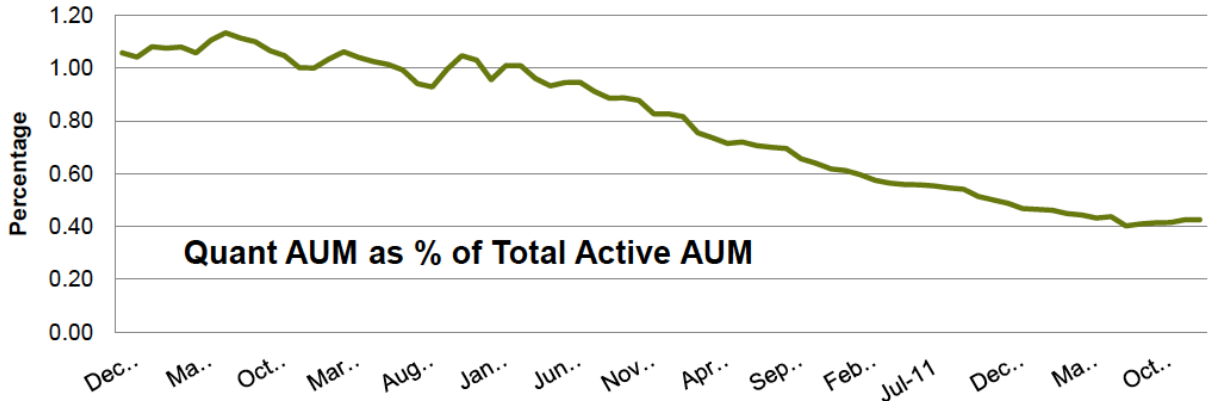
- Efficiency in the eyes of beholder: intellectually appealing but impractical
- Near equilibrium: behavior biases, macro overhang
- Evidence: quant fund success from late 90s to mid to late 2000s, success over the past 2-3 years.

Quant does work in general

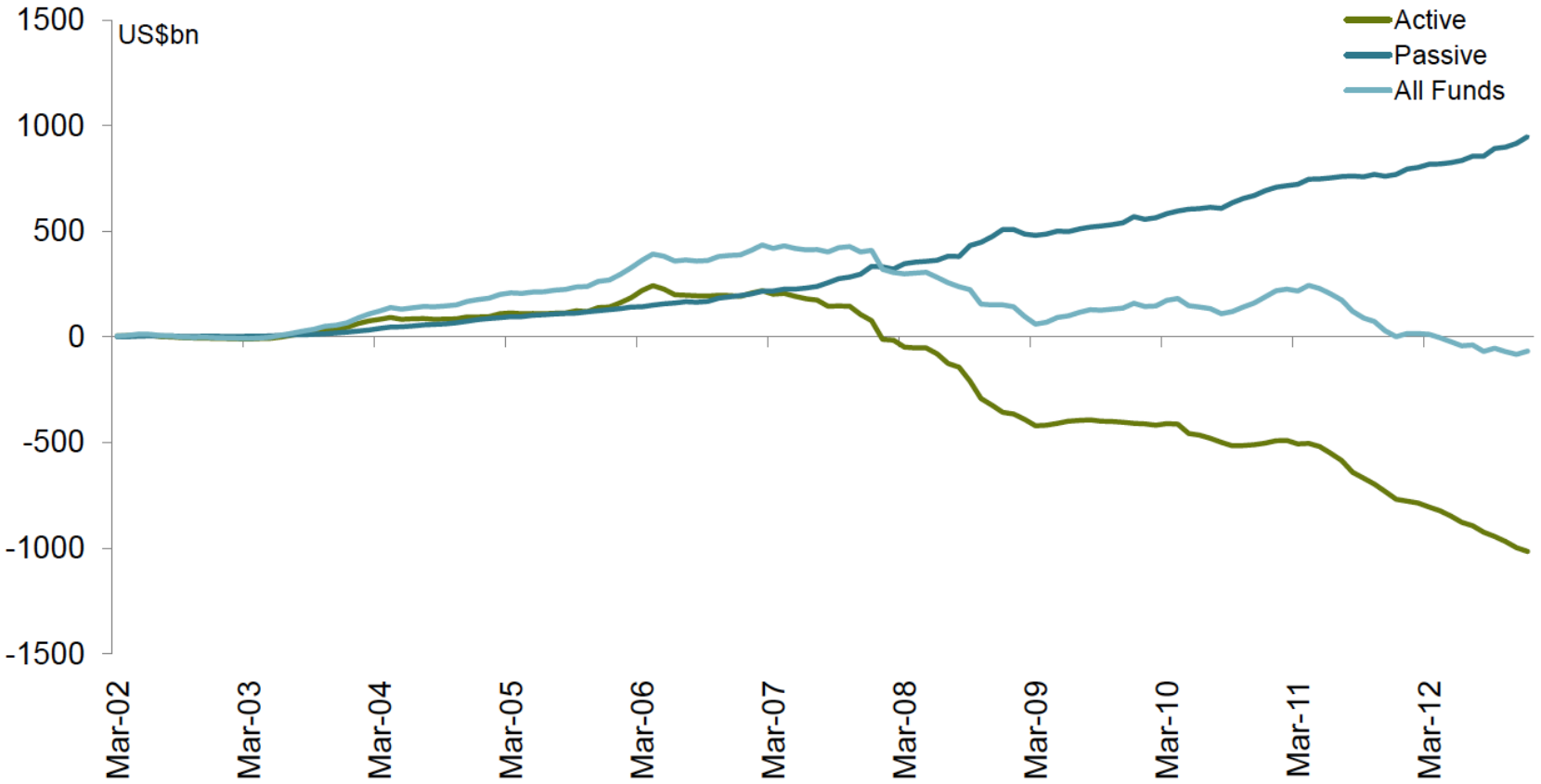


Asset Under Managements by Quants





Struggles post housing bubbles



Quant Crises of August, 2007

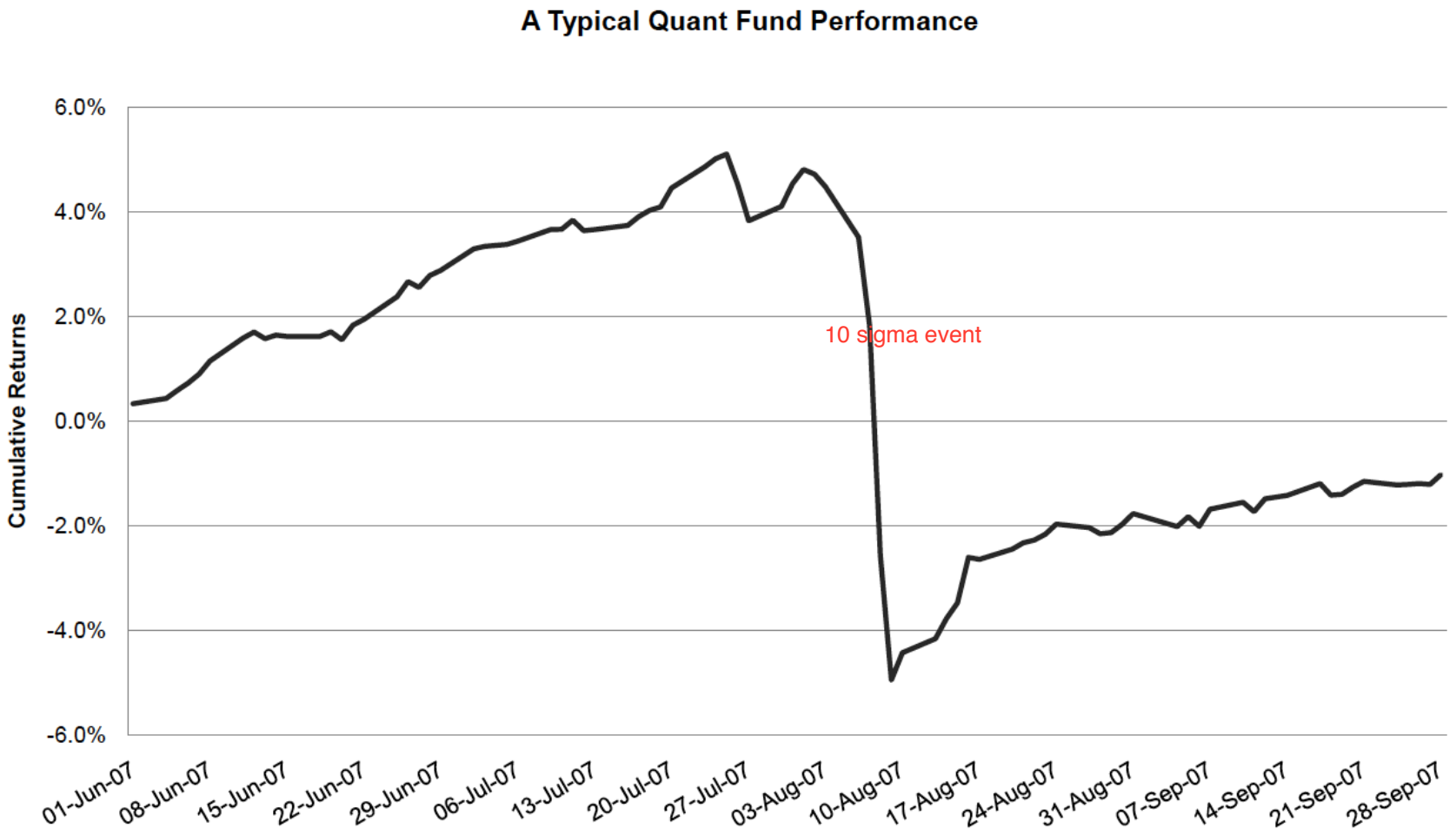
What happened?

Simultaneous underperforming almost all strategies: “10 sigma event” (?!!)

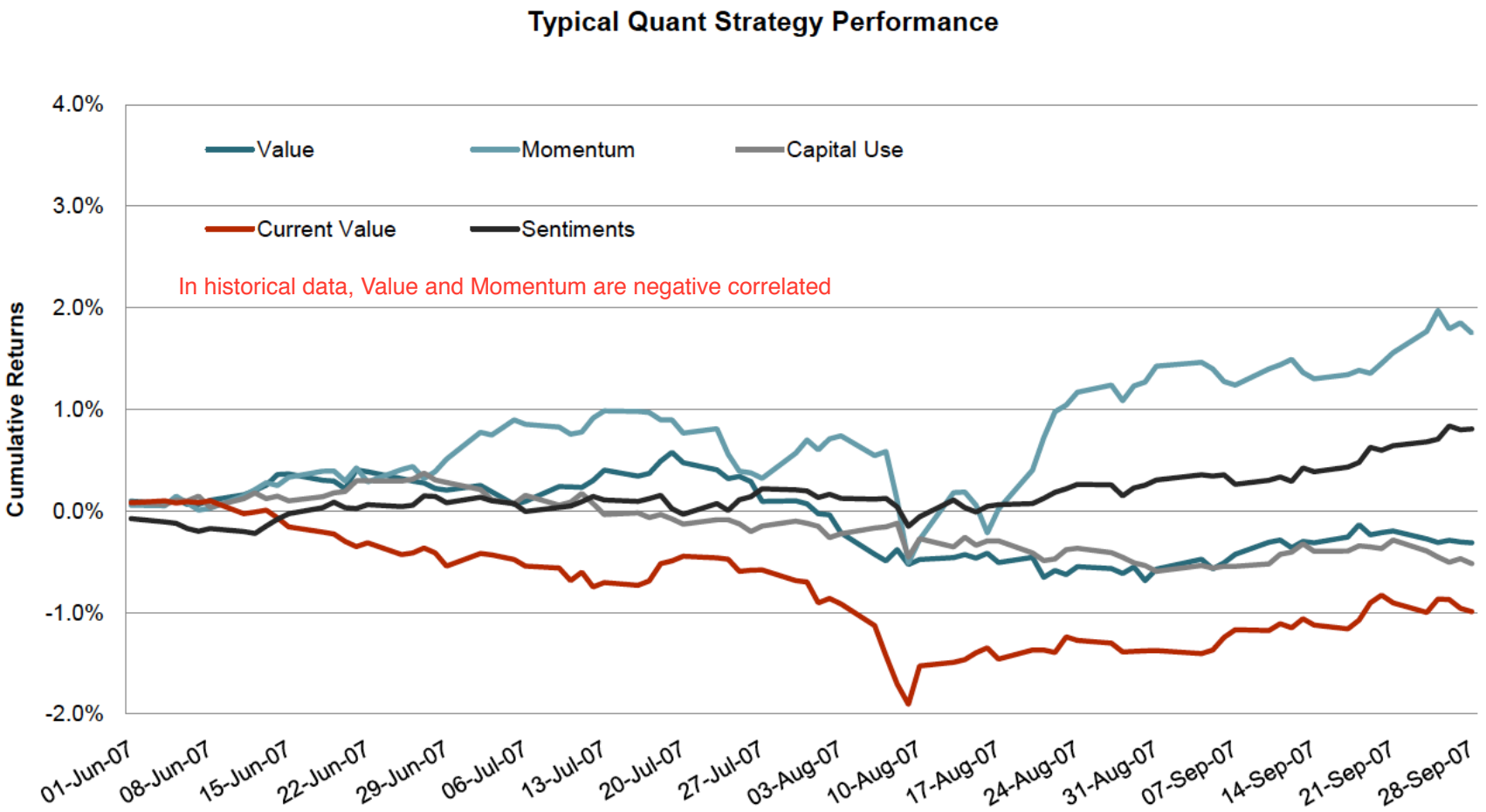
Possible Causes

- Model Similarities
- Liquidity Crises
- Sub-prime

Quant Crises of August, 2007: ~ 10 times risk estimates suggests



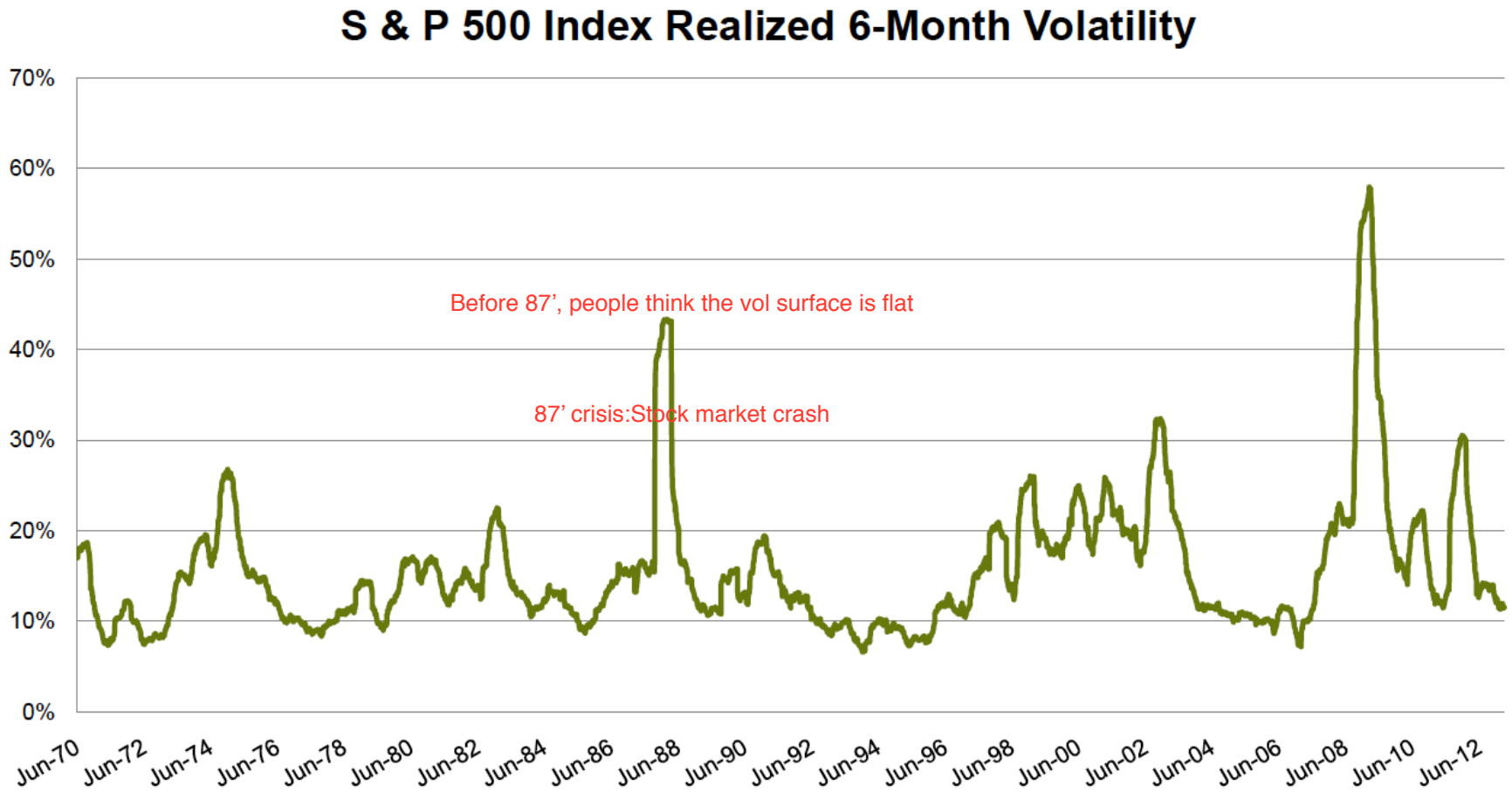
Quant Crises of August, 2007: almost all quant "drivers" at bottom of historical range



Quantitative Investment Process

- Alpha Model (forecasts excess return of stocks)
  - Easier to find random factors that represent non-compensated market risk (beta) than to find alpha factors representing incremental rewards
- Risk Model
- Portfolio Construction / Optimization
- Portfolio Implementation
  - Minimization of implementation shortfall under uncertainty
  - Designing trading process that is “aware” about underlying models and portfolio constraints
- Performance Attribution
  - How much is working and how much is random. Relate ex post returns to ex ante factor exposures.

Risk Forecasting: S & P 500 Index Volatility



Risk Estimation

- Clustering: high volatility begets high volatility, *"autoregressive"*
- Sensitive to outliers: quadratic nature
- Time-varying: duh!
- Non-stationary: *"heteroskedasticity"*
  - GARCH-type: "generalized autoregressive conditional heteroskedasticity"
  - Example: IGARCH Model, "integrated generalized autoregressive...."
  - Loosely speaking: IGARC(1,1) : Sigma^2(t) = (1 – a) x r^2 + a x Sigma^2(t – 1)
  - Equivalent of exponential weighting: time-decay concept
- DCC: "Dynamic Conditional Correlation"
  - Individually analyze pairs of returns
  - R. Engle "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models"

Risk Forecasting

- Principal component analysis Used for short date: interday or day
  - Covariance matrix: positive semi-definite
  - Cholesky Decomposition: A = L D L*
  - Stochastic Factors: P. Carr, L Wu, G. Bakshi *"Stochastic Risk Premiums, Stochastic Skewness in Currency Options, and Stochastic Discount Factors in International Economies"*
- Fundamental/factor based: Barra, Axioma Longer than a day
  - Regression
  - Factor Covariance and Residual Variance
  - Need to include alpha factors as risk factors ("risk machine")

Pi=sum(beta_i*F_i)+e_i

Based on Fi, created own risk factor matrix, build a custom risk model

- Biases around turning points
  - Mostly history-based
  - Undershoot going into a crises
  - Overshoot coming out of a crises
  - Using forward-looking factors (implied volatility) improves forecast

Return Forecasting. Typical Factors

	Theme	Representative Metric	What It Measures
Alpha Factors	Deep Value	P: Price P / Book <1: If bankrupt, company can sell all assets to pay	Measures attractiveness under “mean reversion” in fundamentals
	Current Value	P / Earnings	Measures attractiveness of a stock on current earnings
	Capital Use	Dividend Yield	Measure of shareholder “friendliness”
	Quality	Accruals	Measures earnings quality, accounting
	Profitability	ROE Return on equity	Measures “internal” rate of growth, pricing power
	Momentum	Price Momentum	Measures investor reaction, fund flows, sentiment feedback
Control Factors	Beta	Beta	Measures predicted beta estimated by risk model
	Size	Market Cap	Measures magnitude of “size bias”
	Risk	Residuals	Measures possible embedded risk that can not be controlled

Deep Value: liquidation value

- Typical Definition: P / B = Market Cap / Book Equity
- Market Cap = Price x Shares Outstanding
- Book Equity = Total Asset – Total Liability
- Liquidation Value
- Strategy: “Buy low, Sell High”

Deep Value: Should I long MS and short KKR?

2009

Company	Market Cap	P/B	ROE
JPMORGAN CHASE & CO	$ 178,992,250,000	0.9	11%
CITIGROUP INC	$ 137,021,780,000	0.7	7%
BANK OF AMERICA CORP	$ 126,188,950,000	0.5	2%
GOLDMAN SACHS GROUP INC	$ 66,609,500,000	0.9	10%
BLACKROCK INC	$ 43,504,790,000	1.7	10%
MORGAN STANLEY	$ 40,348,800,000	0.7	0%
BANK OF NEW YORK MELLON CORP	$ 31,361,080,000	0.9	8%
STATE STREET CORP	$ 26,010,240,000	1.3	10%
BLACKSTONE GROUP LP/THE	$ 22,959,130,000	4.3	4%
SCHWAB (CHARLES) CORP	$ 20,946,190,000	2.2	9%
CME GROUP INC	$ 19,684,590,000	0.9	4%
T ROWE PRICE GROUP INC	$ 19,285,390,000	5.0	23%
AMERIPRISE FINANCIAL INC	$ 14,686,610,000	1.6	12%
KKR & Co LP	$ 13,551,990,000	6.9	29%
NORTHERN TRUST CORP	$ 12,560,100,000	1.7	9%
TD AMERITRADE HOLDING CORP	$ 10,586,770,000	2.4	14%

Deep Value: Should I long SU and short EPD?

Company	Market Cap	P / B	ROE
EXXON MOBIL CORP	$ 391,815,310,000	2.3	24%
CHEVRON CORP	$ 225,158,670,000	1.7	19%
CONOCOPHILLIPS	$ 70,194,880,000	1.5	17%
OCCIDENTAL PETROLEUM CORP	$ 64,137,230,000	1.6	12%
ENTERPRISE PRODUCTS PARTNERS	$ 55,502,900,000	4.2	18%
SUNCOR ENERGY INC	$ 41,666,910,000	1.1	11%
ANADARKO PETROLEUM CORP	$ 40,650,740,000	2.0	5%
KINDER MORGAN INC	$ 40,256,450,000	2.9	8%
Phillips 66	$ 35,870,160,000	1.7	19%
KINDER MORGAN ENERGY PRTNRS	$ 32,485,110,000	2.8	18%
EOG RESOURCES INC	$ 30,844,760,000	2.4	4%

Deep Value: Not quite! Some are cheap for good reasons

- What is in a firm's Value?
  - DDM: a firm's value is equal to sum of all future discounted dividends
  - Residual Income Model: current invested capital + present value of net income excess of cost of equity
- DDM

$$\text{Value} = \sum_{k=1}^{\infty} \frac{D_k}{(1+r)^k}$$

- Stable Growth Company ("Gordon Growth Model"): assuming constant dividend growth rate g and cost of equity r

$$\text{Value} = \frac{D_1}{(r-g)}$$

- Where does growth come from:
  - Improving efficiency: increasing ROE (episodic, trends to zero as a firm matures)
  - Re-investment

Deep Value: Not quite! Some are cheap for good reasons

- Growth is closely linked to dividend payout ratio and ROE

$$g = ROE_t \times (1 - payout\ ratio) + \frac{ROE_{t+1} - ROE_t}{ROE_t}$$

- As firm matures

$$g = ROE_t \times (1 - payout\ ratio)$$

- So how much dividend a firm can pay depends on earnings growth and efficiency

$$payout\ ratio = 1 - \frac{g}{ROE}$$

$$dividend = net\ income \times payout\ ratio = Book\ Equity \times ROE \times \left(1 - \frac{g}{ROE}\right)$$

- Putting them all together: $Firm\ Value = Book\ Equity \times \frac{ROE - g}{r - g}$

Deep Value: Not quite! Some are cheap for good reasons

- If market is fair

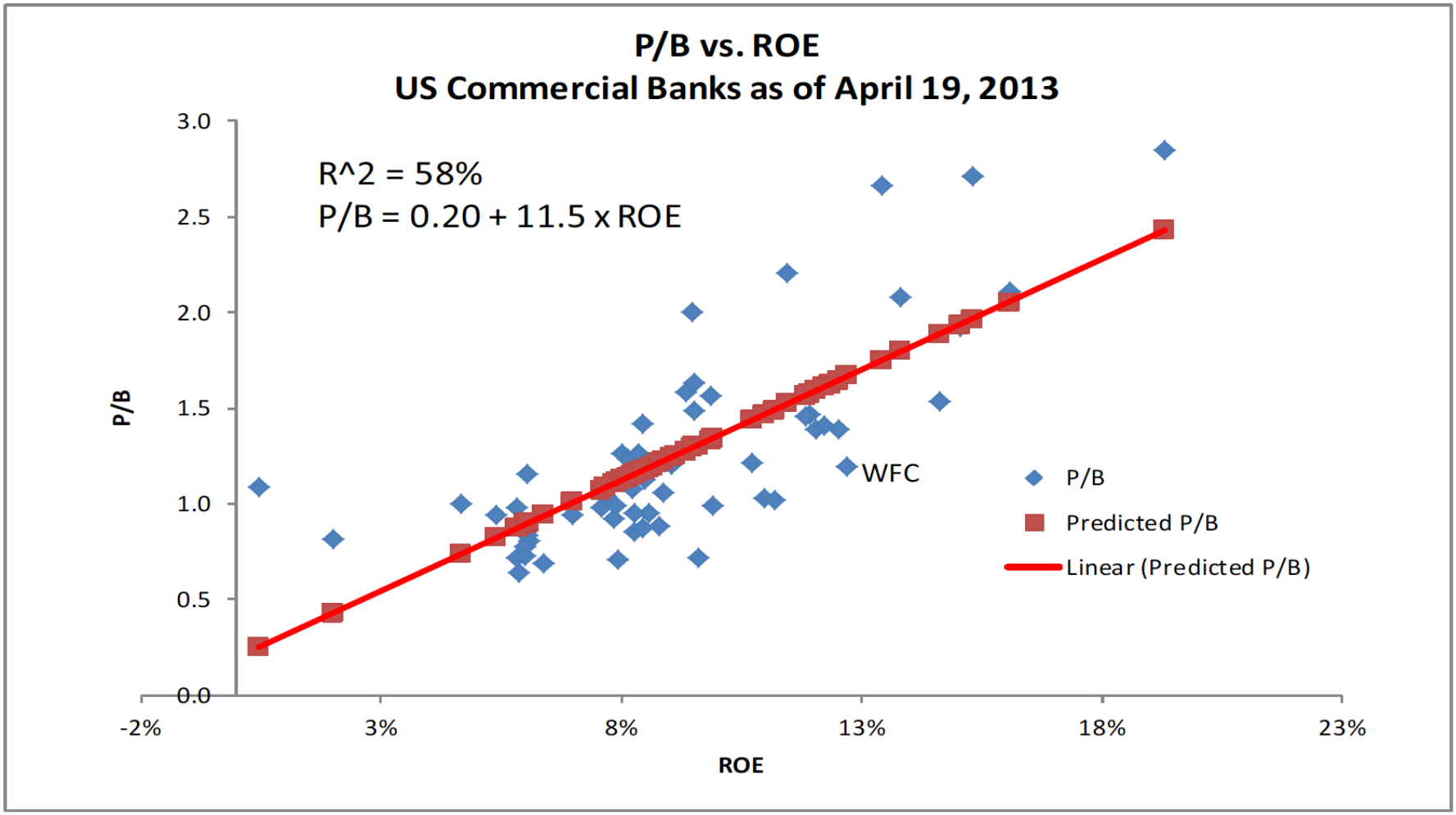
$$\frac{P}{B} \propto \frac{ROE-g}{r-g}$$

- Where r is “cost of equity”. From CAPM

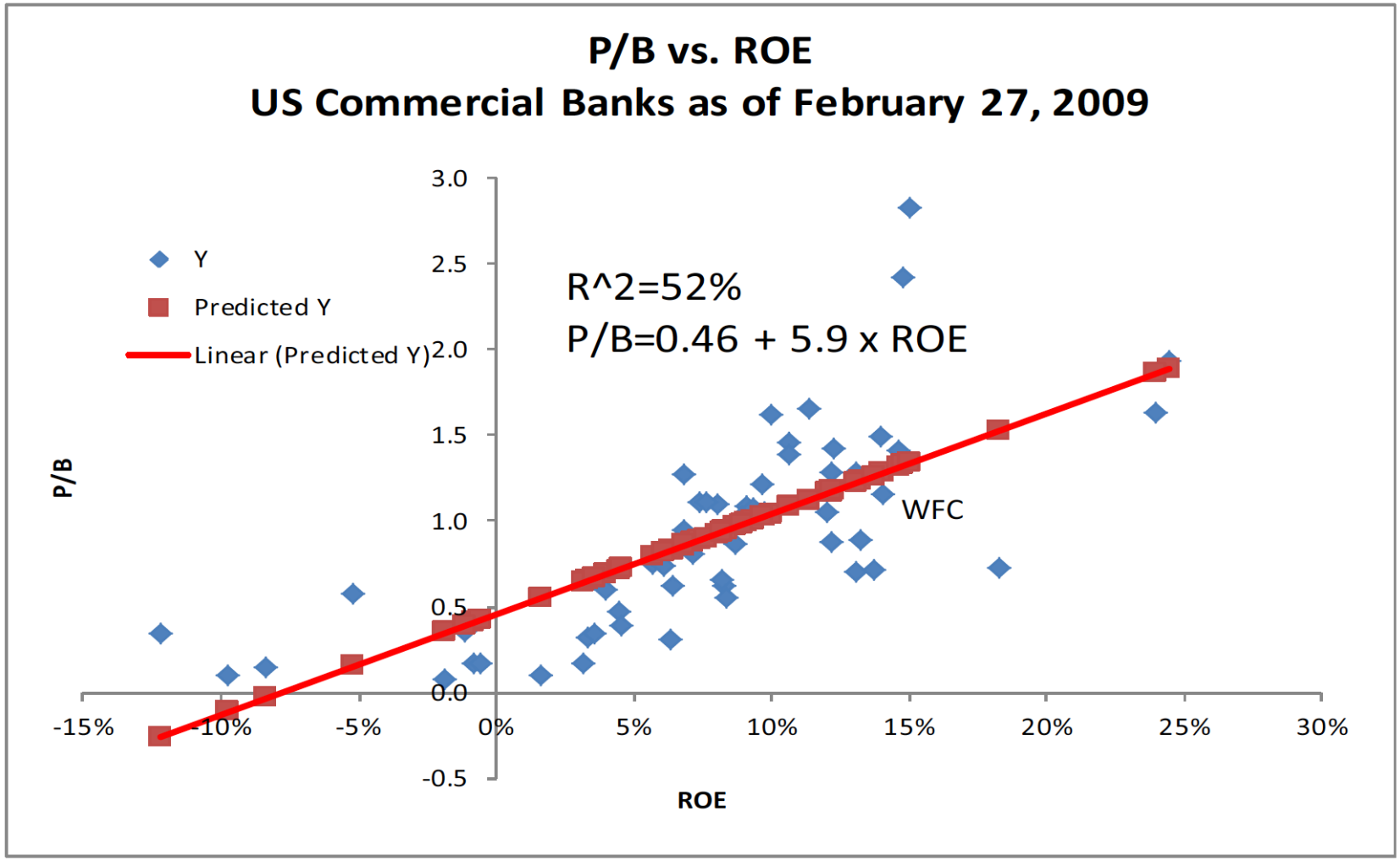
$$r = r_{free} + \beta \times r_{equity}$$

- This means that
  - P/B is proportional to ROE
  - P/B is inversely proportional to beta

Case Study: US Commercial Banks, as of April 19, 2013



Case Study: US Commercial Banks, as of February 27, 2009



Case Study: US Commercial Banks – Market is quite rational

- Regress P/B against ROE (April 19, 2013)

$$\frac{P}{B} = 0.2 + 11.5 \times ROE$$

$$R^2 = 57\%$$

F-statistics: 81

- Adding impact of cost of equity:

$$\frac{P}{B} = 0.8 + 10 \times ROE - 0.5 \times \beta$$

$$R^2 = 62\%$$

F-statistics:47

Implications for deep value investors

- P/B is mainly an express opinion on the a firm's ROE
  - Investors pay up for high profitability, more importantly, sustainability of such profitability;
  - Investors pay fraction of book value when they believe the profitability of a company, or even an industry is permanently damaged;
- Other factors complicate the value proposition by P/B
  - Beta: higher beta→higher cost of equity→lower P/B, when all else being equal
  - Sector biases: more often than not, disbelief in sustainability of profitability isn't isolated to just one firm but the entire industry ("Investment Banks" a case in point)

Two ways to skin the Value

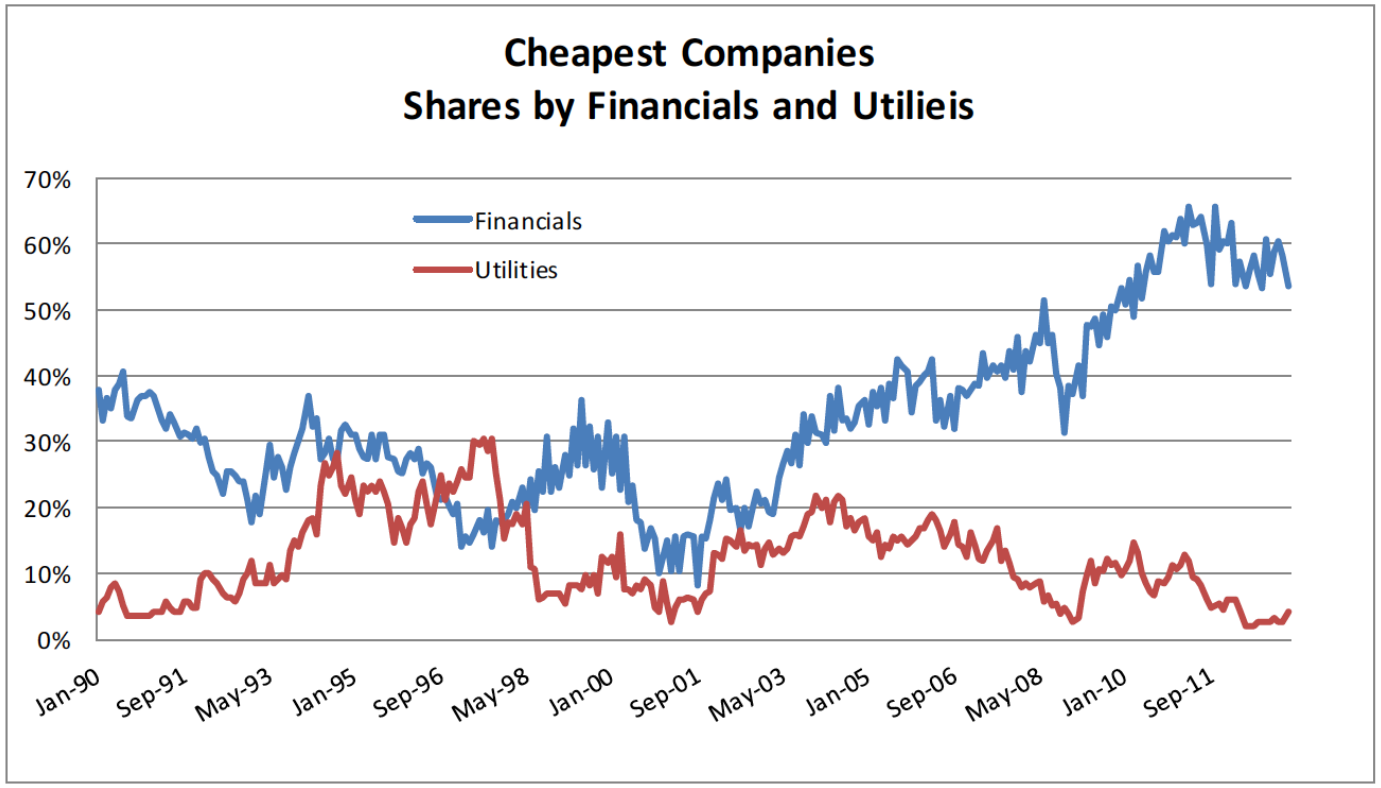
- Naïve implementation
  - Given a universe of stocks
  - Sort these stocks by their price to book ratio;
  - Pick the cheapest decile or quintile to go long;
  - Pick the most expensive decile or quintile to go short (in case of L/S implementation);
- Pure Value – Value Done Right
  - Assign each stock given an exposures to “value” (and beta, and other stuff);
  - Estimate Covariance Matrix of these stocks;
  - Construct a long only (or long/short) portfolio with maximal exposure to value
  - While minimizing overall risk, and
  - Exposures to all other factors
  - Similar to *orthogonalization* process in linear algebra.
  - A portfolio with a unit exposure to a factor is called “factor portfolio”

Naïve Implementation leads to unintended exposures and consequences

Significant Sector Bets

early 00s

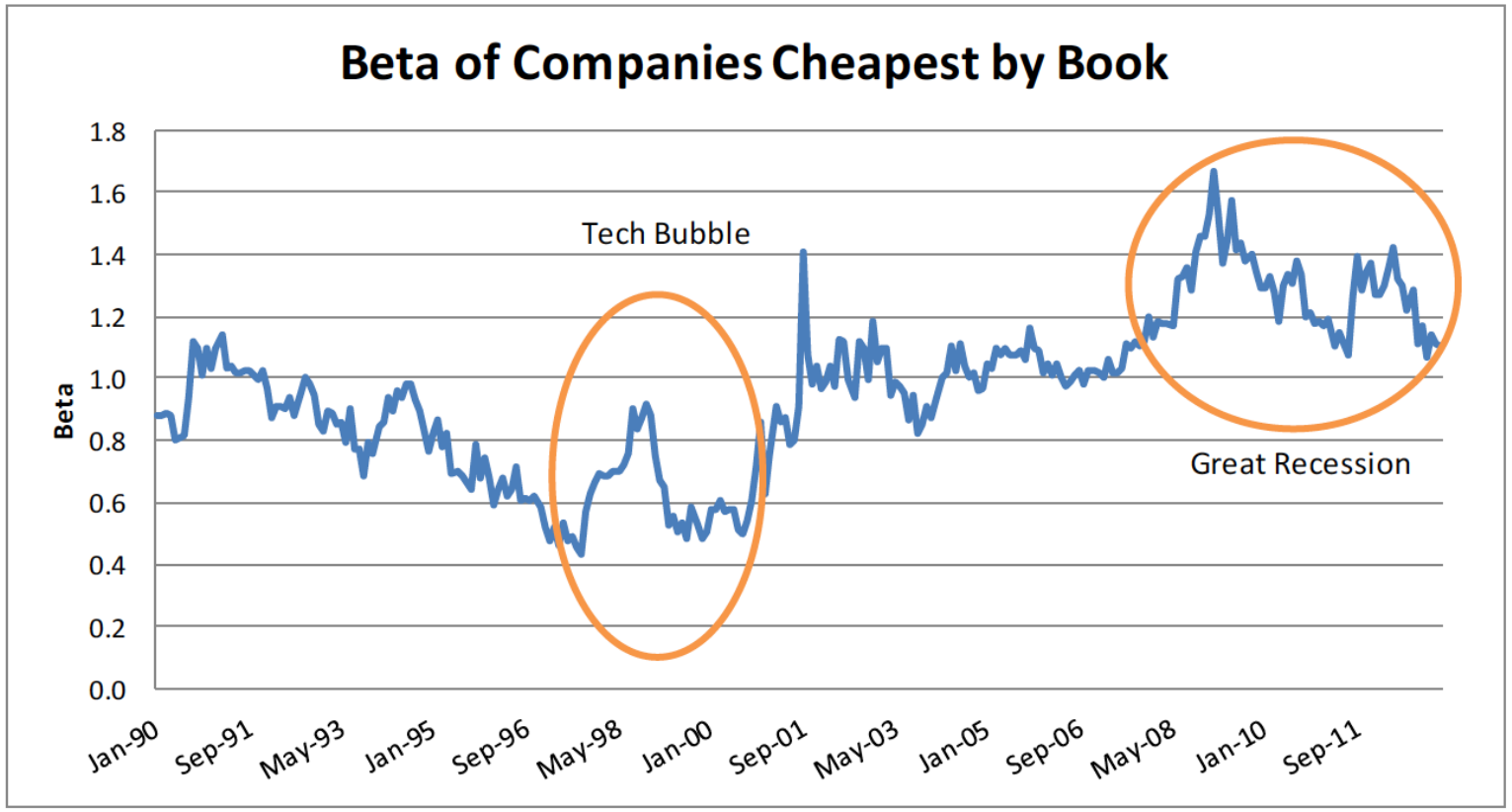
- In tech bubble, deep value means utilities/staples
- Post 2008/2009 crises, deep value means financials



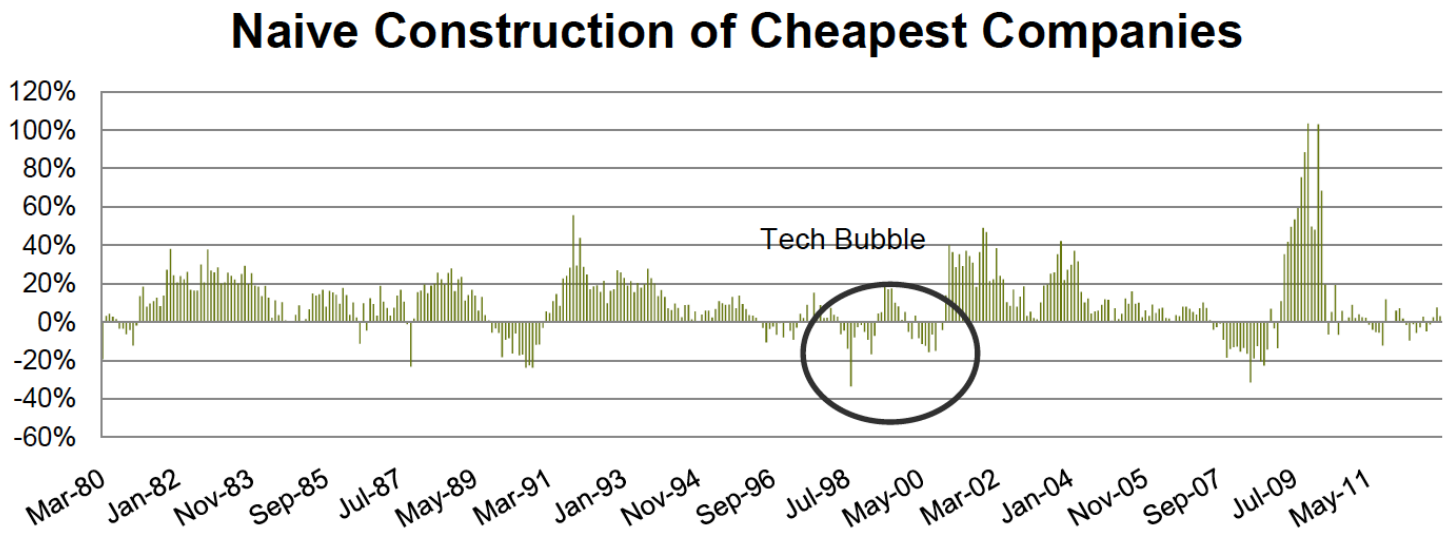
Naïve Implementation leads to unintended exposures and consequences

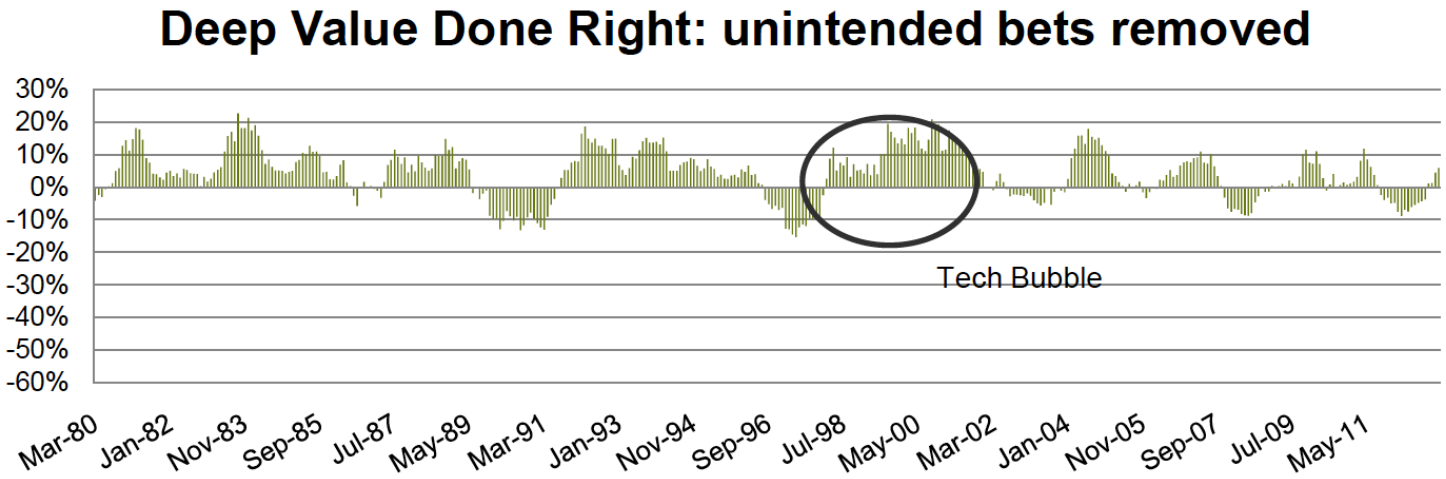
Significant Market Beta

- In tech bubble, lower beta nature leads to significant underperformance
- Post 2008/2009 crises, deep value means early cyclicals, i.e. financials



Compare “naïve value” and “value done right”: rolling 12-month excess returns





Compare “naïve value” and “value done right”

- Naïve Style has more oomph but behave badly
  - Can outperform the market north of 100% over a 12-month period;
  - Can provide large and persistent underperformance from unintended exposures;
- Pure Value offers more direct and better behaving value exposure
  - Monthly drawdowns are limited;
  - Far higher efficient use of risk budget;

Typical statistics	Naïve	Pure Value
Annual Excess Return	3.1%	3.9%
Tracking Error	10.1%	5.8%
Information Ratio	0.3	**0.7**
Maximum Monthly Drawdown (Excess Return)	-14%	-5%
Beta	1.1	1
Skewness	2.5	0.4
Kurtosis	19.9	1.2

Cyclicality of Deep Value

- Cheap can get cheaper
  - Deep Value necessitates an expectation of return to historical ROE
  - Macro environment deteriorates → shrinking risk appetite
  - Spread continue to widen until the Fed cuts rates or resolution of some systemic risk
- Cheap can take a bid
  - Market anticipates recovery 6-12 months on average → re-pricing of risk
  - Cheapest, most beaten shares are also the least owned
  - Cheapest also has the lowest liquidity (least amount of shares trades)
  - Though re-risking leads to all boat floats, least liquid and cheapest bump up the most;
  - It takes the brave to dip toe in this; One month to early could be disastrous;

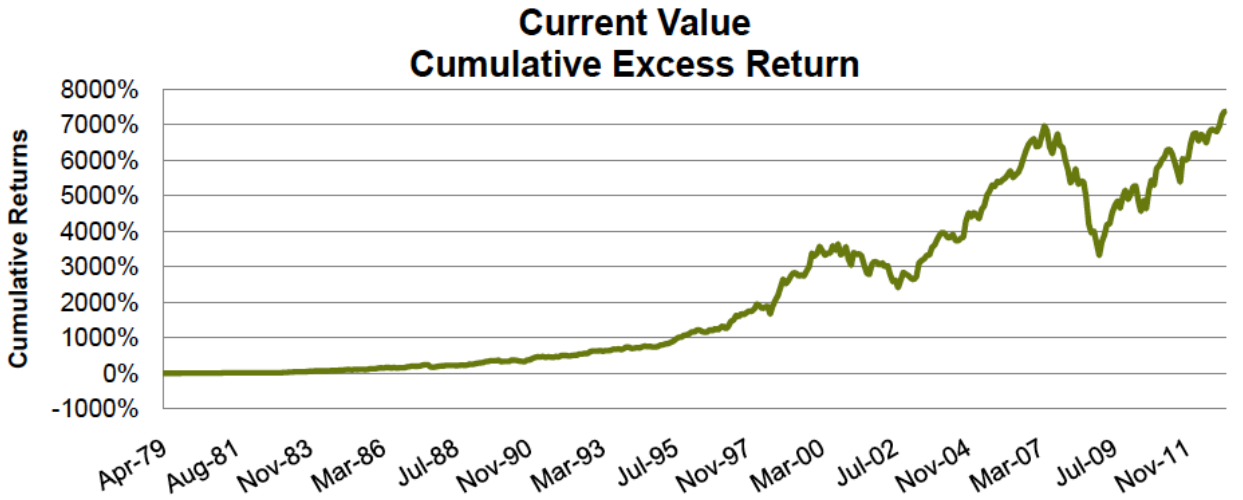
Business Regimes	Excess Return	Tracking Error	Information Ratio
Expansion, Intensifying	7%	6%	1.2
Expansion, Moderating	**6%**	**4%**	**1.5**
Contraction, Intensifying	2%	7%	0.2
Contraction, Moderating	4%	5%	0.8

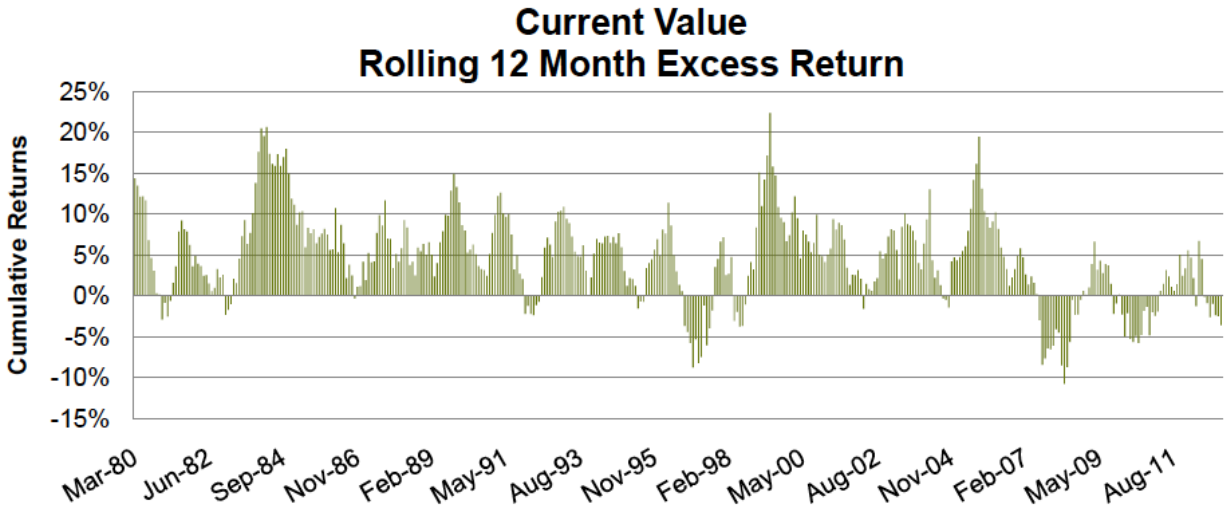
Other Factors: Current Value

- P / E, P / Cash Flow Multiples
  - Go long firms with cheapest P / E multiples
  - Initiate short in firms with the highest P / E multiples, within the same sector
  - Fundamentally mean reversion strategy
  - Not applicable to all sectors: companies with lumpy earnings, or unpredictable cash flows or cash flows are ill-defined such as banks;
- Effectiveness
  - Annual Excess Return: 5%
  - Tracking Error: 5%
  - Information Ratio: 1.0
  - Cyclicality: late expansion strategy

Business Regimes	Excess Return	Tracking Error	Information Ratio
Expansion, Intensifying	3%	4%	0.8
Expansion, Moderating	**6%**	**4%**	**1.6**
Contraction, Intensifying	4%	4%	1.0
Contraction, Moderating	4%	4%	1.0

Other Factors: Current Value





Part 2:

1. Other Factors
2. Factor Diagnostics
3. Multi-Factor return models
4. The curse of T-Cost (turnover, capacity)
5. Factor crowding