

Dynamic Analysis of Hedge Fund Returns: Detecting Leverage and Fraud

Michael Markov
Markov Processes International, LLC (MPI)

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- Hedge funds
- Quantitative analysis of returns
- Limitations, challenges
- Motivation for a dynamic model
- Dynamic Style Analysis (DSA) concepts
- Calibration
- Case studies
- Summary

- ~10,000 hedge funds managing \$2.375 trillion (*Source: HFR*)
- Attrition rate apx 8% annually
- Over 1,000 funds closed in 2009
- Through leverage control much greater capital
- Available only to “qualified” (“rich”) investors
- Charge performance fees (2/20 or similar)
- Lightly regulated, limited transparency
- “Can go anywhere” - no restriction on types of trades
- Employ shorting, leverage, sophisticated arbitrage across asset classes
- Use rapid trading, derivatives
- Limited liquidity – redemption restrictions

- Hedge Funds
 - Monthly performance (as a rule)
 - Disclosure: Form PF, OPERA, etc. (more recent)
 - Generally no full holdings info provided (13F at most)
 - Investor letters with a strategy/results overview
 - No SEC registration required

- Mutual Funds
 - Daily performance
 - Daily liquidity
 - Full transparency: semi-annual/qtr/monthly holdings
 - Prospectus with detailed info about management, strategy, fees and expenses
 - Regulated by SEC

- High incentive fees create an appetite for risk and leverage
- About 10% of hedge funds close every year (apx 800 funds)
- Investment returns are frequently manipulated
- Notable cases of fraud and failure:
 - 2008 Bernard Madoff (\$60B fraud)
 - 2008 Peloton Fund (\$2B fund collapsed - subprime bet)
 - 2006 Amaranth Fund (~\$5B lost within a week)
 - 2005 Bayou Fund (\$300M fraud)
 - 2002 Beacon Hill (\$300M fraud)
 - 1999 The Manhattan Fund (\$400M fraud)
 - 1998 Long Term Capital (LTCM) (\$4.6B fund collapse)
- Recent “insider trading” cases
 - 2009 Galleon
 - 2013 SAC

HF | Largest Cases of Fraud (>\$100M)

Institution Name	The Accused	Date	Alleged Fraud Amt (\$MM)
Madoff Investments LLC	<i>Bernard Madoff</i>	December 2008	64,800
Stanford Financial Group	<i>R. Allen Stanford</i>	February 2009	8,000
Petters Group Worldwide	<i>Tom Petters</i>	September 2008	3,500
Frankel International	<i>Barry Tannenbaum</i>	June 2009	1,200
Satyam Computer Services	<i>Ramalinga Raju</i>	January 2009	1,000
Westgate Capital Management, LLC	<i>James Nicholson</i>	February 2009	900
Capitol Investments USA, Inc	<i>Nevin K. Shapiro</i>	April 2010	900
Dreier LLP	<i>Marc Dreier</i>	December 2008	700
WG Trading Co	<i>S. Walsh & P. Greenwood</i>	February 2009	554
Weavering Capital	<i>M. Peterson</i>	March 2009	500
Provident Royalties LLC	<i>P.R. Melbye, B. Coughlin...</i>	July 2009	485
Bayou Capital	<i>Samuel Israel</i>	June 2008	450
Manhattan Capital Management	<i>Michael Berger</i>	January 2000	393
Lake Shore Asset Management Ltd	<i>Philip J. Baker</i>	June 2007	312
Beacon Hill Asset Management	<i>Barry, Daniels, Irwin ..</i>	November 2002	300
Philadelphia Alternative Asset Mgmt	<i>Paul Eustace</i>	May 2005	300
Scoop Management	<i>Arthur Nadel</i>	January 2009	300
Investors Overseas Service, Ltd.	<i>Robert Vesco</i>	January 1972	224
Diversified Lending Group, Inc	<i>Bruce Friedman</i>	March 2008	216
Lancer Group	<i>Michael Lauer et al.</i>	July 2003	200
K.L. Group, LLC	<i>John & Yung Kim, W. S. Lee</i>	March 2005	195
International Mgmt Associates	<i>Kirk Wright</i>	February 2006	150
McGinn, Smith & Co	<i>T. McGinn & D. Smith</i>	April 2010	120

Role of Quantitative Analysis

- Does performance make sense given a fund's strategy?
- Is it made up or "beautified"?
- Any extraordinary unexplained gains?
- Was there a recent strategy change?
- What is the leverage level?
- What is fund's risk – scenarios and stress-tests
- Where is the skill (long/short picks, arbitrage)?
- What is the value added (attribution)?
- Any conflict/overlap in a multi-fund portfolio (pension/FOF)?
- Is hedging required and how to implement?

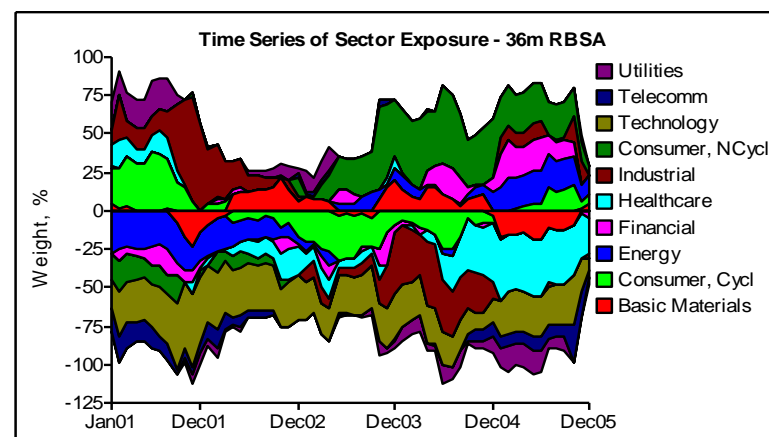
Regression Analysis of Fund Returns

- Origins in pricing models
 - CAPM (Sharpe-Lintner-Mossin), APT (Roll, Ross), Fama-French, etc.
- Returns-Based Style Analysis (RBSA) Sharpe (1988, 1992)
 - Strategy-related constraints
 - Moving window to sense dynamics

$$r^{(p)} \cong \alpha + \sum_{i=1}^n \beta^{(i)} r^{(i)}$$

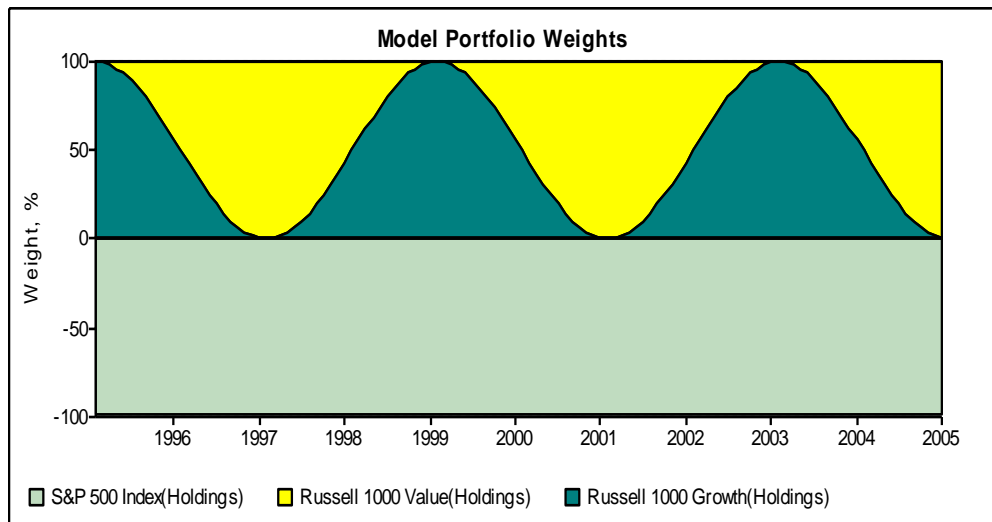
$$\begin{cases} (\hat{\alpha}, \hat{\beta}^{(1)}, \dots, \hat{\beta}^{(n)}) : \sum_{t=1}^N \left(r_t^{(p)} - \alpha - \sum_{i=1}^n \beta^{(i)} r_t^{(i)} \right)^2 \rightarrow \min, \\ \beta^{(i)} \geq 0, \sum_{i=1}^n \beta^{(i)} = 1. \end{cases}$$

- Known issues with regressions:
 - Noisy results
 - Cannot sense rapid trading
 - Limited # of factors
 - Short fund histories (<12m)

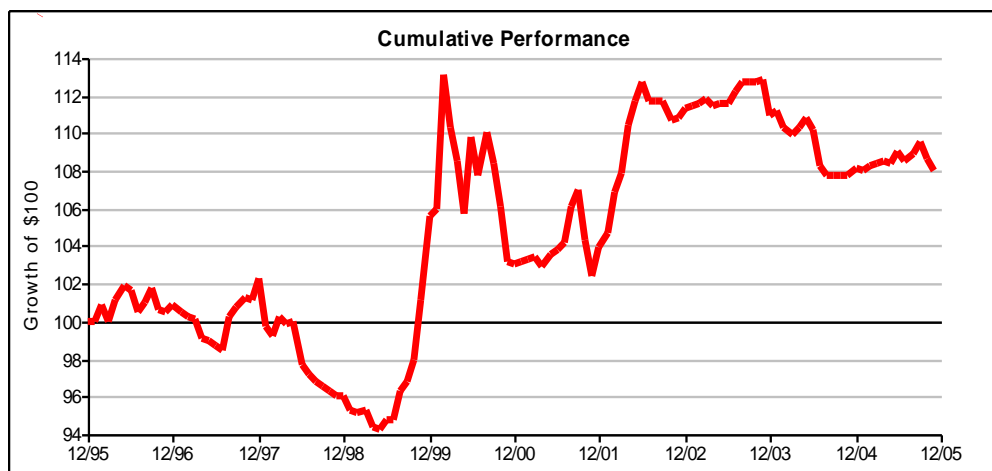


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Motivation | Model Hedge Fund



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Hypothetical style rotation strategy

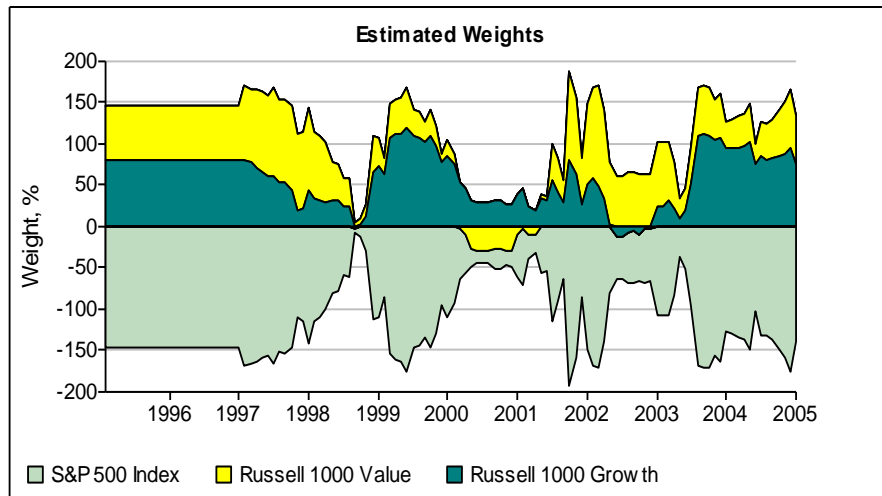
- Long R1000 Value (yellow)
- Long R1000 Growth (teal)
- Short S&P 500 Index

Composite returns

- no noise added



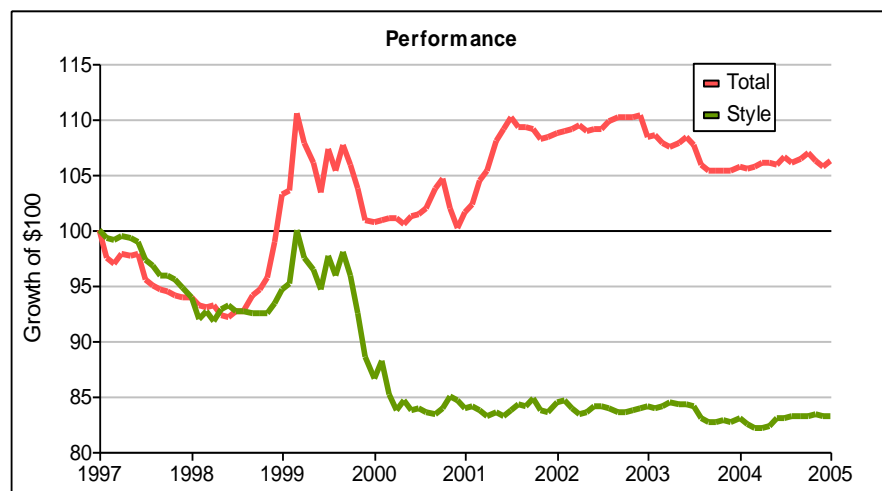
Motivation | Model Hedge Fund Analysis



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Rolling 24m regressions of composite model returns

No data error, no model error (same factors are used) in regressions

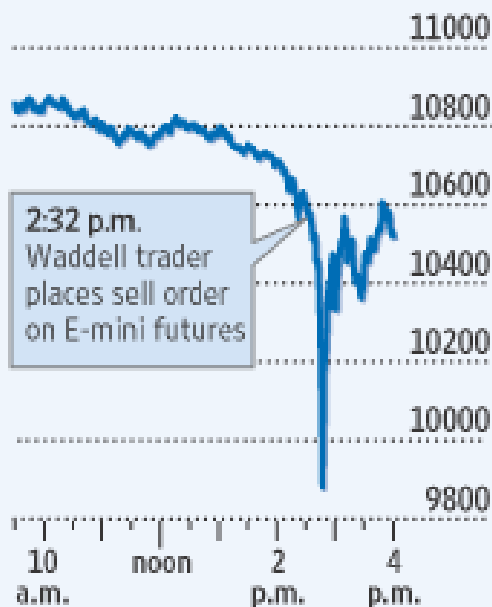


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Motivation | May 6, 2010 “Flash Crash”

Waddell's Impact

Waddell & Reed trading has been called a key factor in the May 6 'flash crash'

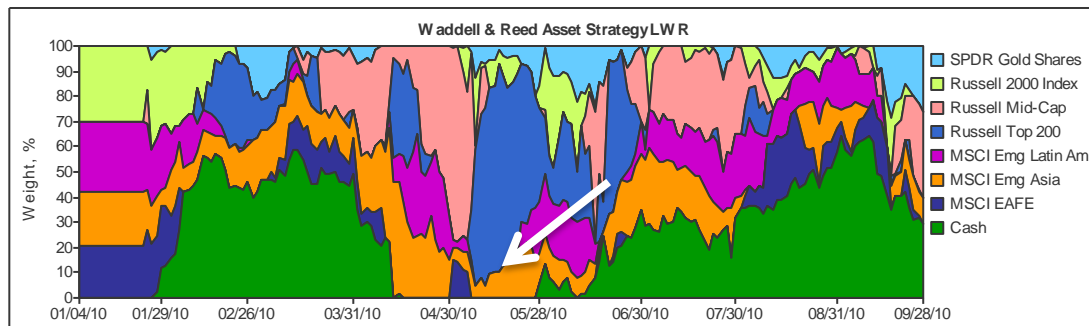


Sources: WSJ Market Data Group;
WSJ reporting

- On May 6, 2010 in which the Dow Jones Industrial Average plunged about 600 points in 5 min only to recover those losses within minutes. It was the biggest one-day point decline, 998.5 points, in DJIA history
- “Market (was) so fragmented and fragile that a single large trade could send stocks into a sudden spiral” (SEC/CFTC report, 2010)
- The report pointed to a \$20B fund managed by Waddell & Reed as the primary trigger of the May 6 “flash crash” (without naming the firm)
- " At 2:32PM (EDT), against a "backdrop of unusually high volatility and thinning liquidity" that day, "a large fundamental trader (a mutual fund complex) initiated a sell program to sell a total of 75,000 E-Mini contracts (apx \$4.1 billion) as a hedge to an existing equity position."
- The computer algorithm the trader used to trade the position was set to "target an execution rate set to 9% of the trading volume calculated over the previous minute, but without regard to price or time." (SEC/CFTC report, 2010)
- Only in April, the Waddell fund had been bullish, with 87% of its assets in stocks. W&R holdings report as of end of May showed neither hedging nor significant position in cash

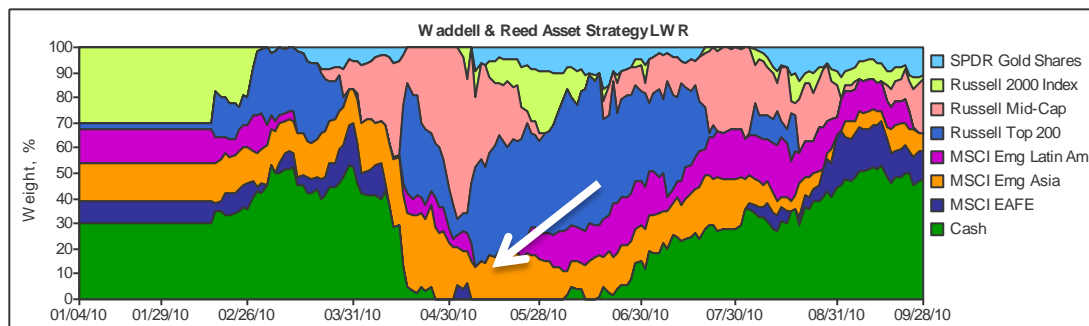
Motivation | “Flash Crash”

15d



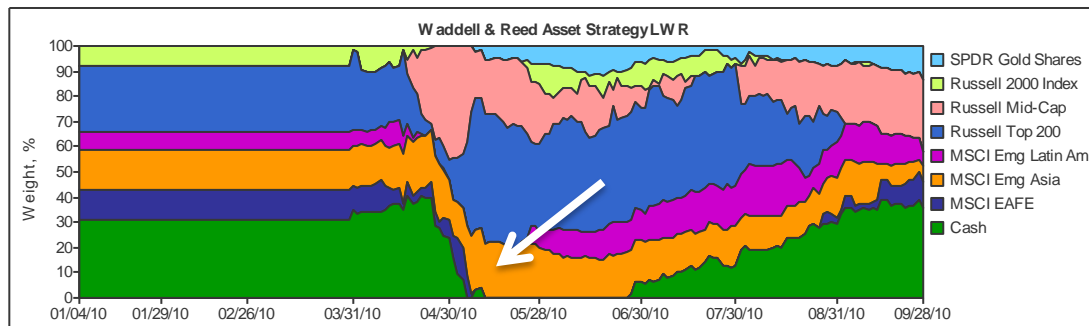
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30d



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60d



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Rolling window RBSA
analysis of W&R Asset
Strategy daily NAVs

Shows no sign of hedging
in May 2010

- Dynamic regression

Old objective : $(\hat{\alpha}, \hat{\beta}^{(1)}, \dots, \hat{\beta}^{(n)}) : \sum_{t=1}^N \left(r_t^{(p)} - \alpha - \sum_{i=1}^n \beta^{(i)} r_t^{(i)} \right)^2 \rightarrow \min$

New objective : $(\hat{\alpha}, \hat{\beta}_t^{(1)}, \dots, \hat{\beta}_t^{(n)}) : \sum_{t=1}^N \left(r_t^{(p)} - \alpha_t - \sum_{i=1}^n \beta_t^{(i)} r_t^{(i)} \right)^2 \rightarrow \min$

- Regularization: smoothness penalty

$$\begin{array}{ccc} \beta_{1,2} - \beta_{1,1} & \beta_{1,3} - \beta_{1,2} & \beta_{1,120} - \beta_{1,119} \\ \beta_{2,2} - \beta_{2,1} & + \beta_{2,3} - \beta_{2,2} & + \dots + \beta_{2,120} - \beta_{2,119} \\ \dots & \dots & \dots \\ \underbrace{\beta_{8,2} - \beta_{8,1}}_{\Delta\beta_1} & \underbrace{\beta_{8,3} - \beta_{8,2}}_{\Delta\beta_2} & \underbrace{\beta_{8,120} - \beta_{8,119}}_{\Delta\beta_{119}} \end{array}$$

- Estimation (Markov, Mottl, Muchnik 2004a, 2004b)

$$(\hat{\beta}_t, t = 1, \dots, N) = \arg \min_{\beta_t, t=1, \dots, N} \left[\sum_{t=1}^T (y_t - \mathbf{x}_t^T \beta_t)^2 + \lambda \sum_{t=2}^T (\beta_t - \beta_{t-1})^T \mathbf{U} (\beta_t - \beta_{t-1}) \right]$$

- Flexible Least Squares (FLS) Kalaba, Tesfatsion (1989)

$$(\hat{\beta}_t, t = 1, \dots, N) = \arg \min_{\beta_t, t=1, \dots, N} \left[\sum_{t=1}^T (y_t - \mathbf{x}_t^T \beta_t)^2 + \lambda \sum_{t=2}^T (\beta_t - \mathbf{V} \beta_{t-1})^T \mathbf{U} (\beta_t - \mathbf{V} \beta_{t-1}) \right]$$

- State-space model
$$r_t^{(p)} = \sum_{i=1}^n \mathbf{r}_t^T \beta_t + e_t$$
$$\beta_t = \mathbf{V} \beta_{t-1} + \xi_t$$

- Non-linear matrix \mathbf{V}

$$\beta_t^{(i)} = \frac{1 + r_{t-1}^{(i)}}{\sum_{k=0}^n \beta_{t-1}^{(k)} (1 + r_{t-1}^{(k)})} \beta_{t-1}^{(i)} + \xi_t^{(i)}$$

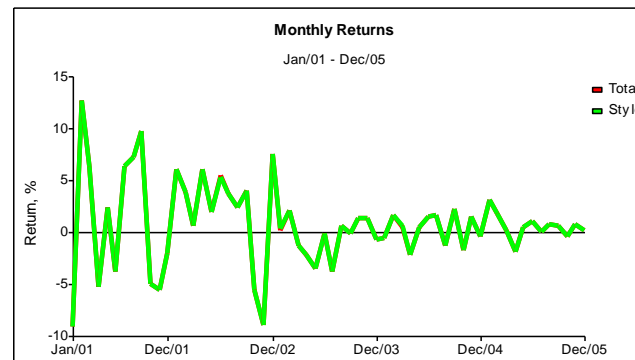
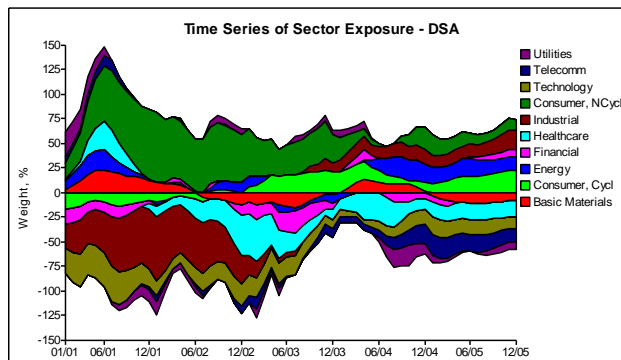
- Smoothness parameter

$$\lambda \rightarrow 0$$

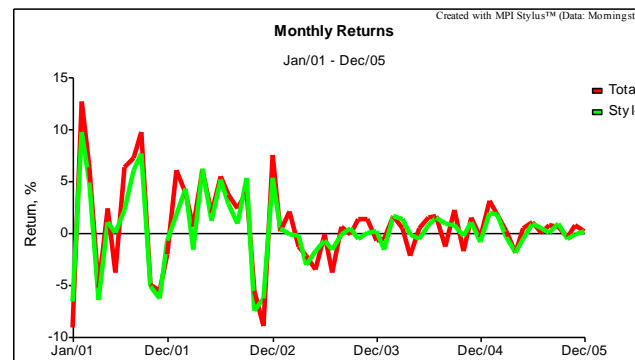
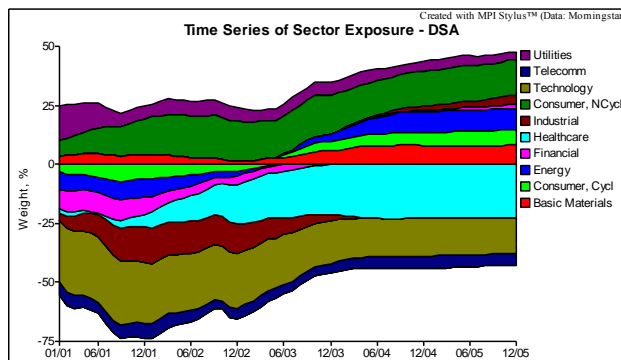
$$\lambda \rightarrow \infty$$

Smoothness | Long/Short

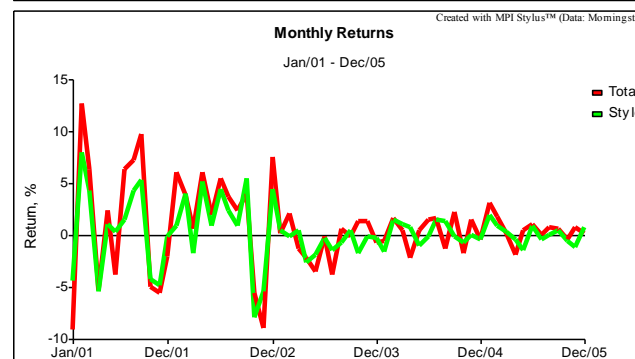
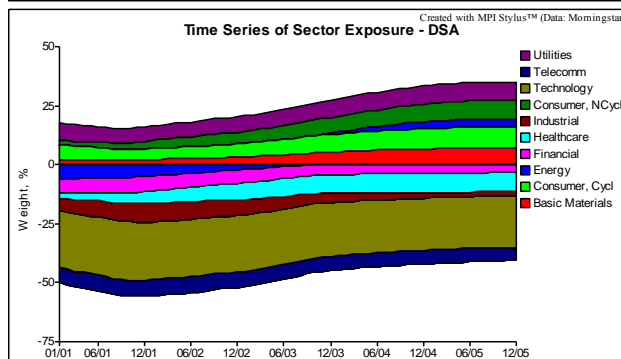
$\lambda = 0.1$



$\lambda = 100$



$\lambda = 1000$



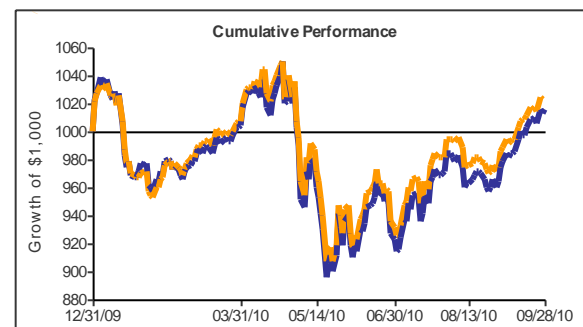
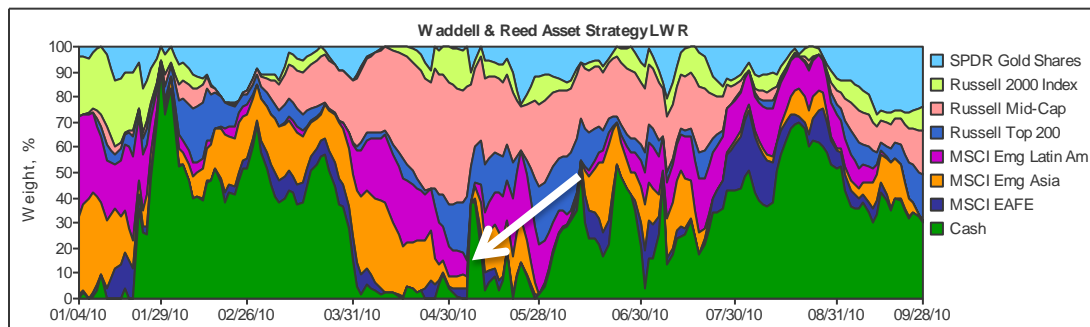
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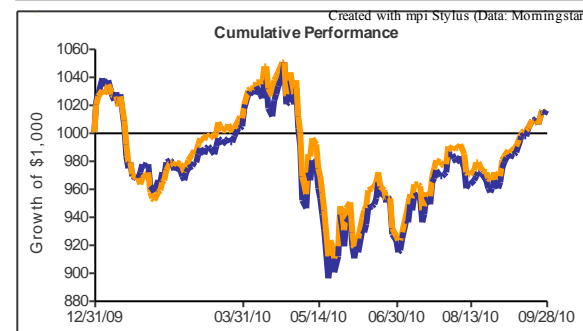
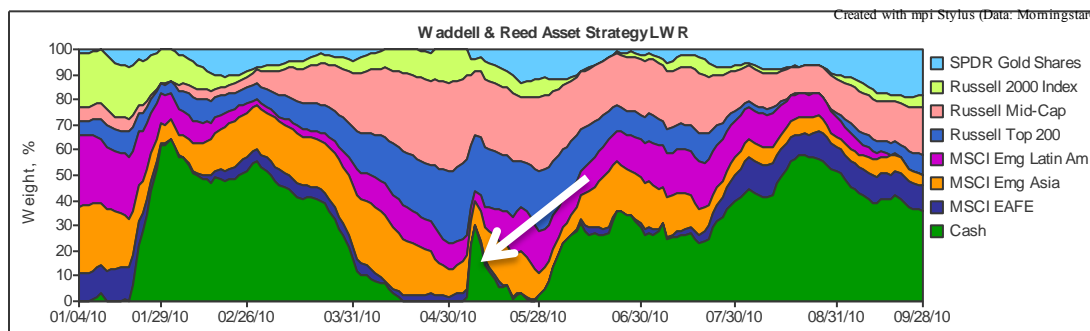
Smoothness | “Flash Crash”

- Analysis of W&R Asset Strategy (for varying levels of log-smoothness)

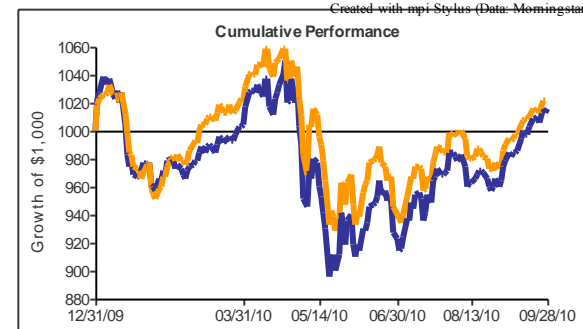
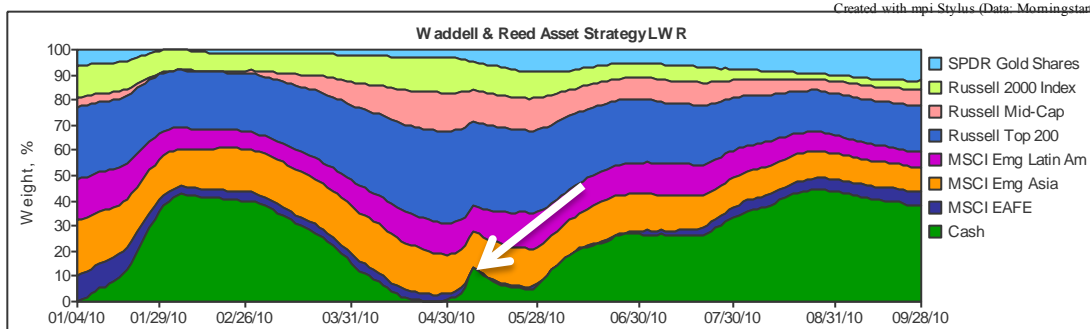
0.55



0.65



0.75



Calibration | Cross-Validation

$$\hat{\beta}(1): \quad \cancel{r}_1^{(p)} \quad r_2^{(p)} \quad \dots r_{t_k}^{(p)} \quad \dots \quad r_T^{(p)}$$

...

$$\hat{\beta}(t_k): \quad r_1^{(p)} \quad r_2^{(p)} \quad \dots \cancel{r}_{t_k}^{(p)} \quad \dots \quad r_T^{(p)}$$

...

$$\hat{\beta}(T): \quad r_1^{(p)} \quad r_2^{(p)} \quad \dots r_{t_k}^{(p)} \quad \dots \quad \cancel{r}_T^{(p)}$$

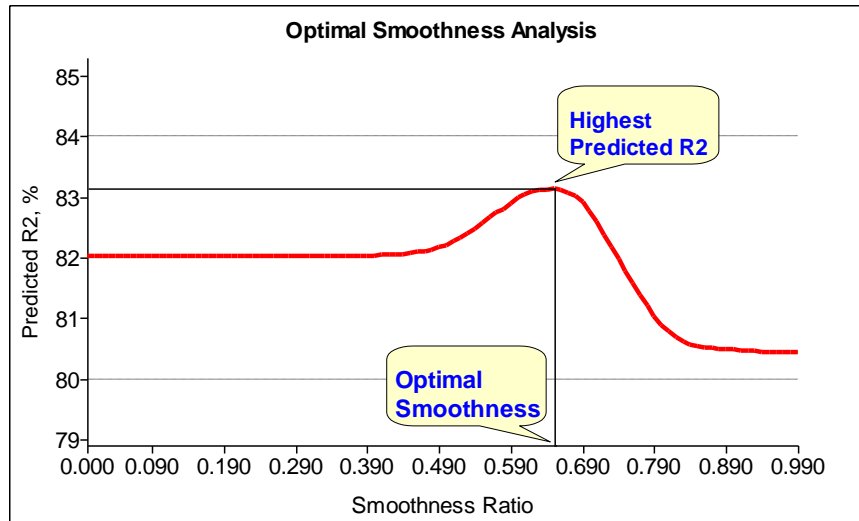
- R^2 is not a good measure of fit: by lowering smoothness we attain 100% R^2
- *Predictive R^2* : cross-validation through “leave-one-out” (Vapnik 1988)
- Computation-intensive

$$(\hat{\beta}_t(t_k, \lambda)): \left[\sum_{t \neq t_k} \left(r_t^{(p)} - \sum_i \beta_t^{(i)} r_t^{(i)} \right)^2 + \lambda \sum_{i,t} d_t^{(i)} \left(\beta_t^{(i)} - \beta_{t-1}^{(i)} \right)^2 \right] \rightarrow \min_{\beta}$$

$$\text{Prediction Error: } \hat{D}_{CV}(e|\lambda) = \sum_{t=1}^T \left(r_t^{(p)} - \sum_i \hat{\beta}_t^{(i)}(t) r_t^{(i)} \right)^2 / T$$

$$PR^2(\lambda) = 1 - \frac{\hat{D}_{CV}(e|\lambda)}{Var(r^{(p)})}$$

Calibration | Comp Complexity



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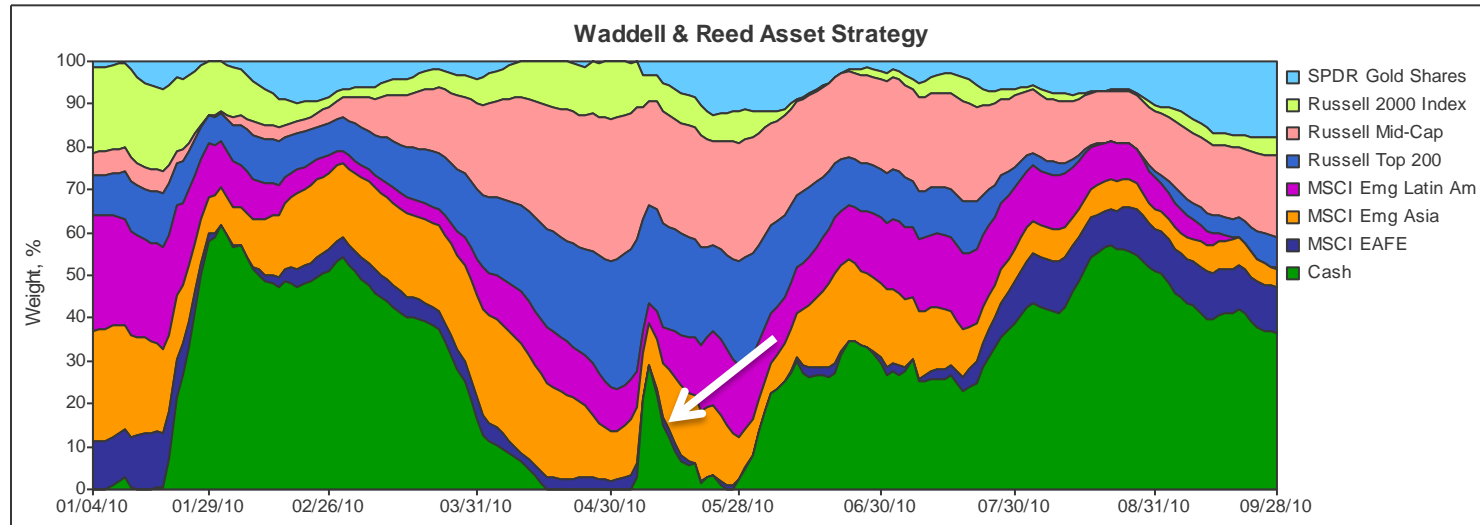
Highest Predictive R² defines optimal smoothness parameter



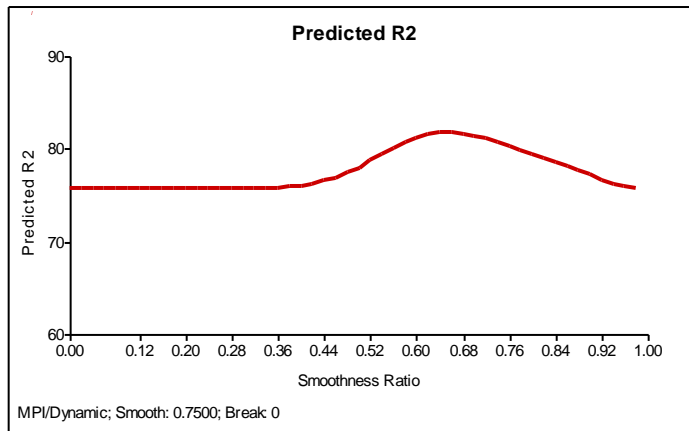
Computational complexity

- 120 monthly (or daily/weekly) returns and 8 Indices
- One quadratic optimization: 960 variables
- 1 Predicted R-squared: 120 optimizations
- Smoothness selection: a grid of 100 values
- Total optimizations to produce one chart: 120 x 100 = 12,000
- Linear complexity algorithm (Krasotkina, Markov, Mottl and Muchnik, 2006)

Calibration | “Flash Crash”



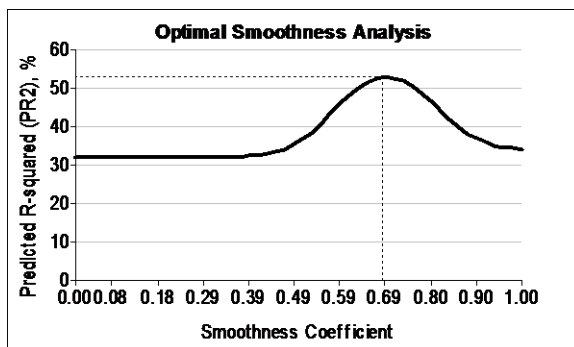
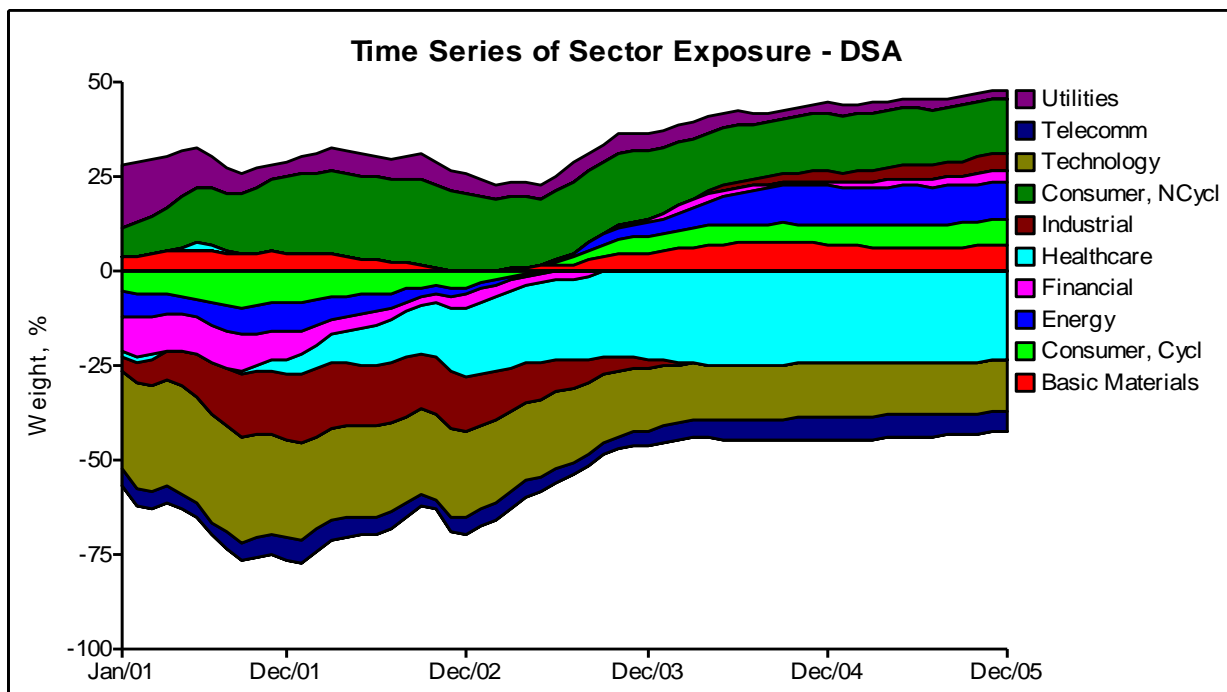
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Optimal smoothness provides a reasonable value of the May 6, 2010 spike in cash exposure (given size of the fund and the amount of hedge)

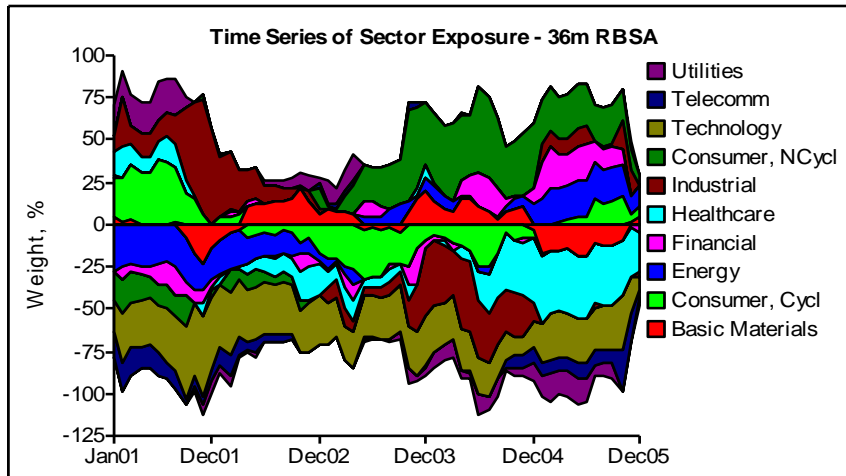
Calibration | Long/Short



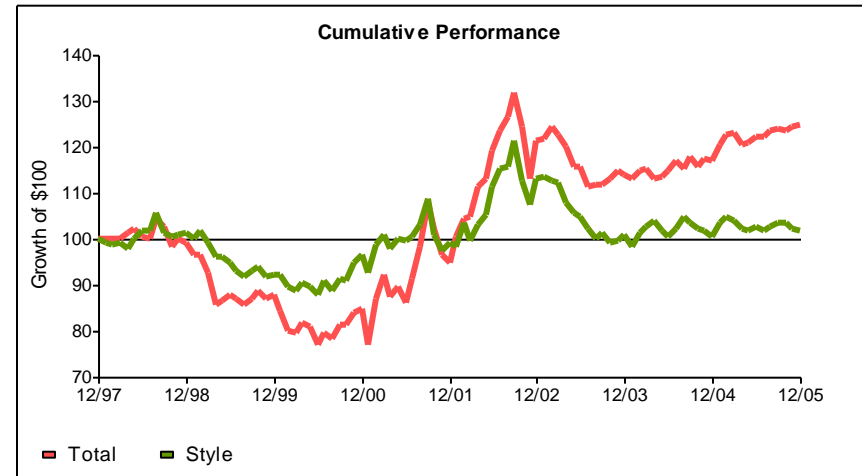
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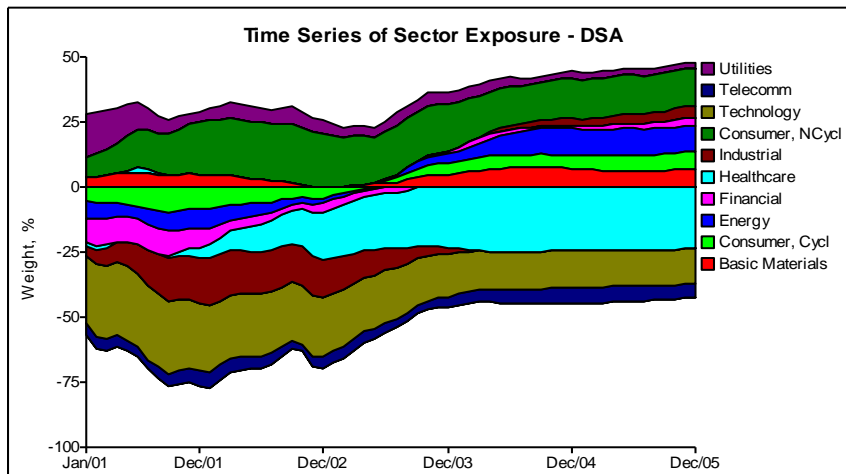
Long-Short | DSA vs. Rolling Regressions



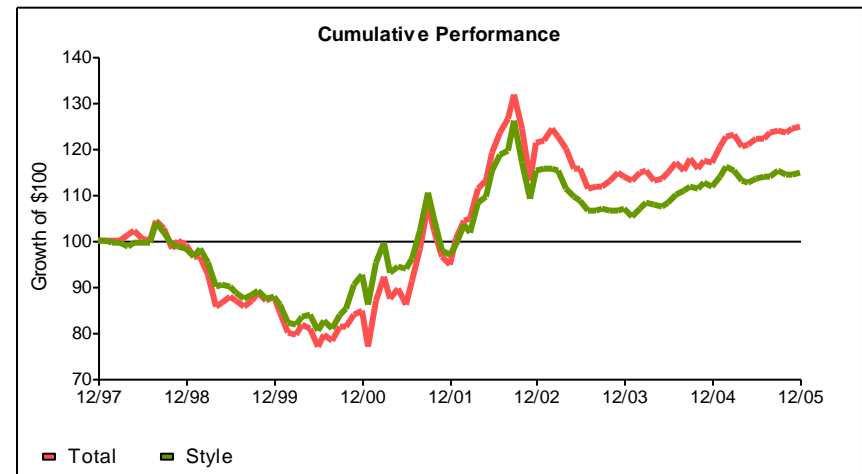
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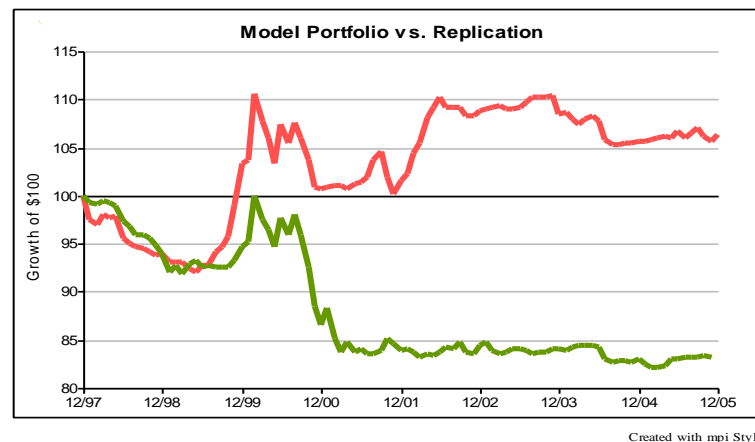
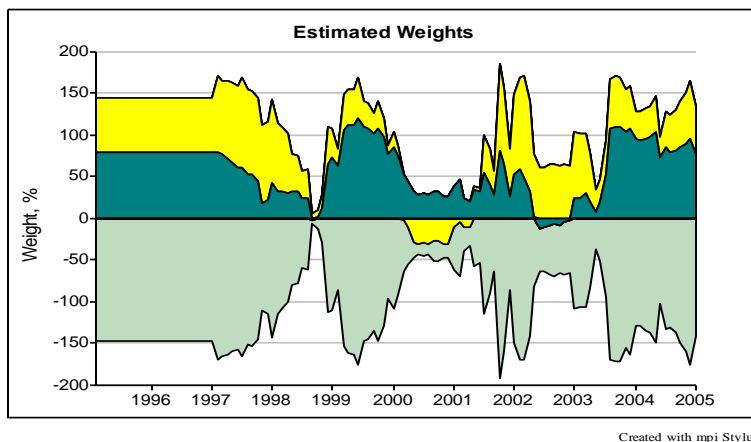


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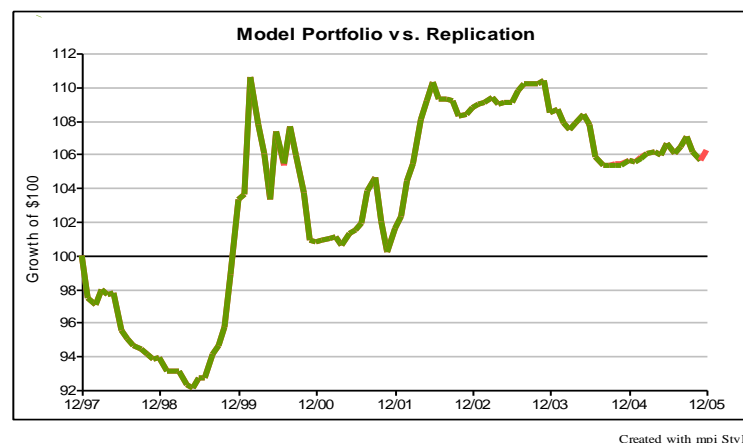
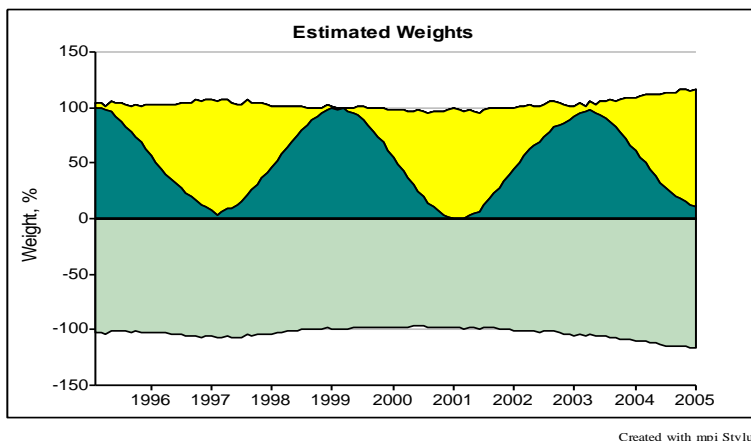


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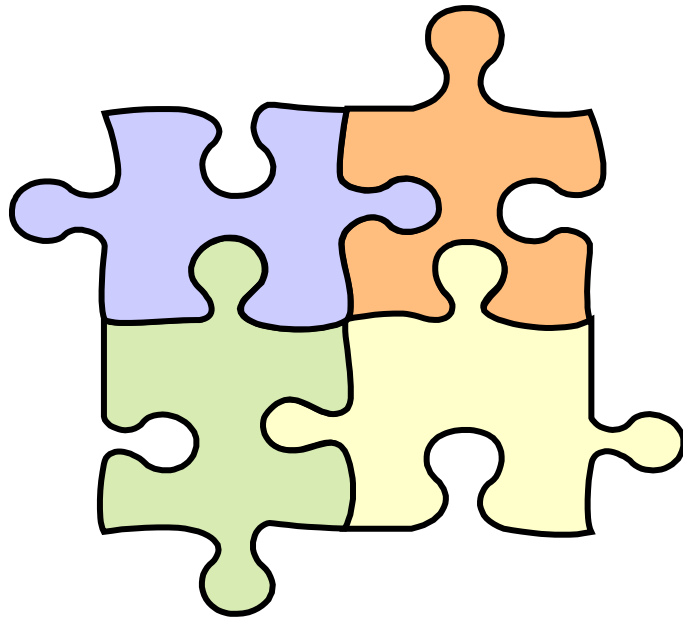
Rolling Regressions: 24-month window



Dynamic Style Analysis (DSA)

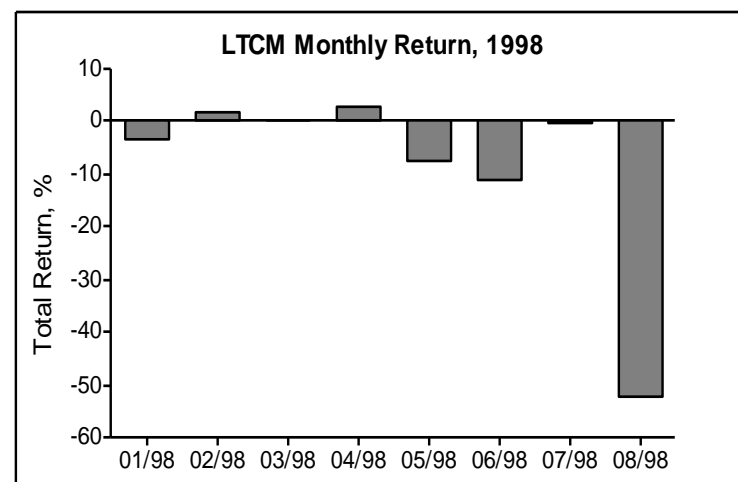
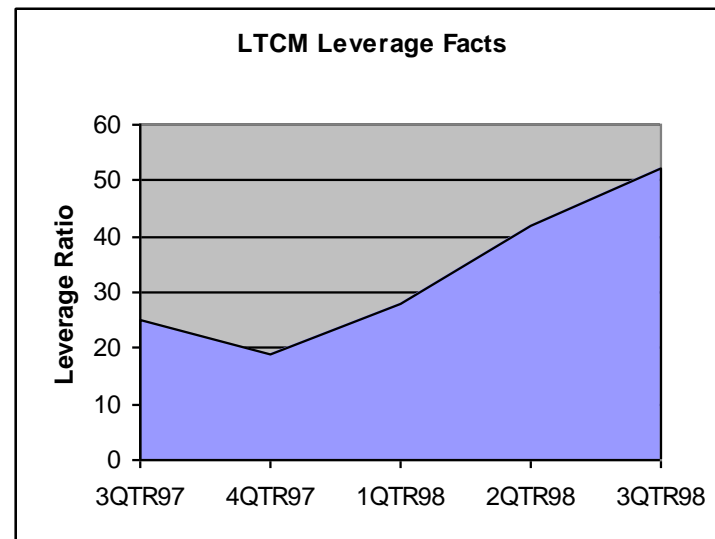


Case Studies



LTCM 1998

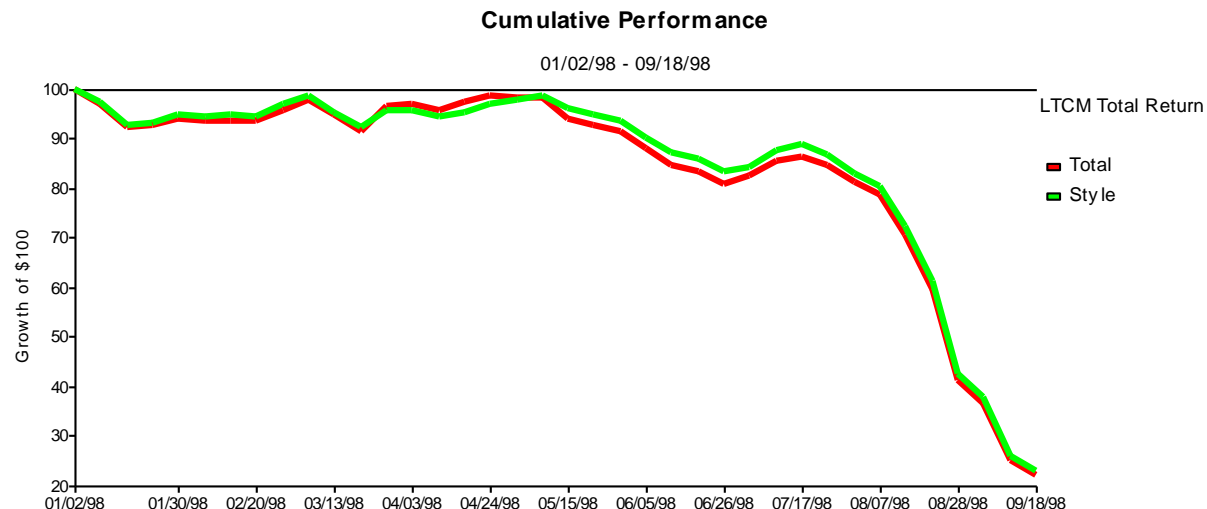
- Fund management team included 2 Nobel Prize academics
- Fund strategy involved highly leveraged bets on bond spreads. Over 60,000 positions
- In Dec 1997 had \$4.7B in assets and through leverage controlling about \$125B. The value of derivative positions was over \$1.2 trillion
- Leverage ratio rose from 25:1 to 50:1 in 1998
- In August 1998, the fund had lost 52%. On September 23, 1998, the fund has lost 92% of its December 1997 assets.
- The New York Federal Reserve fearing disruption of world markets, orchestrated a \$3.625B bailout of the fund by a consortium of 14 banks
- President Clinton appointed a government committee to analyze the cause of the fund's losses



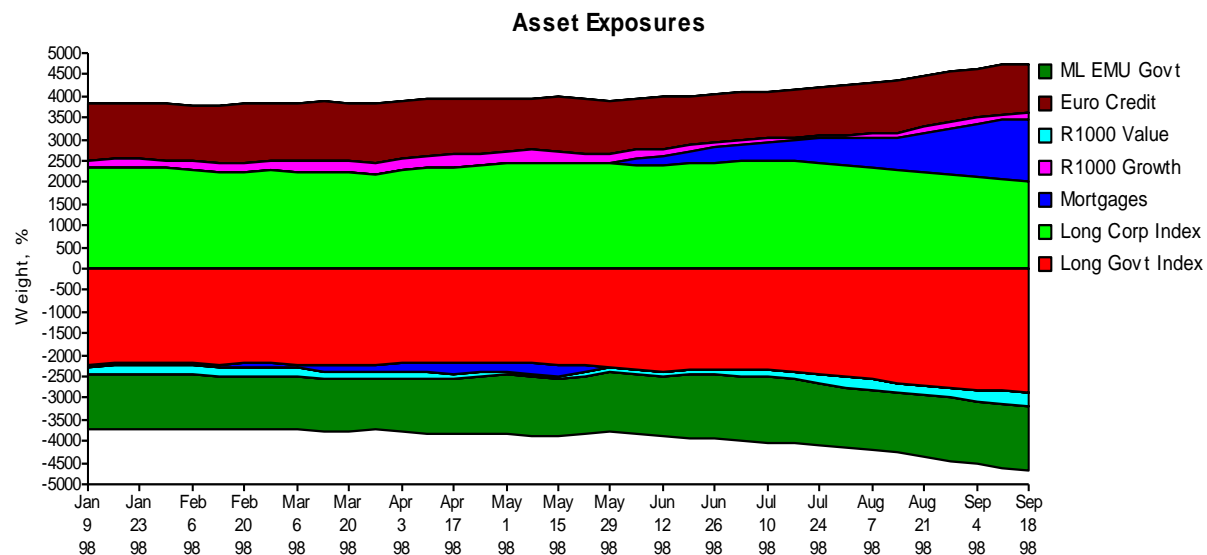
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LTCM 1998 | Analysis with Weekly Data

- Weekly data
- R2=99%
- PR2=86%
- Major bets confirmed
- Leverage 1:35-50



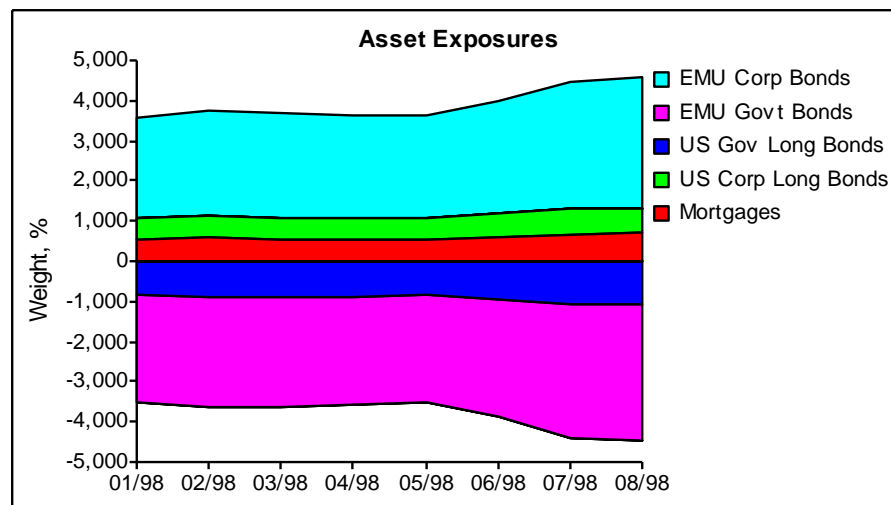
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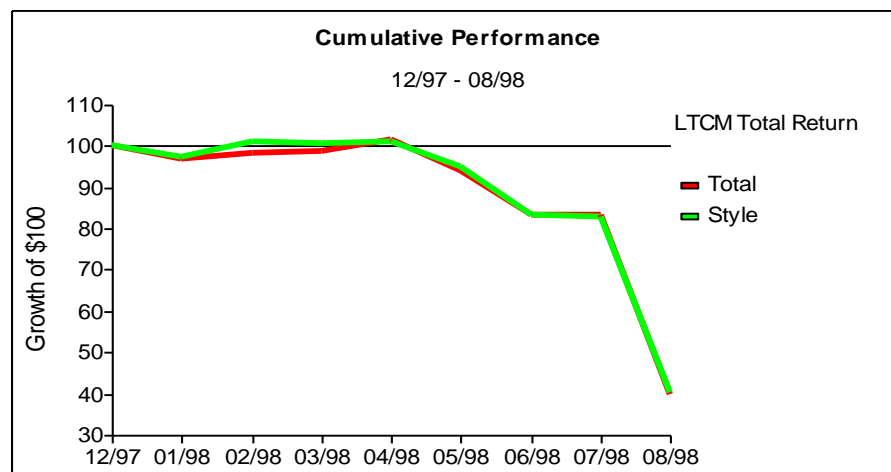
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LTCM 1998 | Monthly Data Analysis

- Only 8 monthly datapoints
- Major bets, leverage confirmed
- Cross-validation was used in model selection (KMMM, 2006)
- 99% monthly VaR in June-August 1998 is 35-55%



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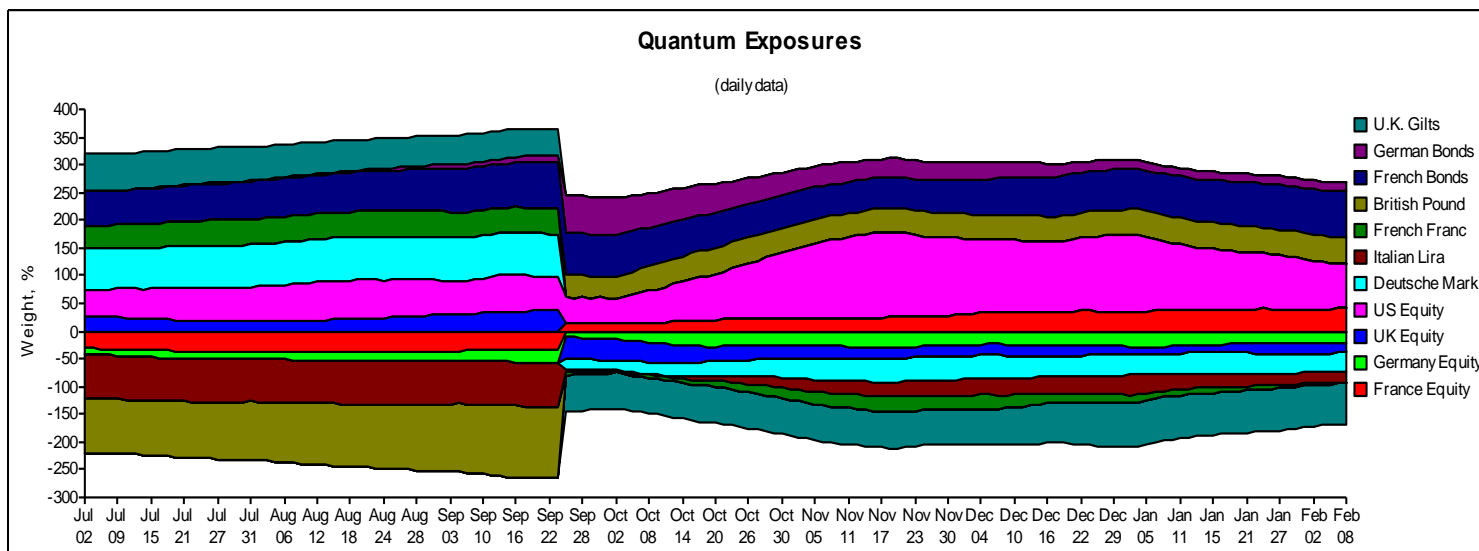


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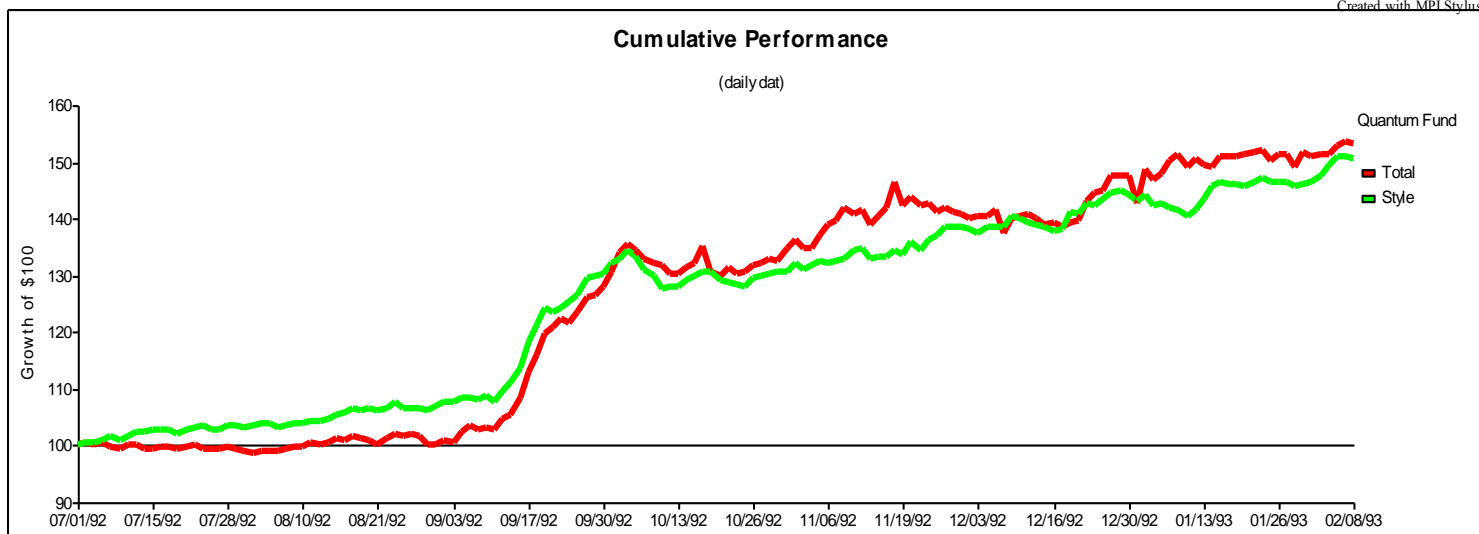
Soros 1992: Breaking the Bank of England

- British Pound tied to DM through ERM
- George Soros, through \$4B Quantum Fund and several other funds, borrowed almost \$10B of UK Pound
- European Central Banks couldn't support the price of Pound relative to the DM
- On September 16, 1992, “Black Wednesday”, the Central Banks of Britain and Italy devaluated their currencies and pulled from ERM
- Soros, buying back Pounds and selling marks, made about a \$1Billion profit
- We will perform an analysis of the Quantum fund using daily fund NAVs from Bloomberg

Soros 1992: Breaking the Bank of England

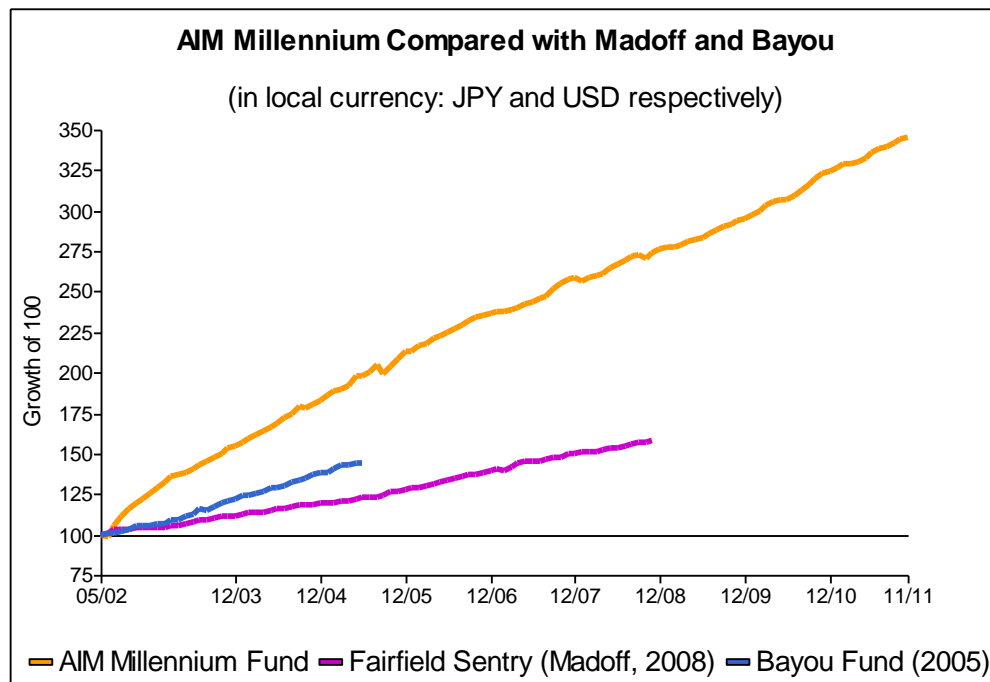


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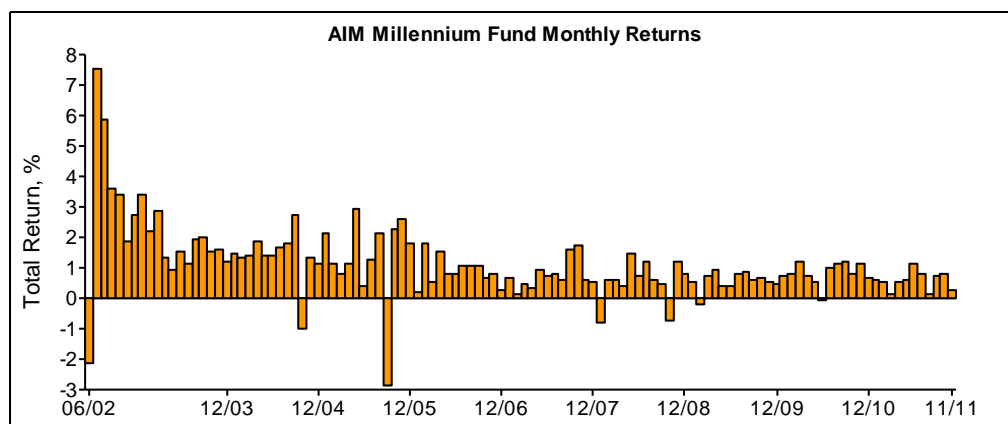
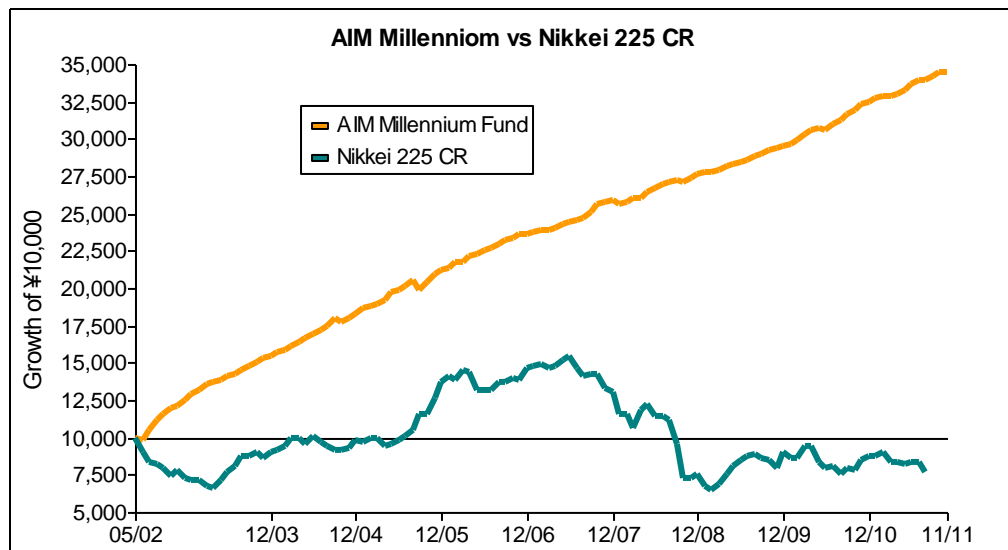
- In February 2012 Japan's financial authorities halted operation of AIJ Advisors – a money-management firm after finding that they lost billions of yen in clients' money
- It was reported AIJ losses totaled \$1.4B in over 100 corporate pension funds with 880,000 employees



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- In 2009, per client's request MPI Japan performed an analysis of the AIJ fund and couldn't find a strategy that could have explained the fund's exceptional long-term performance
- Like Madoff and Bayou, AIJ funds claimed sophisticated options strategies as the source of their exceptional performance

AIM Millennium | What We Do Know

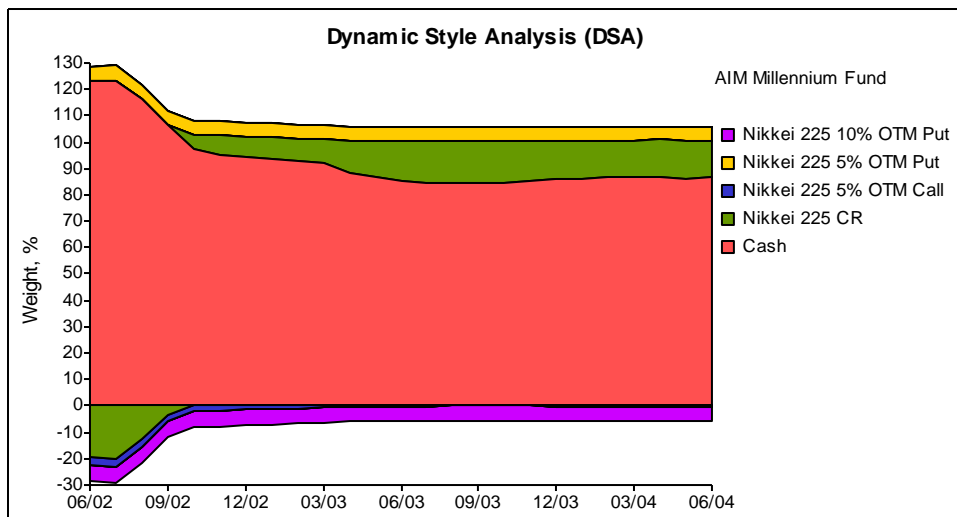


- “Delta neutral” volatility strategy - selling options on Nikkei 225 index
- Strike ~ Nikkei 225 +/- ¥1 000
- Fund’s performance 2002-2011 is exceptionally smooth despite market volatility
- The following factors used for the analysis:

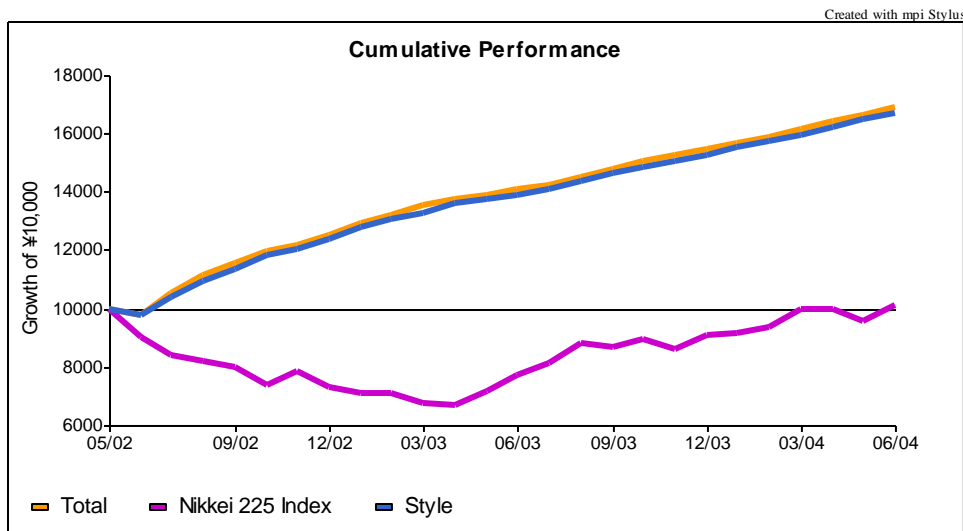
6 synthetic portfolios of Nikkei 225
Calls and Puts rolled forward at the
end of the month with strikes:

+/-10% +/-5% and ATM

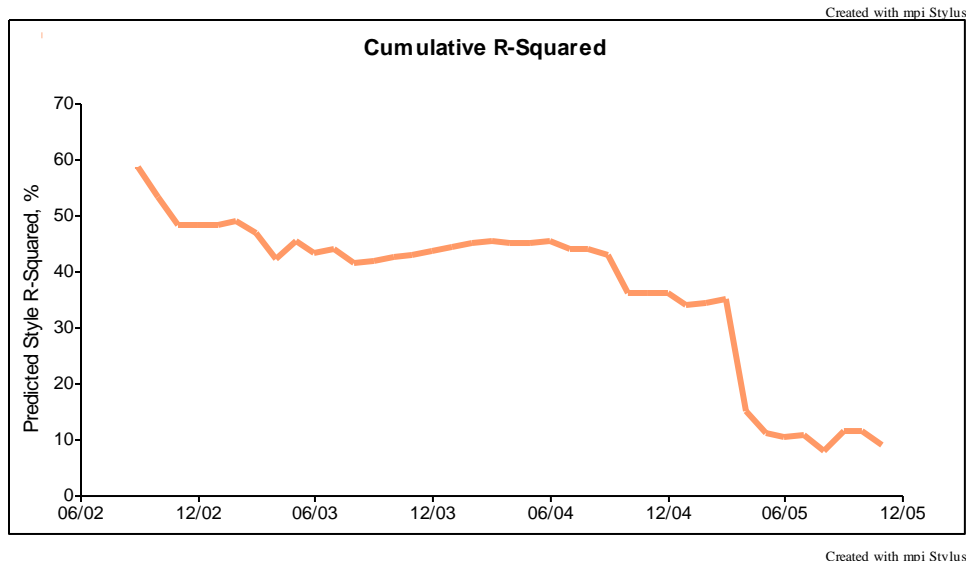
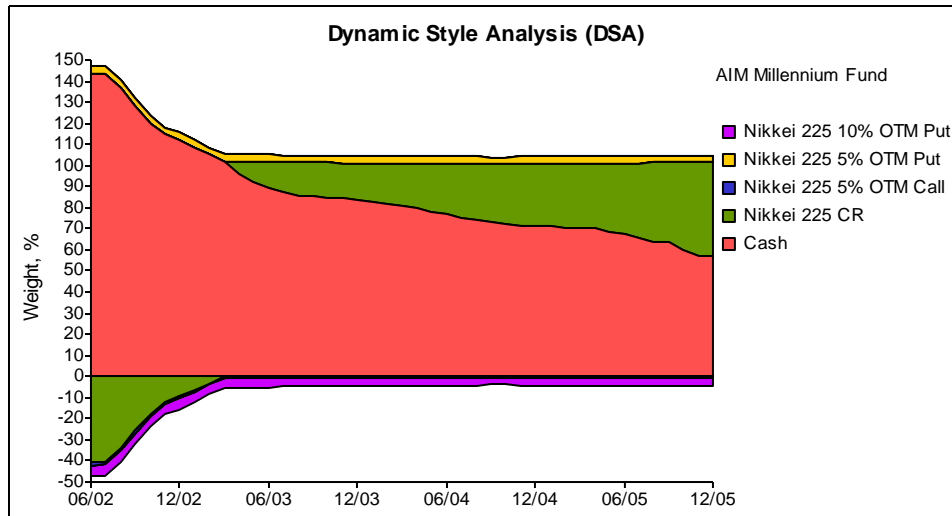
AIM Millennium | Analysis through June 2004



- We found that through June 2004 the fund's strategy could be explained by a portfolio invested in short-term Japan's govt bonds, Nikkei 225 index and also long and short 10% and 5% OTM puts and calls
- Fund's performance is replicated perfectly (blue and yellow lines coincide) although we cannot claim any validity or merit to it: it can be validated only through a manager interview or analysis of fund's positions and trading information

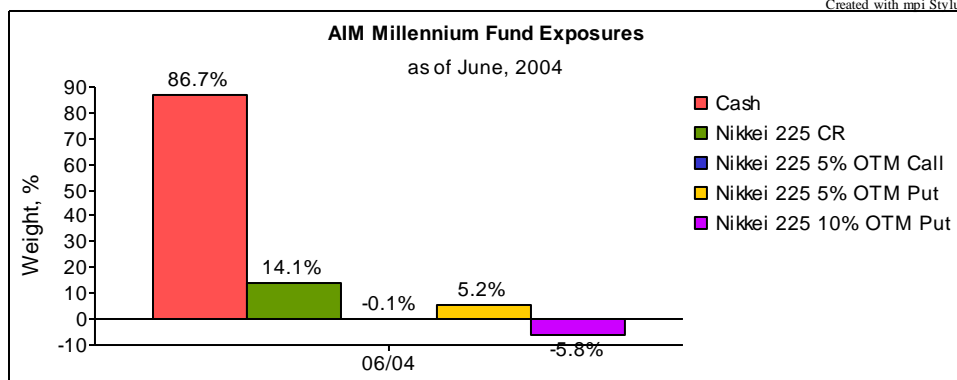
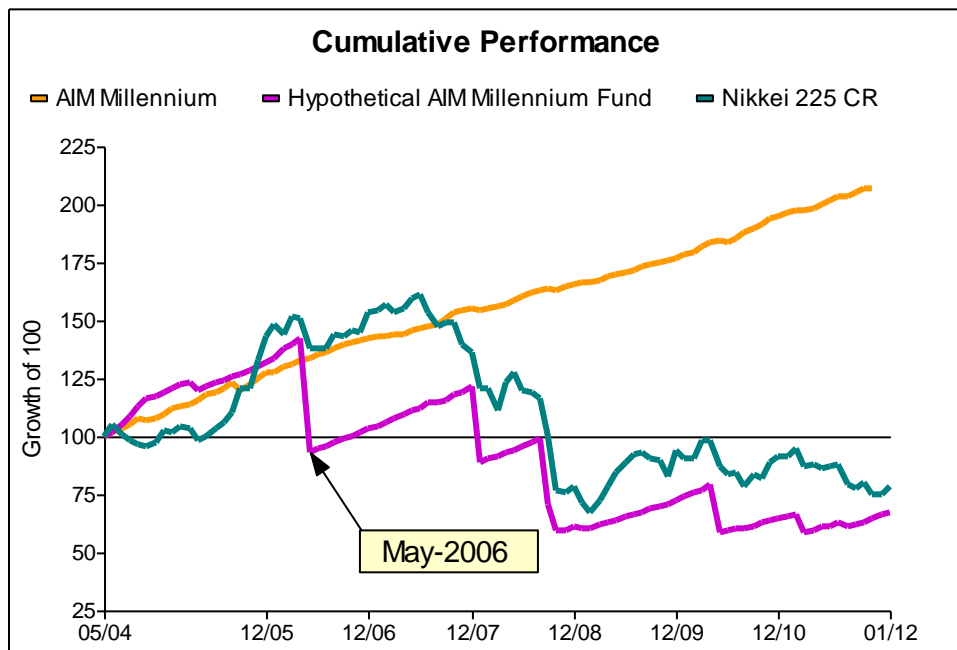


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- As new monthly performance data from the fund manager comes in it is prudent to repeat the analysis with an extended data set
- When we added returns month-by-month through Dec 2005 the quality of analysis – as measured by Predicted R-Squared – deteriorated noticeably (from 50% to 10%)
- At the same time the structure and level of exposures to market indices and put/call option strategies remained similar with a good tracking of performance results.
- Once we added May 2006 fund return of 0.79% (vs Nikkei 225 loss of -8.5%), the entire analysis collapsed as if such a return would have contradicted the strategy
- This typically would warrant a call to the fund manager to validate the course of the strategy or the return data accuracy

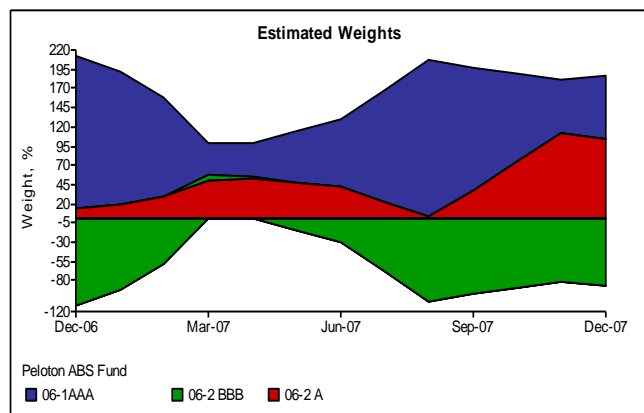
AIM Millennium | Hypothetical Scenario



- When there's limited transparency on one's investment, as often the case with hedge funds, a prudent investor needs to monitor hypothetical performance of the fund using the "starting point" analysis as the proxy
- In our case, we simulated performance of the fund using a hypothetical portfolio defined by exposures from our June 2004 analysis (chart below)
- Such a strategy would inevitably collapse in May 2006 losing appx. 50% of portfolio value (magenta – hypothetical fund).
- At the same time, the fund continued to report steady positive returns.

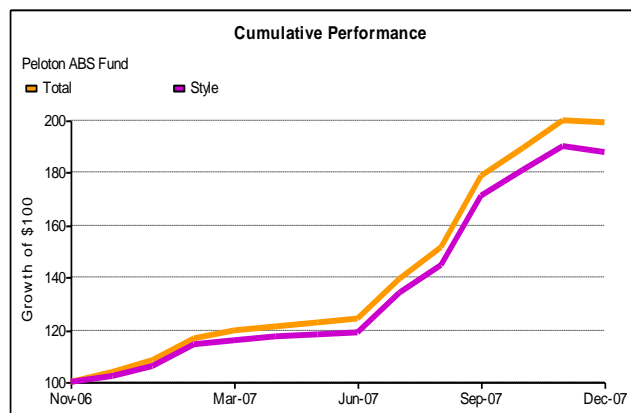
Peloton ABS Fund 2007

Estimated exposures



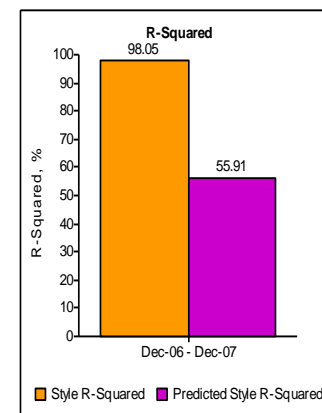
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Performance Tracking



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Credibility

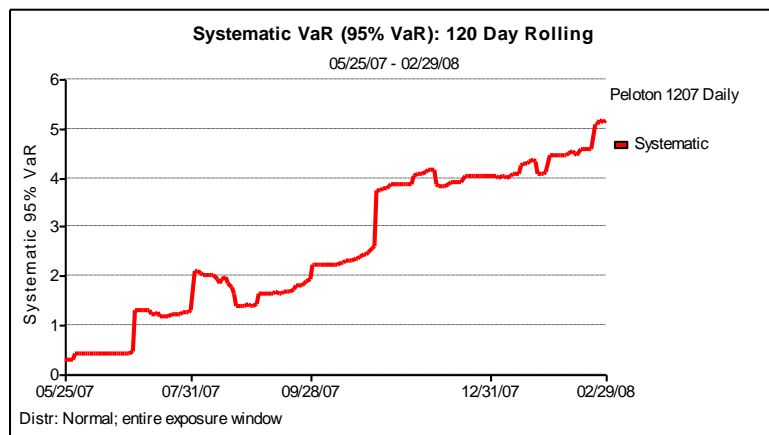


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- Peloton ABS Hedge Fund won Eurekahedge “Credit Fund of the Year” award in January 2008
- A month later, in Feb 2008 was forced to liquidate due to heavy losses. As of Dec’07 nothing in the fund’s monthly performance indicated embedded risks
- Only 13 monthly returns were available from Dec’ 06 to Dec’07
- For the analysis we used 15 ABX indexes with three different issuance dates (06-1, 06-2 and 07-1) and five different tranches (AAA, AA, A, BBB, BBB-)
- Performing exhaustive search the system automatically selected a dynamic combination of 3 tranches providing the most predictive result. Results were later confirmed by a former Peloton analyst

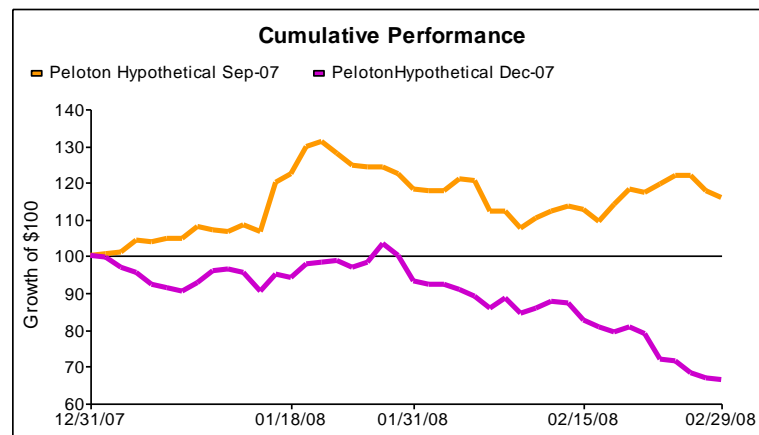
Peloton ABS Fund: Scenario Analysis

120 Days Rolling VaR (95%)



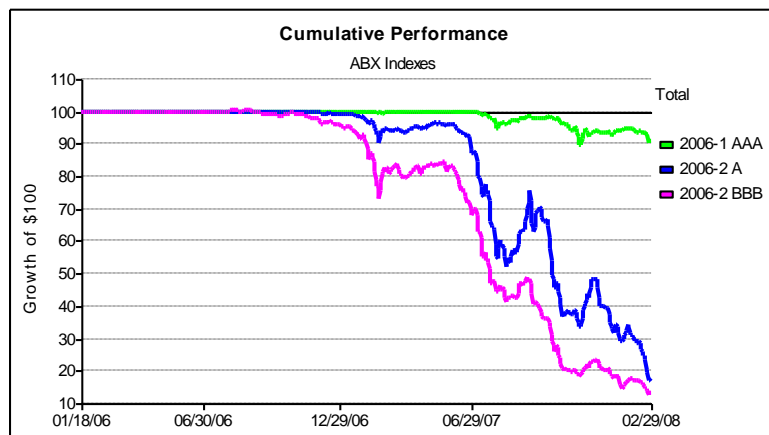
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Hypothetical Results Sep'07 & Dec'07 portfolios



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ABX Index Tranches Performance

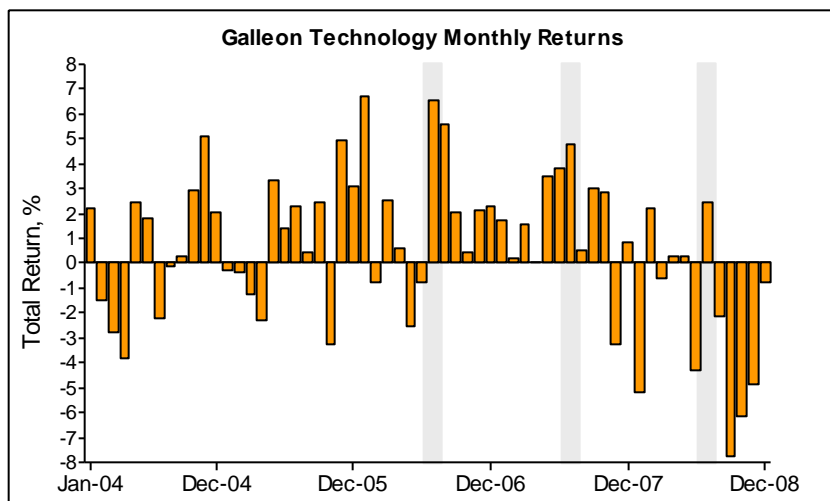


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- To understand the fund's risks in 2008 we projected hypothetical daily performance using factor exposures as of Sep-07 and Dec-07
- If the fund didn't make a move into the A tranche, it would have made money in Feb-08 vs. hypothetical loss of about 35%
- Note steady increase in daily systematic VaR through the year. Largest component VaR came from the fund's exposure to "06-2 A" tranche

Galleon Technology Fund 2009

- Galleon Group was one of the largest hedge funds in the world (apx. \$7B)
- In October 2009, Raj Rajaratnam, the founder of Galleon Group, and several other executives were charged with insider trading. Sentenced to 11 years in prison on the 13th October, 2011.
- The US Government used wiretaps and informants to collect evidence
- The complaint focused on July 2007 and July 2008 as the months with the most significant alleged illegal profit: \$12M in Jul'07 and \$4M in Jul'08
- In January 2010, DOJ and SEC brought additional charges against the manager alleging that in July 2006 Galleon profited from insider information about AMD/ATI transaction in the amount of \$19M

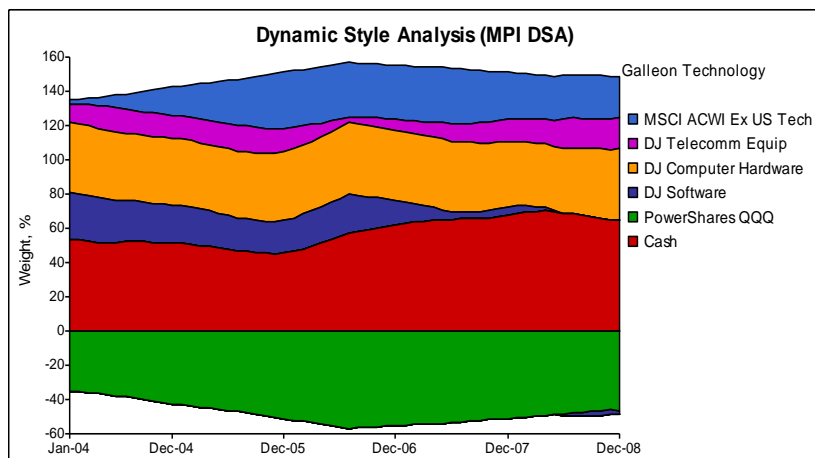


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Galleon monthly returns in 2004-2008 show no signs of abnormality in highlighted months

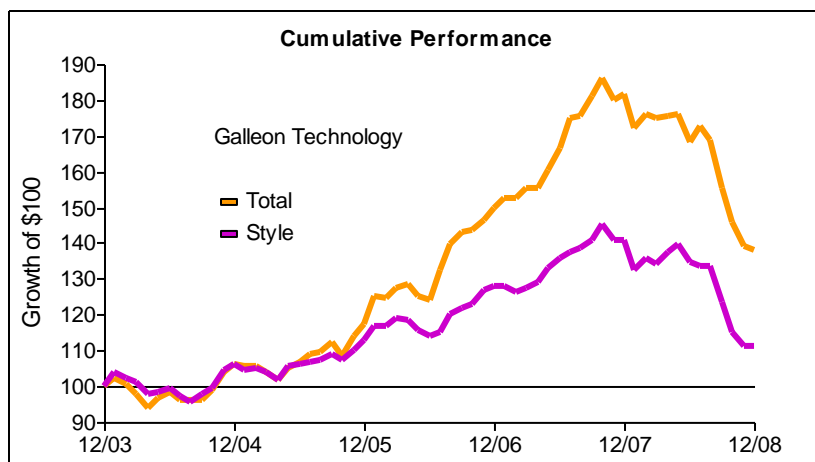
MPI does not claim to know or insinuate the actual strategy, positions or holdings of the Galleon Technology Fund; nor are we commenting on the quality or merits of the fund's strategy.

Galleon Fund 2009 | DSA Analysis



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- Forensic analysis of monthly returns
- Long factors:
Telecomm Equip, Comp. Hardware, Software
- Hedge: Nasdaq100 (QQQ)
- R-Squared = 80%
- Credibility (Predicted R2) = 65%



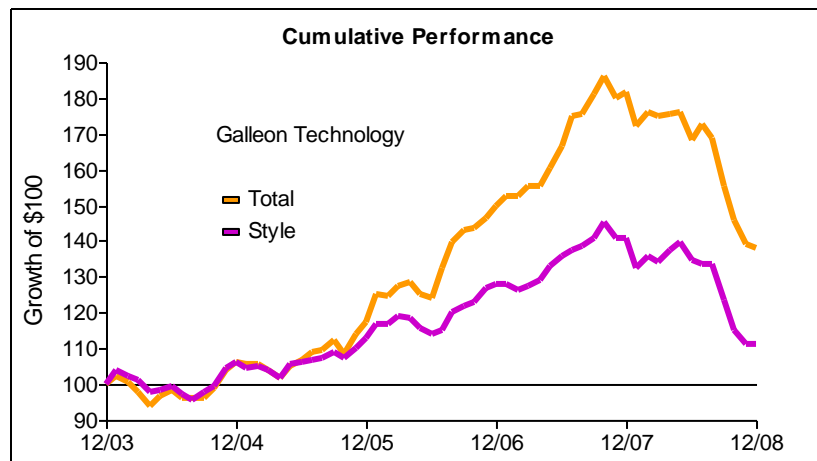
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**Large portion of returns
is unexplained**

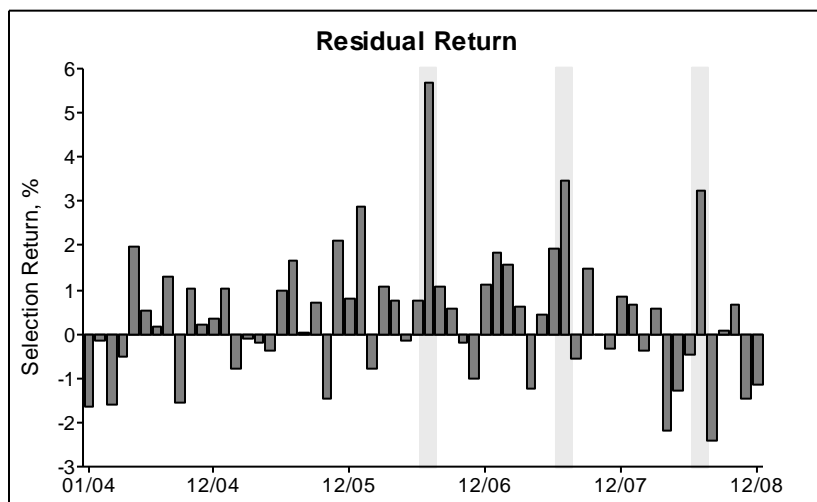
- Alpha?

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Galleon Fund 2009 | Residuals



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Residuals analysis

- All three outliers linked to the case
- Jul'07, Jul'08 subject of the original complaint (Oct'09)
- Jul'06 subject of additional Jan'10 amendment
- The size of Jul'06 gain exceeds other two months of alleged insider trading

MPI does not claim to know or insinuate the actual strategy, positions or holdings of the Galleon Technology Fund; nor are we commenting on the quality or merits of the fund's strategy.

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