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The price of fear

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ANALYST CERTIFICATION AND REQUIRED DISCLOSURES BEGIN ON PAGE 40

Outline

- The risk/return tradeoff: An empirical puzzle
- Why do volatile stocks *under*performance globally?
  - Is it a liquidity issue?
  - Is it an effect of high beta?
  - Is it an effect of sector tilts/ geographic tilts?
- Market volatility as a risk factor:
  -Is it priced globally?
  -Does it explain the puzzle?
  -Disentangling short and long term effects
- Conclusion

Introduction

- Ang et al. (2006) show that stocks with high idiosyncratic volatility relative to the Fama and French (1993) model tend to underperform the market. In addition, they argue that this phenomenon cannot be explained by liquidity effects.
- Blitz and van Vliet (2007) argue that a similar result can be obtained by screening stocks based on *total* volatility measured over periods of three years. Unlike the universe used in Ang et al. (2006), theirs is made up of global large cap companies. Blitz and van Vliet (2007) argue that investors who are not benchmark-driven and are willing to apply leverage should consider a strategy based on buying low volatility stocks and shorting high volatility ones.
- Bali and Cakici (2008) dispute the results in Ang et al. (2006). Using US data they show that the result depends heavily on the data frequency used to estimate volatility, the weighting scheme (equally or value-weighted) and the choice of universe. The high volatility strategy, in particular, tends to result in large positions in small, extremely illiquid stocks.

Data

- Daily and monthly data on prices and dividends from Dow Jones. Source merged with HSBC to fill gaps.
- Sample period 1992Q1-2008Q1.
- Universe:
  - All constituents of Dow Jones World for North America
  - All constituents of Dow Jones World for (developed) Europe
  - All constituents of Dow Jones World for Japan
- Interest rates for Germany and Japan taken from Bloomberg. The source for US interest rates is the Federal Reserve.
- Style indices are calculated by the UBS Quant team.
- Turnover is measured as the proportion of market cap in the portfolio that is traded (bought or sold). If the portfolio remains unchanged the turnover is zero. If all holdings are liquidated and substituted with an entirely new portfolio then the turnover equals 2 (100% sold and 100% bought).

Methodology (1)

- Total volatility is calculated as realised volatility of the (total) return from daily data, i.e. the sum of squared daily returns.

- Idiosyncratic volatility is computed as the realised volatility of the residuals of a Fama-French (1993) model, i.e. a factor model made up of three factors, market, SML and HML:

  $$r_{it} = \alpha_i + \beta_{i,MKT} MKT_t + \beta_{i,SMB} SMB_t + \beta_{i,HML} HML_t + u_{it}$$

  The model is estimated, company by company, on monthly windows from daily data (as in Ang et al. (2006)).

- Portfolios are equally weighted, as in Blitz and van Vliet (2007).

- Two volatility screens are simulated:
  - ‘1m’ based on volatilities calculated from windows of one month
  - ‘3Y’ based on volatilities calculated from three year windows.

- ‘High’ and ‘Low’ volatility portfolios are the top and bottom deciles of the universe

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Methodology (2)

- In the sector neutral screen, volatility threshold are calculated on a sector by sector basis and then the portfolios are gathered across sectors. We use the ten-group ICD classification.
- *F*-statistics and *t*-statistics are calculated by using the Newey and West (1987) correction for heteroscedasticity and autocorrelation.
- The methodology of Ledoit and Wolf (2008) is used to test for the significance of the difference between Sharpe ratios.
- Transaction costs are not considered.

Empirical results – Global universe

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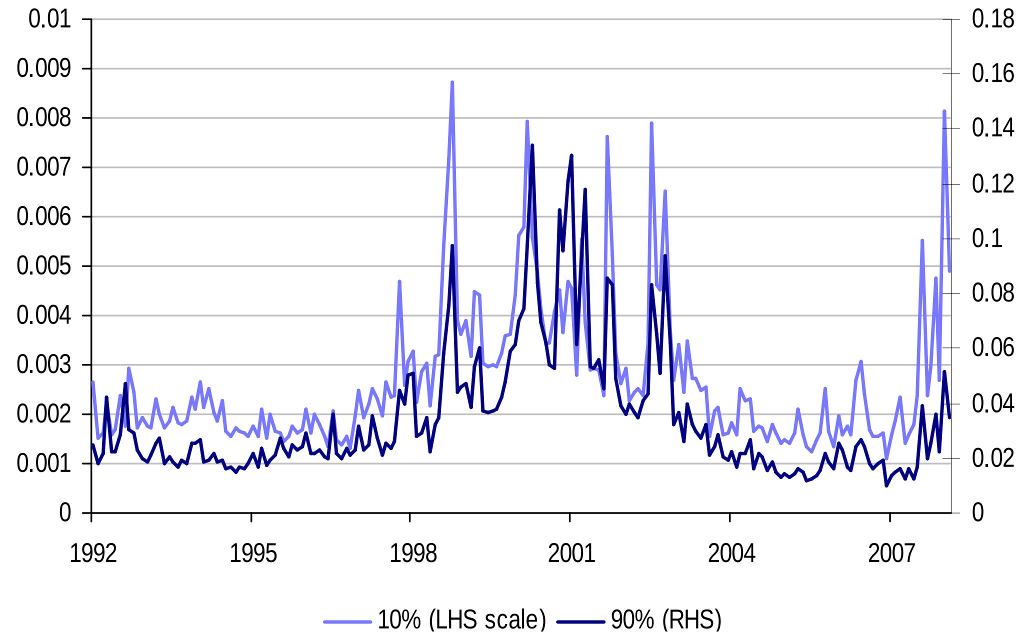
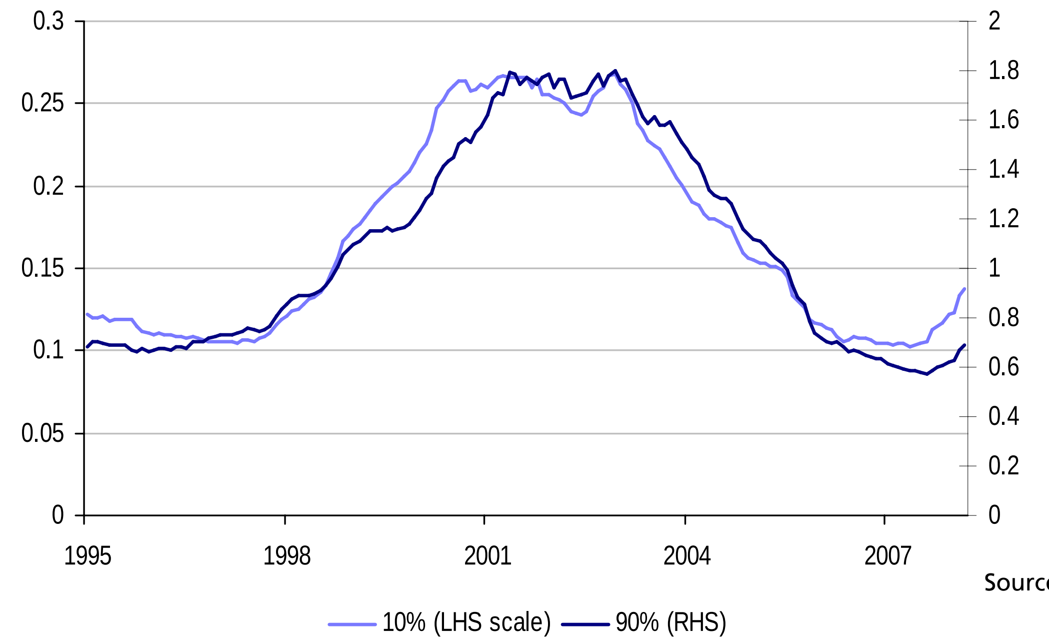
Realized variance thresholds



1- month variance



3-year variance

Source: UBS estimates

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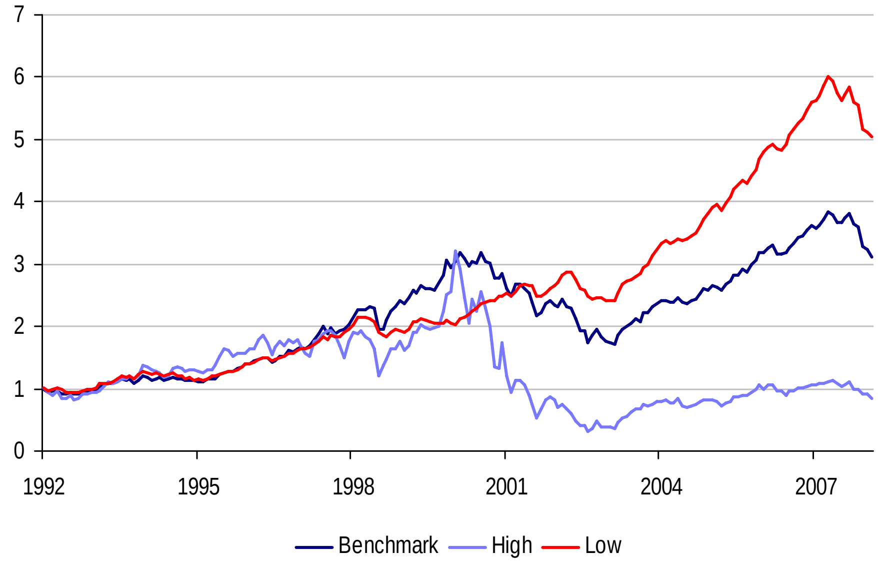
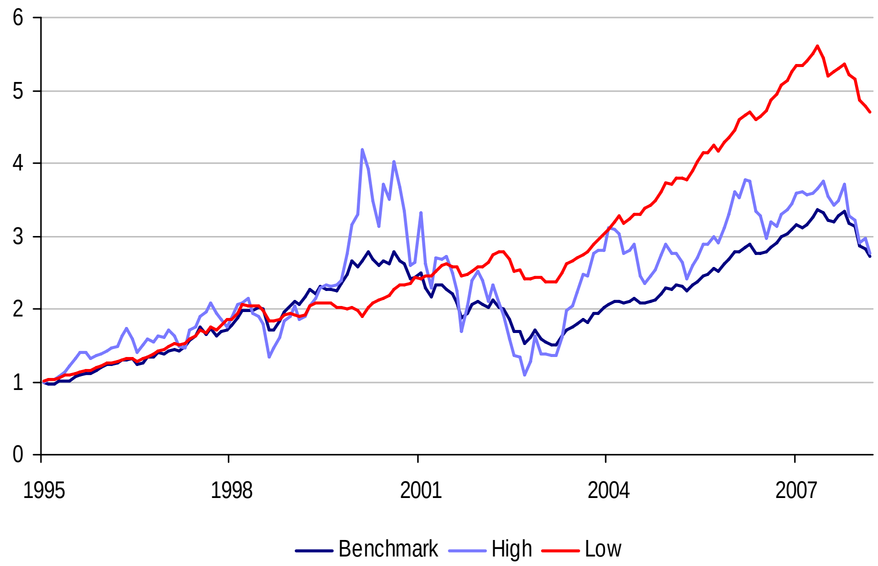
Performance: total return indices



1- month volatility



3-year volatility

Source: UBS estimates

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Main result, global universe (decile Sharpe ratios)

Decile	1 (low)	2	9	10 (high)	H - L	p-value
1 month volatility						
Mean	6.50%	7.13%	4.43%	1.09%		
Standard Dev	8.28%	10.02%	24.26%	34.12%		
Sharpe Ratio	0.79	0.71	0.18	0.03	-0.75	0.017
3 year volatility						
Mean	8.13%	7.53%	2.93%	9.10%		
Standard Dev	8.27%	10.36%	21.31%	32.89%		
Sharpe Ratio	0.98	0.73	0.14	0.28	-0.71	0.039

Source: UBS estimates

P-values are from the Ledoit-Wolf (2008) test of the hypothesis that the Sharpe ratios are equal.

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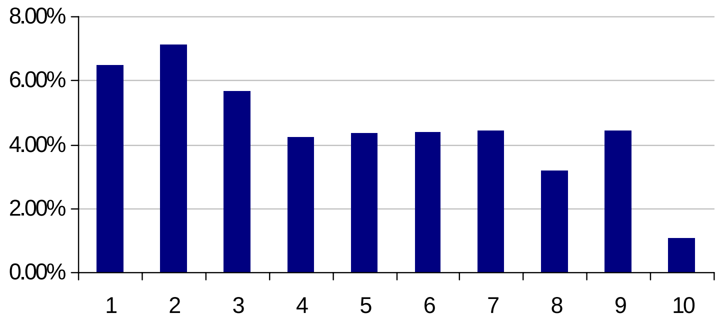
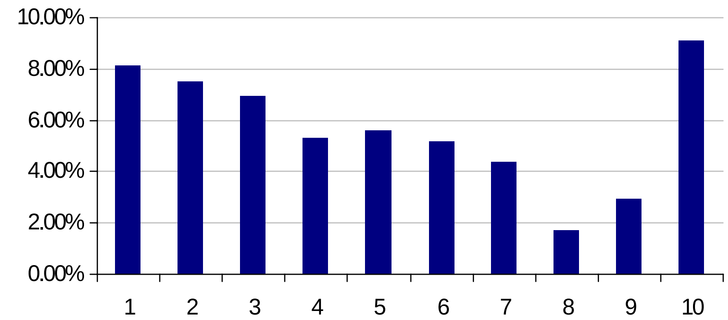
Main result, global universe (decile Sharpe ratios)

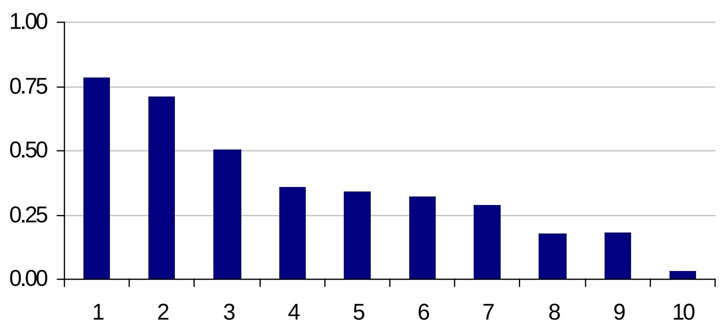
1-month vol | 3-year vol

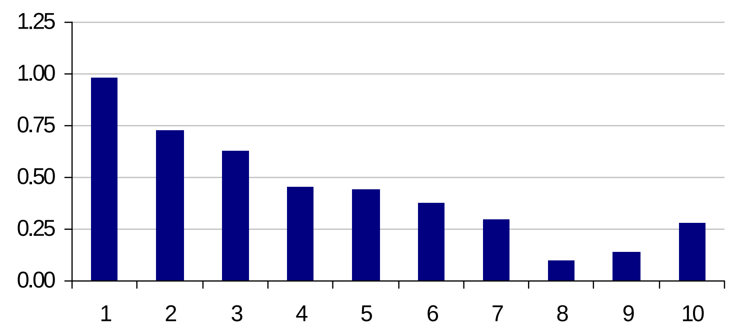
Mean excess return





Sharpe ratio





Source: UBS estimates

Performance summary, global universe

	High vol	Low vol	Benchmark	*p value*
1m				
TotRet	-0.96%	10.06%	8.24%	
On BM	-6.16%	2.10%	0.00%	
On Risk Free	-4.89%	6.16%	4.34%	
CAPM alpha	-0.011	0.005		
p value	0.028	0.000		
FF alpha	-0.004	0.004		
p value	0.334	0.000		
FF plus MOM alpha	-0.001	0.003		
p value	0.874	0.004		
Turnover	1.128	1.106		
Sharpe	0.032	0.786	0.394	0.017
Sortino	0.031	0.720	0.350	
3Y				
TotRet	7.68%	11.75%	8.39%	
On BM	1.88%	3.08%	0.00%	
On Risk Free	3.70%	7.79%	4.42%	
CAPM alpha	-0.004	0.007		
p value	0.408	0.000		
FF alpha	0.001	0.005		
p value	0.725	0.000		
FF plus MOM alpha	0.003	0.004		
p value	0.458	0.000		
Turnover	0.088	0.078		
Sharpe	0.277	0.984	0.391	0.039
Sortino	0.274	0.847	0.341	

Source: UBS estimates

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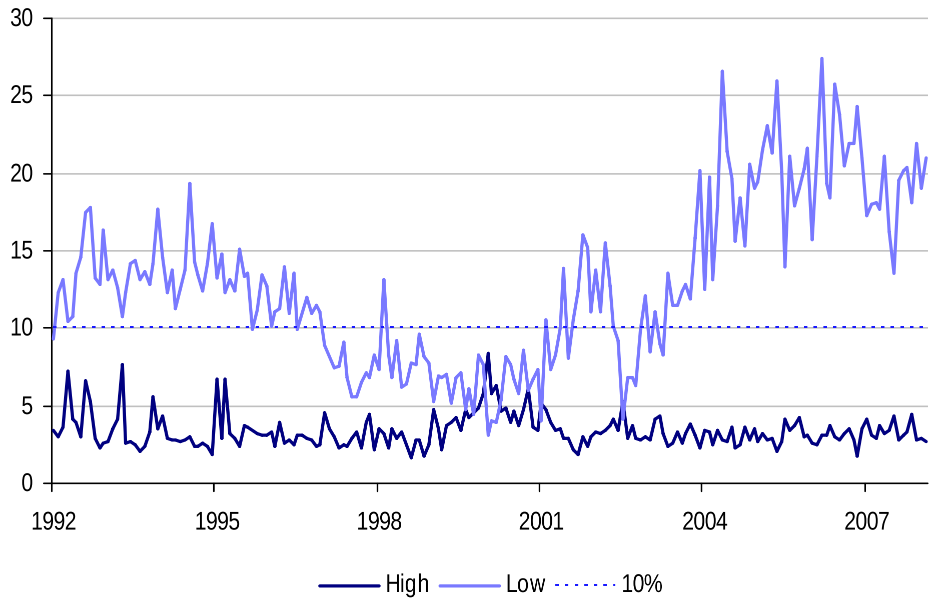
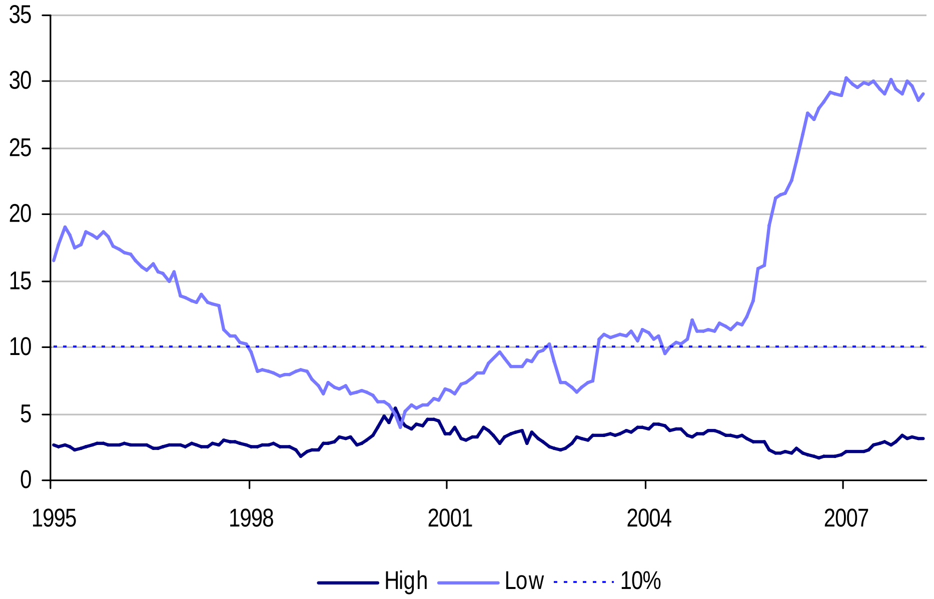
Total market cap of the stocks in the H/L portfolios



1- month volatility



3-year volatility

Source: UBS estimates

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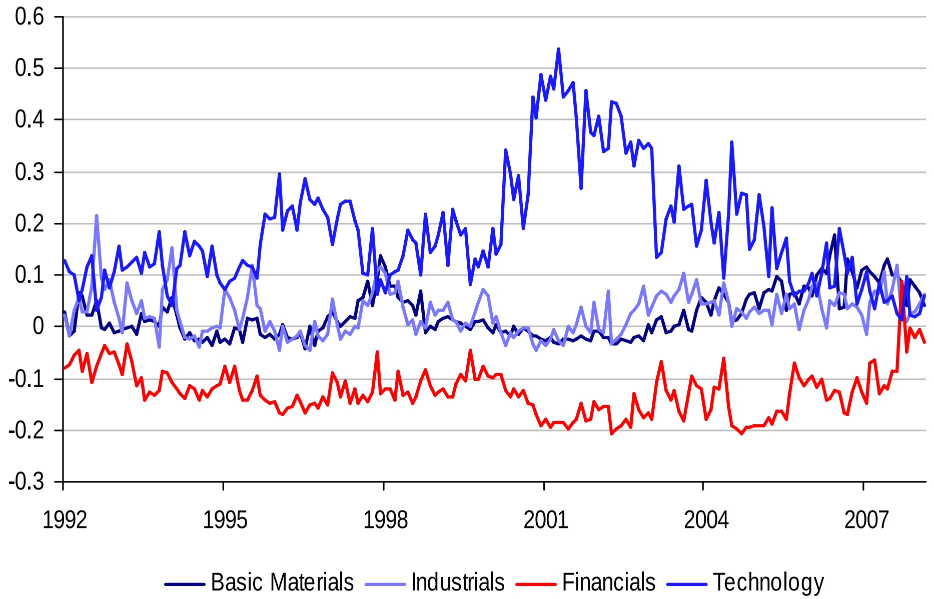
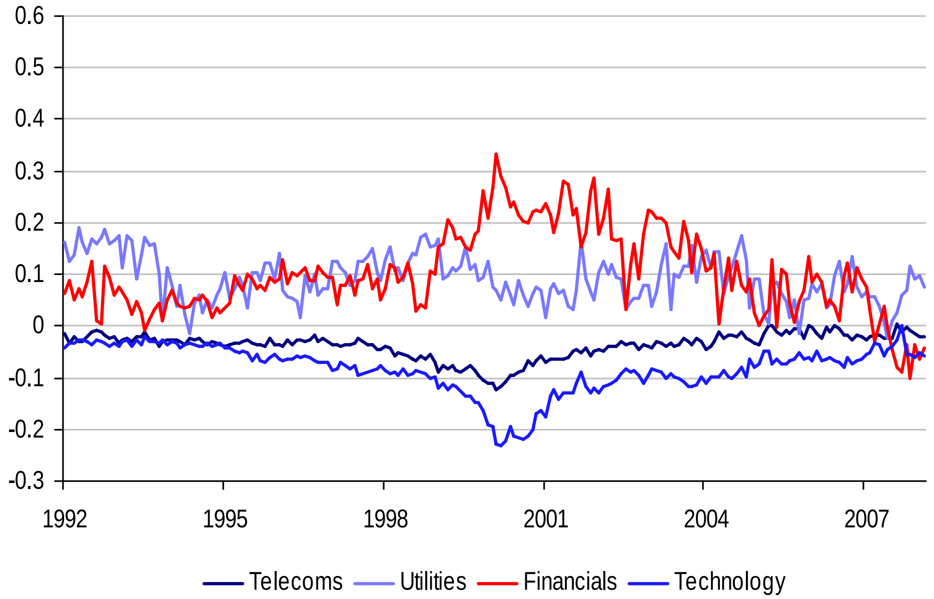
Main sector tilts (short term volatility)



1- month volatility, High



1-month volatility, Low

Source: UBS estimates

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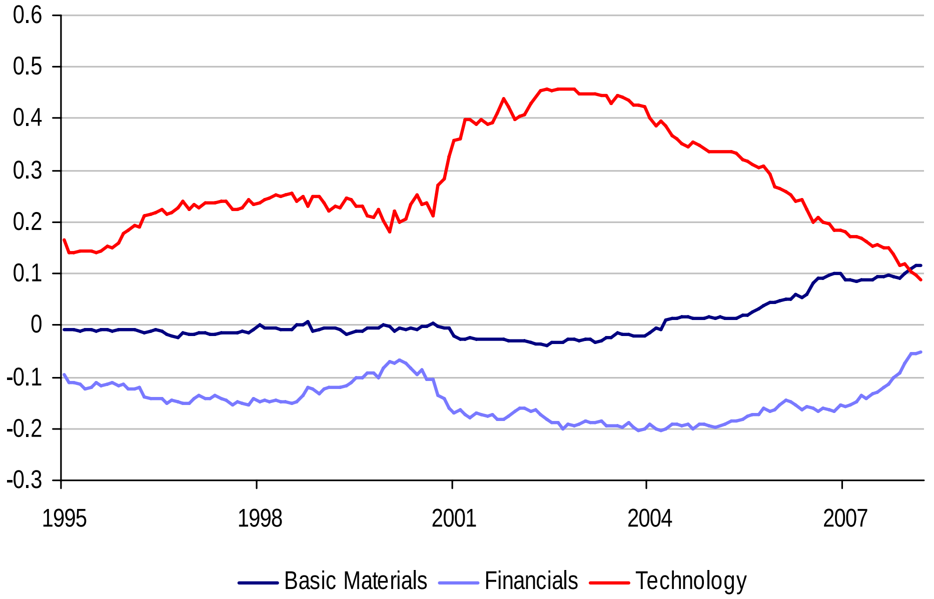
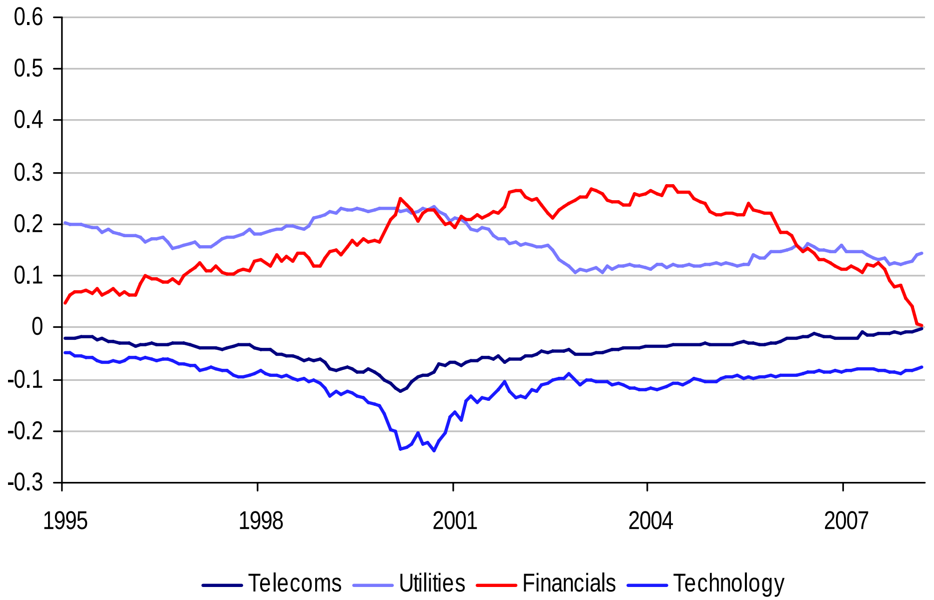
Main sector tilts (three-year volatility)



3-year volatility, High



3-year volatility, Low

Source: UBS estimates

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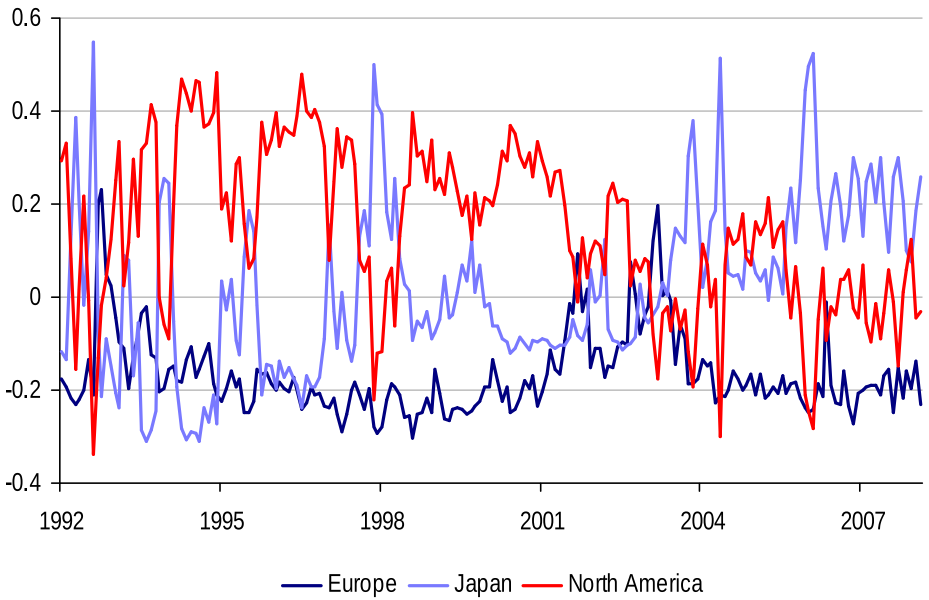
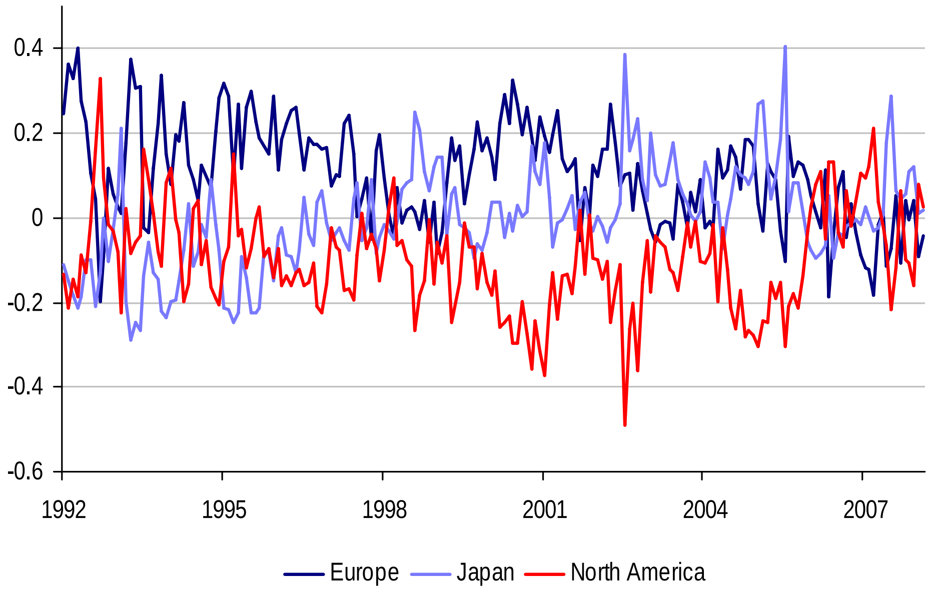
Geographic tilts (short term volatility)



1- month volatility, High



1-month volatility, Low

Source: UBS estimates

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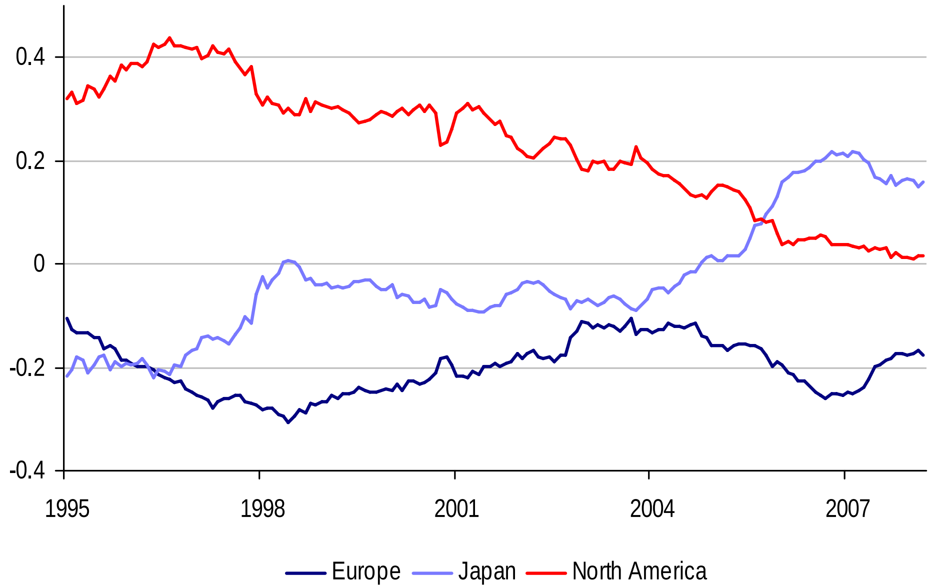
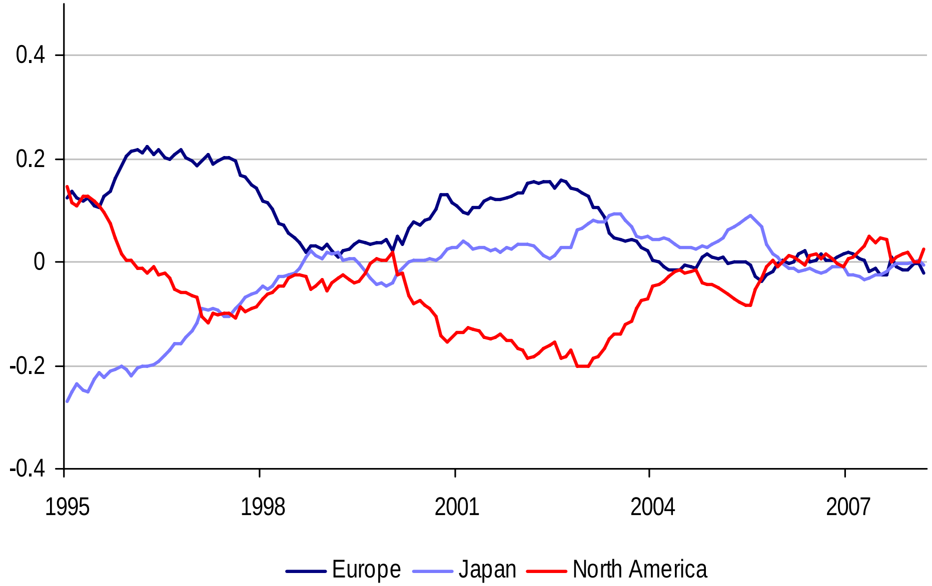
Geographic tilts (three-year volatility)



3-year volatility, High



3-year volatility, Low

Source: UBS estimates

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Performance summary, using idiosyncratic volatility

1m	High vol	Low vol	Benchmark	*p value*
TotRet	-0.61%	9.87%	8.38%	
On BM	-6.11%	1.91%	0.00%	
On Risk Free	-4.53%	5.97%	4.48%	
CAPM alpha	-0.010	0.005		
p value	0.020	0.000		
FF alpha	-0.005	0.003		
p value	0.225	0.003		
FF plus MOM alpha	-0.002	0.003		
p value	0.653	0.013		
Turnover	1.158	1.181		
Sharpe	0.019	0.736	0.404	0.017
Sortino	0.018	0.650	0.358	
3Y				
TotRet	8.37%	11.22%	8.63%	
On BM	2.19%	2.44%	0.00%	
On Risk Free	4.41%	7.28%	4.68%	
CAPM alpha	-0.003	0.006		
p value	0.449	0.000		
FF alpha	0.002	0.004		
p value	0.685	0.001		
FF plus MOM alpha	0.003	0.003		
p value	0.499	0.003		
Turnover	0.091	0.080		
Sharpe	0.298	0.871	0.409	0.081
Sortino	0.283	0.743	0.356	

Source: UBS estimates

Performance summary, sector neutral

	High vol	Low vol	Benchmark	*p value*
1m				
TotRet	1.19%	9.34%	8.24%	
On BM	-4.78%	1.61%	0.00%	
On Risk Free	-2.72%	5.44%	4.34%	
CAPM alpha	-0.008	0.004		
p value	0.023	0.003		
FF alpha	-0.004	0.003		
p value	0.152	0.009		
FF plus MOM alpha	-0.002	0.002		
p value	0.472	0.039		
Turnover	1.199	1.187		
Sharpe	0.030	0.615	0.394	0.016
Sortino	0.030	0.552	0.350	
3Y				
TotRet	4.39%	11.27%	8.39%	
On BM	-2.26%	2.85%	0.00%	
On Risk Free	0.42%	7.31%	4.42%	
CAPM alpha	-0.005	0.006		
p value	0.134	0.000		
FF alpha	-0.002	0.004		
p value	0.438	0.000		
FF plus MOM alpha	-0.001	0.004		
p value	0.646	0.001		
Turnover	0.106	0.100		
Sharpe	0.141	0.851	0.391	0.008
Sortino	0.140	0.704	0.341	

Source: UBS estimates

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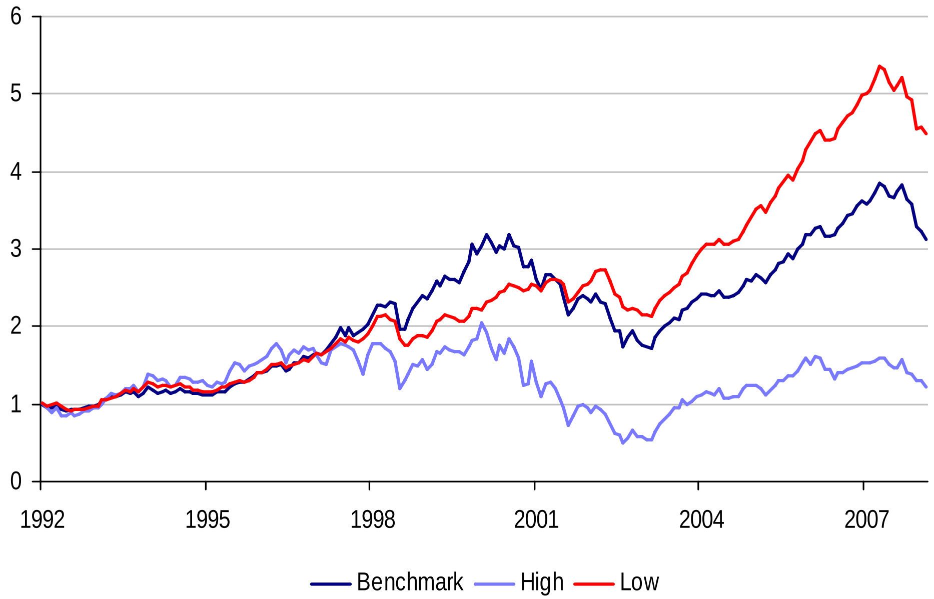
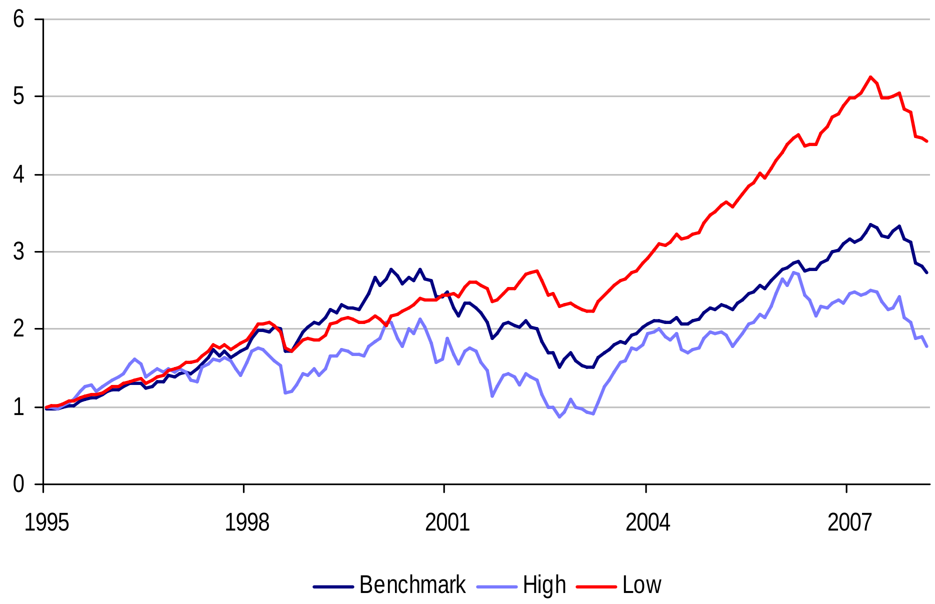
Performance: total return indices (sector neutral)



1- month volatility



3-year volatility

Source: UBS estimates

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Performance summary, region neutral

1m	High vol	Low vol	Benchmark	*p value*
TotRet	-2.34%	9.04%	8.24%	
On BM	-7.92%	1.04%	0.00%	
On Risk Free	-6.26%	5.14%	4.34%	
CAPM alpha	-0.012	0.005		
p value	0.003	0.000		
FF alpha	-0.007	0.003		
p value	0.058	0.001		
FF plus MOM alpha	-0.004	0.003		
p value	0.214	0.007		
Turnover	1.240	1.121		
Sharpe	-0.062	0.689	0.394	0.016
Sortino	-0.060	0.623	0.350	
3Y				
TotRet	4.24%	10.45%	8.39%	
On BM	-1.89%	1.69%	0.00%	
On Risk Free	0.26%	6.48%	4.42%	
CAPM alpha	-0.006	0.006		
p value	0.148	0.000		
FF alpha	-0.001	0.005		
p value	0.735	0.000		
FF plus MOM alpha	0.000	0.004		
p value	0.902	0.000		
Turnover	0.110	0.078		
Sharpe	0.156	0.886	0.391	0.027
Sortino	0.155	0.774	0.341	

Source: UBS estimates

Summary of regional results

- Performance of portfolios sorted by total volatility
- P-values refer to the Ledoit-Wolf (2008) test for the hypothesis that two Sharpe ratios are equal

1m	High vol	Low vol	Benchmark	L - H spread	p-value
North Am	0.010	1.025	0.476	1.015	0.002
Europe	-0.059	0.647	0.389	0.706	0.014
Japan	-0.081	-0.008	0.029	0.073	0.737
3Y					
North Am	0.388	1.001	0.499	0.613	0.075
Europe	0.089	0.884	0.436	0.795	0.018
Japan	-0.254	0.288	0.061	0.542	0.034

Source: UBS estimates

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Performance excluding illiquid stocks

1m	High vol	Low vol	Benchmark	L - H spread	p-value
TotRet	-4.98%	11.47%		16.45%	
On BM	-11.29%	2.02%		13.31%	
On Risk Free	-8.24%	8.25%		16.49%	
Sharpe ratio	-0.079	0.808	0.397	0.887	0.013
CAPM alpha	-15.84%	6.84%		22.68%	
FF alpha	-15.12%	6.48%		21.60%	

Source: UBS estimates

Turnover levels (median over time): 1.31 (H), 1.20 (L) for the 1m strategy. Stocks in the bottom decile of the ranking by volume traded (in EUR) are dropped

Empirical results - Conclusion

- High volatility stocks tend to underperform low volatility stocks, particularly in risk-adjusted terms
- The result holds when we control for liquidity, sector and regional exposure, known effects such as value, size and momentum, choice of methodology and window length in the calculation of the volatility
- Possible explanations:
  - Effect of borrowing constraints Blitz and van Vliet (2007) point out that a benchmark driven investor would need a considerable amount of leverage to benefit from the low volatility strategy
  - Inefficient asset allocation practices Low volatility stocks should be considered as a separate asset class in the strategic asset allocation process
  - Behavioural effects

Is aggregate volatility a pricing factor?

- Ang et al (2006) propose using implied volatility indices as risk factors in a linear model. Using Fama-MacBeth (1973) regressions, they show that the risk premium associated with a volatility factor is typically significant. The inclusion of (a factor based on) the VIX index leaves the puzzling behaviour of stocks with high idiosyncratic volatility unexplained.
- Carr and Wu (2008) adopt an alternative approach based on option prices data. They derive a model-free estimator of the variance risk premium and study a cross section of equity indices and single stocks for the US market. They conclude that variance risk premia are negative and significant. Also, both the CAPM model and the Fama-French (1993) model fail to explain the returns to synthetic variance swaps.
- Adrian and Rosenberg (2008) introduce two volatility factors, estimated from index returns through a two-component GARCH models. Their long term component is closely related to the business cycle, while the short-term one seems to track the change in market skewness risk over time. Again, their Fama-MacBeth (1973) regressions suggest significant volatility risk premia for both components.

Is aggregate volatility a pricing factor?

- Bollerslev, Tauchen and Zhou (2008) show that the variance risk premium on the S&P 500 is able to explain a significant part of the ex-post time series variation in the returns to the index at quarterly frequency. In particular, it compares favourably with traditional predictors like the aggregate P/E ratio or the default spread.

Aggregate volatility and the cross section of expected returns

- Suppose that the cross section of stock returns can be described by factor model of the form

$$r_{it} = \alpha_i + \beta_{i,MKT} MKT_t + \beta_{i,SMB} SMB_t + \beta_{i,HML} HML_t + \beta_{i,VOL} VOL_t + \varepsilon_{it}$$

- If, however, we fit a Fama-French factor model to the data at firm level, then the component related to aggregate volatility will affect the residuals
- On average, we expect to find that firms with larger exposures to the volatility factor have more volatile Fama-French residuals if the regression is estimated repeatedly over time

A global factor model

	Estimate	p-value
Intercept	0.0015	0.725
Market	1.7511	0.000
SML	0.9629	0.000
HML	-0.8762	0.000

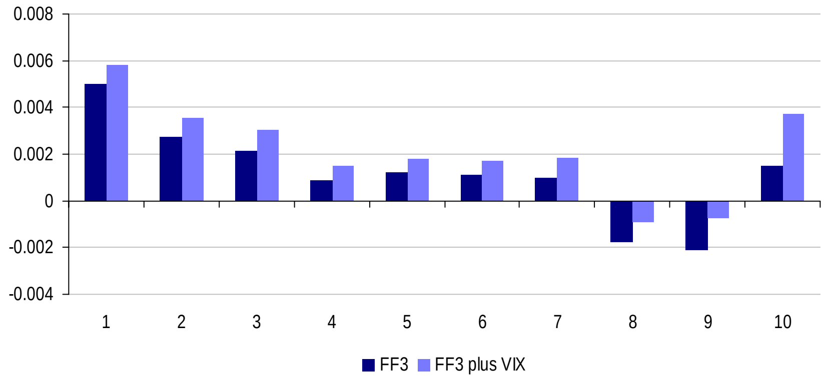
3-Year volatility, High volatility portfolio

	Estimate	p-value
Intercept	0.0050	0.000
Market	0.4354	0.000
SML	-0.0978	0.022
HML	0.4902	0.000

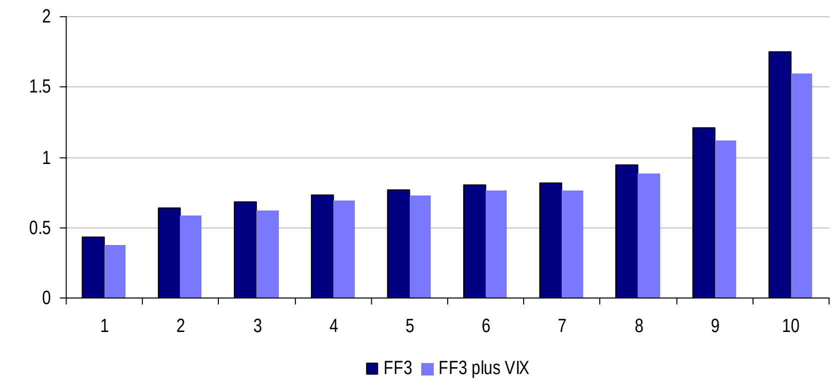
3-Year volatility, Low volatility portfolio

Source: UBS estimates

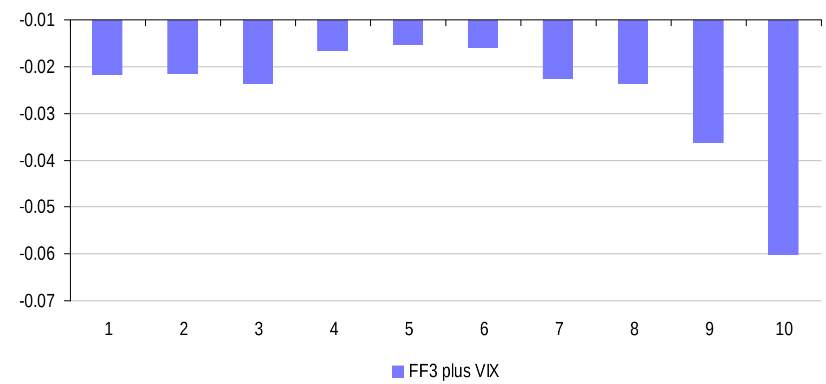
Adding a volatility factor (%ΔVIX) to the model



Estimated alpha for each decile (total volatility over three years)



Market beta



VIX beta

Source: UBS estimates

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Fama-MacBeth regressions

- To estimate the market prices of risk λ we run a regression of the form

$$r_{it} = c + \beta_{i,MKT}\lambda_{MKT} + \beta_{i,SMB}\lambda_{SMB} + \beta_{i,HML}\lambda_{HML} + \beta_{i,VOL}\lambda_{VOL} + e_{it}$$

- Assets: for each geographic area (Japan, Europe and North America) we use 10 decile portfolios ranked by long term volatility and 10 ranked by short term volatility

- Inferential procedures described in Jagannathan and Wang (1998)

Fama-MacBeth regression results

Estimated Market prices of risk, using 30 portfolios sorted by 3-year volatility

	FF3		Adrian-Rosenberg		FF3 plus VIX	
	Estimate	p-value	Estimate	p-value	Estimate	p-value
Intercept	0.0077	0.001	0.0053	0.006	0.0073	0.000
Market	0.0052	0.000	0.0113	0.000	0.0014	0.224
SML	-0.0105	0.000	-0.0142	0.000	-0.0097	0.000
HML	-0.0043	0.114	-0.0074	0.004	-0.0042	0.027
l.res			-1.1081	0.165		
s.res			-0.1783	0.000		
VIX					-0.1440	0.000
Adjusted R^2	0.77		0.86		0.89	
RMSPE	0.24%		0.19%		0.16%	

l.res and s.res are innovations to the long- and short-term volatility factors

Measuring the contribution of each risk premium to the variation in expected returns across portfolios (FF3 plus VIX):

	Market	SML	HML	VIX
$IQ(\beta) * \lambda$	0.0007	0.0065	0.0024	0.0033
$\sigma(\beta) * \lambda$	0.0006	0.0048	0.0019	0.0024
$IQ(\beta) * \lambda$	0.0028	0.0070	0.0025	
$\sigma(\beta) * \lambda$	0.0022	0.0051	0.0019	

Source: UBS estimates

Fama-MacBeth regression results

Estimated Market prices of risk, using 30 portfolios sorted by 1-month total volatility and all volatility sorted portfolios

	1-month vol		Both	
	Estimate	p-value	Estimate	p-value
Intercept	0.0079	0.000	0.0068	0.000
Market	-0.0041	0.006	-0.0002	0.832
SML	-0.0045	0.017	-0.0075	0.000
HML	0.0020	0.358	-0.0004	0.843
VIX	-0.1374	0.000	-0.1517	0.000
Adjusted R^2	0.90		0.83	
RMSPE	0.14%		0.20%	

Source: UBS estimates

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Conclusion

- We have reviewed the evidence found by Blitz and van Vliet (2007) that stocks with low volatility tend to outperform, particularly in risk-adjusted terms, stocks with high volatility *in a large cap universe*. The result turns out to be robust to liquidity screens, choice of methods to compute volatility, choice of window lengths.
- The strategy does tend to select small cap companies – however, screening out the least liquid names does not materially affect the conclusions of the backtest.
- In addition, we find that the result is not driven by the huge sector and regional tilts which characterise a volatility screen.
- We found some evidence that including implied volatility indices as factors helps explaining the variation in the cross section of expected returns among volatility sorted portfolios. Nevertheless, the underperformance of volatile stocks remains unexplained in our augmented factor model, as found by Ang et al. (2006).
- Both the VIX index and the short term volatility factor of Adrian and Rosenberg (2008) seem to capture a global risk factor.

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Appendix: The Adrian-Rosenberg (2008) model

- Market returns in equilibrium are characterised by a two-factor EGARCH model:

$$r_{M,t} = \mu_{M,t-1} + \sqrt{\nu_{t-1}}\varepsilon_t$$

where

$$\log \sqrt{\nu_t} = s_t + l_t$$

and

$$s_t = \theta_4 s_{t-1} + \theta_5 \varepsilon_t + \theta_6 \left(|\varepsilon_t| - \sqrt{2/\pi} \right)$$

$$l_t = \theta_7 + \theta_8 l_{t-1} + \theta_9 \varepsilon_t + \theta_{10} \left(|\varepsilon_t| - \sqrt{2/\pi} \right)$$

The autoregressive coefficient in the equation of the long term component, θ_8, is constrained to be larger than the corresponding coefficient in the short term component, θ_4.

- Adrian and Rosenberg show that the expected return depends in turn on both long term and short term volatility:

$$\mu_{M,t} = \theta_1 + \theta_2 s_t + \theta_3 l_t$$

Appendix: The Adrian-Rosenberg (2008) model

- The model is estimated by maximum likelihood from daily data
- The factors used in our Fama-MacBeth regressions are innovations to the estimated conditional log-volatility series, s_t and l_t, aggregated to monthly frequency

Appendix: The Adrian-Rosenberg (2008) model

- Estimation result for the global index (DJ World):

Parameter	Estimate	St Err
1	0.049	0.015
2	-2.026	0.237
3	0.042	0.021
4	0.270	0.069
5	-0.057	0.006
6	0.000	0.001
7	-0.005	0.001
8	0.984	0.000
9	-0.033	0.003
10	0.052	0.005

- Estimation results for DJ Western Europe:

Parameter	Estimate	St Err
1	-0.023	0.013
2	-0.073	0.052
3	0.479	0.201
4	0.807	0.051
5	-0.015	0.004
6	0.057	0.006
7	0.016	0.005
8	0.990	0.000
9	-0.049	0.008
10	0.014	0.010

Source: UBS estimates

UBS

Appendix: The Ledoit-Wolf (2008) test

- Ledoit and Wolf (2008) consider the bivariate vector of returns $(r_{it}, r_{Mt})'$ having a strictly stationary distribution. $\widehat{\mu}_i$ and $\widehat{\sigma}_i$ are, respectively, estimates of the expected return and (unconditional) volatility.

- They argue that under mild regularity conditions an asymptotic distribution can be obtained for the difference of two Sharpe ratios:

$$\widehat{\Delta} = \frac{\widehat{\mu}_i}{\widehat{\sigma}_i} - \frac{\widehat{\mu}_M}{\widehat{\sigma}_M}$$

$$\sqrt{\widehat{\Delta} - \Delta} \xrightarrow{d} \mathcal{N}\left(0, \omega^2\right)$$

- They devise two methods to estimate the asymptotic variance ω^2:
  - Using heteroskedasticity and autocorrelation robust kernel estimation
  - Constructing a studentized time series bootstrap

- Evidence from their simulations suggests that when the return distribution is heavy-tailed traditional tests based on normality can be significantly misspecified

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