Liquidity metrics improve understanding of portfolio risk

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Liquidity metrics improve understanding of portfolio risk

- Liquidity metrics including trading volume, turnover ratio, bid-ask spread, quote size, and order book depth, can be normalised to produce standardised liquidity benchmarks. Liquidity analysis provides another view of risk, especially during periods of stress.

- Degree of automation key variable for asset class liquidity. Corporate bonds mostly bilateral / off-exchange.

- Bid-ask spreads and order book depth can provide increased granularity for source of risk not captured by the VIX index. For example 2018 volatility spikes in February and December can be better defined using standard deviation of bid-ask spreads for SPY and IWM than simple observation of VIX variance. Absolute level of risk implied by VIX can be misleading when not qualified by additional liquidity measures.

- Bid-ask spreads might provide additional explanatory value to quant strategy returns.

- Volatility has non-linear relationship with liquidity metrics, for example exponential relationship of futures market depth and VIX with regression slope getting steeper over time as demonstrated by JP Morgan quant research (Jan. 2019).
  Given the importance of VIX Calls as significant component of a tail hedge, VIX vs E-mini S&P futures order book depth statistical relationship could be monitored and inform hedge ratio.

- Funds have a variety of internal liquidity filters such as days of turnover to define position limits, and days to liquidate used to monitor fund liquidity underlying vs fund level redemption terms. Generic HF disclosure may provide fund asset classification into level 1,2,3 assets including days to liquidate for each category, but in general high level.

- Quant Quake analysis highlighted unwind risk of ‘very liquid’ equity ‘market neutral’ exposure but when crowded positions were challenged by high leverage and margin constraints as per the episode in August 2007, significant losses occured.

Degree of automation key variable for asset class liquidity

Asset class	Equity futures	Treasury futures	Cash Equities	Foreign exchange	Sovereign bonds	Corporate bonds
Liquidity metrics	Bid-ask spread	Bid-ask spread	Bid-ask spread	Bid-ask spread	Bid-ask spread	Liquidity cost score (bid-ask)
	SD of Bid-ask spread	SD of Bid-ask spread	SD of Bid-ask spread	SD of Bid-ask spread	SD of Bid-ask spread	Trading Volume
	Trading Volume	Trading Volume	Trading Volume	Trading Volume (CLS)	On/off-the-run Spread	Turnover ratio
	Turnover Ratio	Turnover Ratio	Turnover Ratio	Order flow (CLS)	Trading Volume	Average Trade size
	Return to Volume ratio		Return to Volume ratio		Return to Volume ratio	Return to Volume ratio
	Quote size				Turnover ratio	Hist. bid-ask spreads (BBG)
	Order book depth					
E-Trading	90%	90%	50-80%	80%	60-70%	15-50% *
Automated Trading			70%	45%		
HF Trading	40%	60%	35-70%	25-30%		

Source: Global Financial Stability Report, Liquidity risk in capital markets, IMF, April 2019, Carlyon AG

*** Modernization of corporate bond market will improve liquidity**

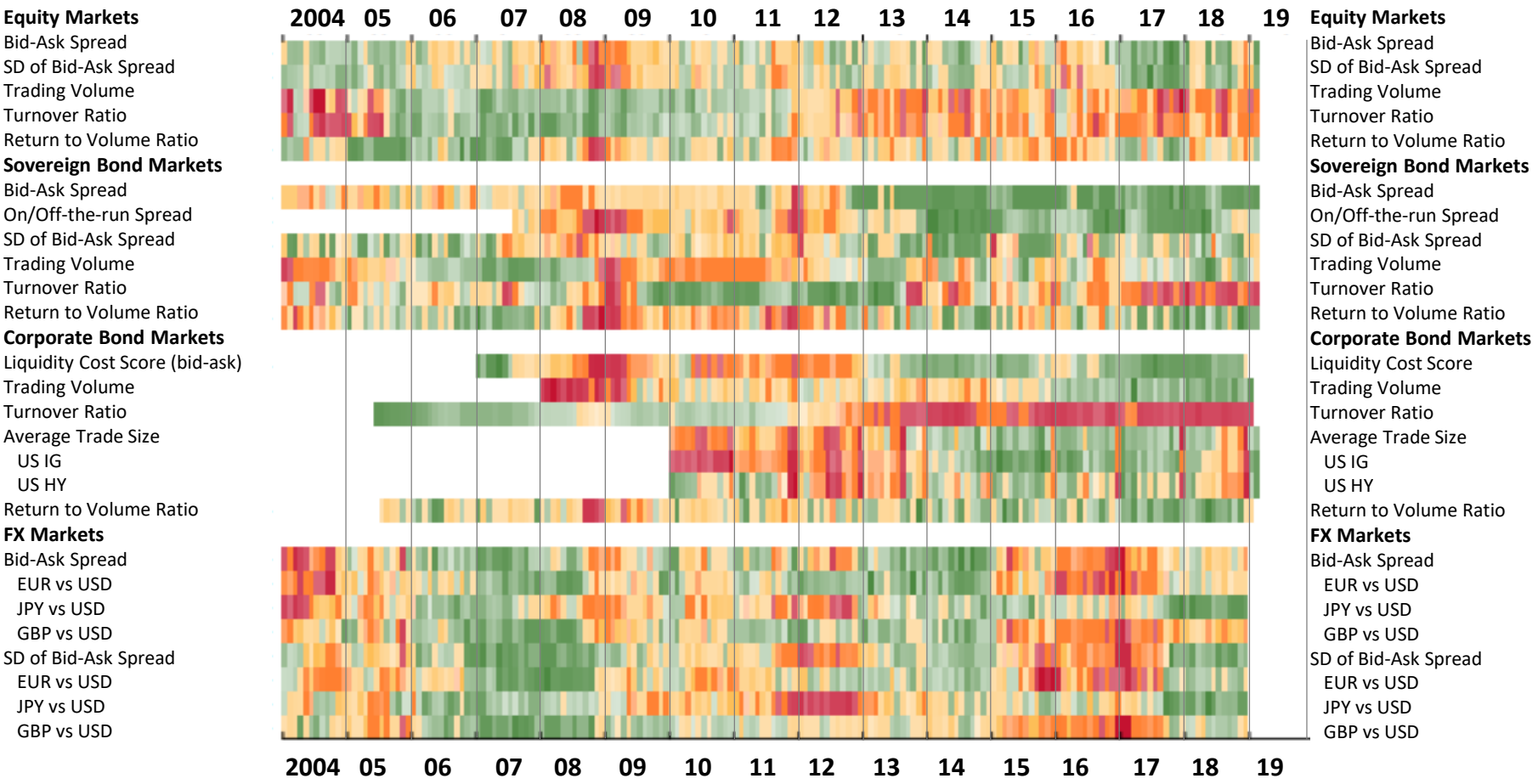
'Electronic trading marketplaces like MarketAxess and Tradeweb handle roughly 26% of all US corporate bond trading. BoA, Citi, GS, JPM and MS are actively working with hedge funds and asset managers to allow electronic trading of corporate bonds.'

'BlackRock points out that ETF market makers and authorized participants are becoming increasingly good at managing bond inventories, increasing market transparency, liquidity and real time valuation.'

'Global Trading Systems views corporate bonds as the natural next step for its business following to its recent completed acquisition of Cantor Fitzgerald's exchange-traded fund business.'

Evolution of market liquidity measurement

Market liquidity heat map



Source: Global Financial Stability Report, Liquidity risk in capital markets, IMF, April 2019

Structural drivers for changes in liquidity

- **Post crisis financial regulatory reforms:** Volcker Rule (introduced April 1, 2014) curtailed banks' prop trading activities, tighter financial regulation and supervision affected banks' incentives and ability to provide market making service. Increased margin requirement in FX markets led to widening in bid-ask spreads.

- **Technological innovation and changes in market structure:** New regulation and changes to market structure such as the implementation of MiFID II and the concept of multilateral trading facilities (MTFs), have improved strength and transparency of financial markets. Increasing market share of nonbank principal trading firms as alternative market makers with higher speed and lower transaction costs by using automated / high frequency trading strategies.

- **Monetary policies:** As a response to GFC, asset purchases and QE affected supply of and demand for liquidity and reduced the free float of securities available for investors.

- **Passive investing flows:** Index tracking products allowing participation in less liquid markets, but also increase the correlation of component securities and the likelihood of herding behaviour.
  Strong flows into credit ETFs have enhanced liquidity in index constituent bonds.

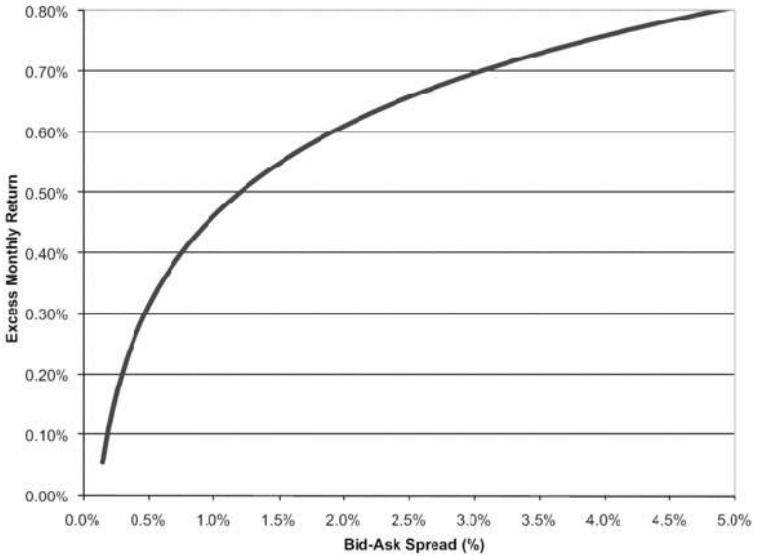
- **Share buy-backs:** Large US corporations have increased share buybacks (approx. 4% of S&P 500 market cap over last year) reducing amount of shares outstanding but also reducing volatility in equities.

Source: Global Financial Stability Report, Liquidity risk in capital markets, IMF, April 2019

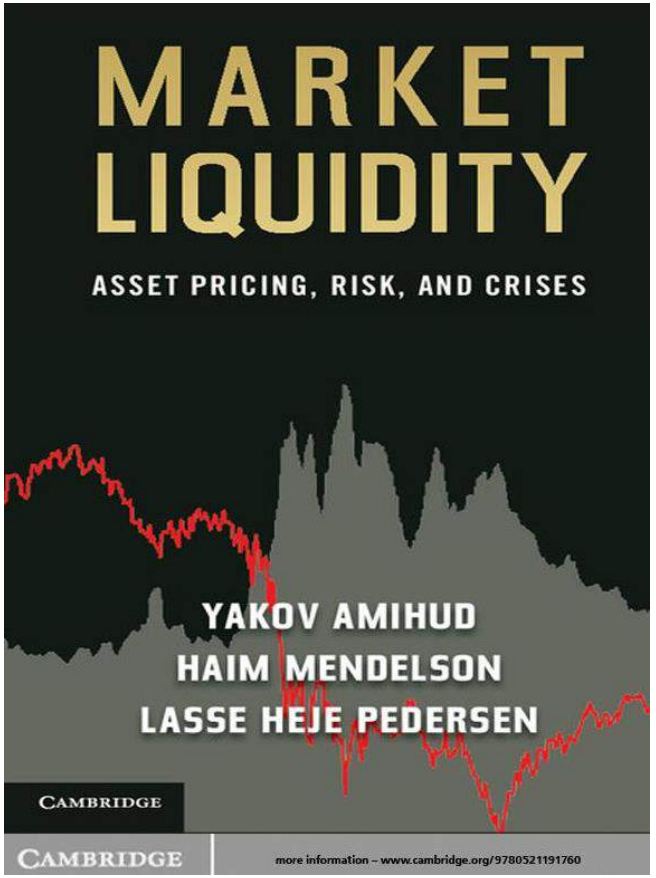
Bid-ask spread as liquidity indicator

Y. Amihud and H. Mendelson lead work on bid-ask spread as liquidity indicator

- Amihud and Mendelson (1986) propose that investors require a return premium to compensate for illiquidity costs (bid-ask spread served as the proxy for liquidity)
- This premium differs by investors' holding-period and exceeds expected illiquidity costs because of funding constraints and investor type.
- Trading volume (or turnover) has negative and significant effect on expected return (Amihud, 2000)
- **In a 2018 revisit of his early theories**, Amihud showed that the risk-adjusted predicted return on illiquid-minus-liquid stocks (IML) is positive and significant in the last 63 years and while it is lower in the period following 2002, it remains positive and significant. IML also has the predicted response to market illiquidity shocks (Amihud 2018)

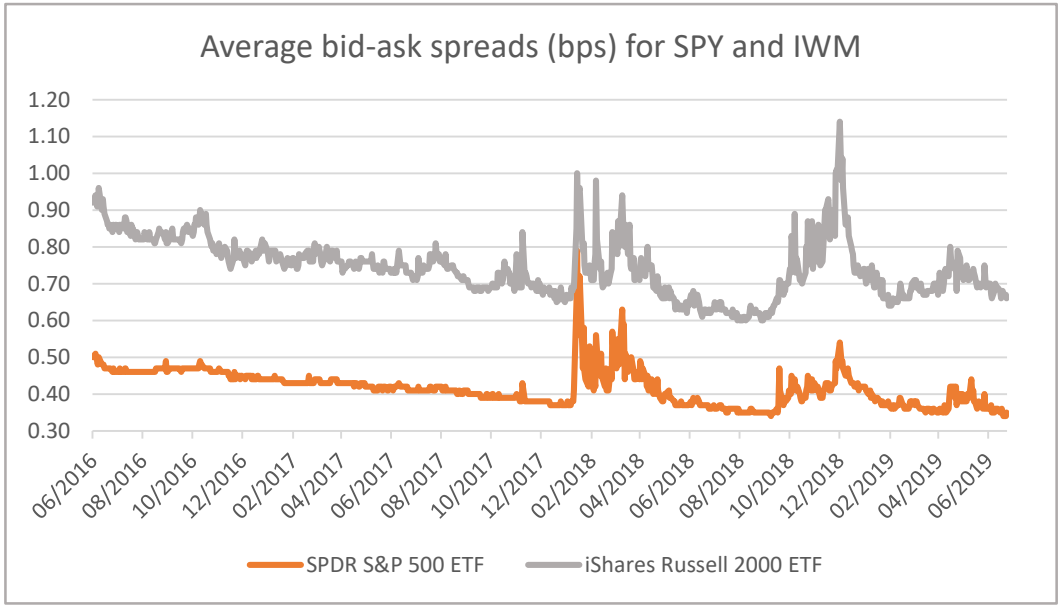


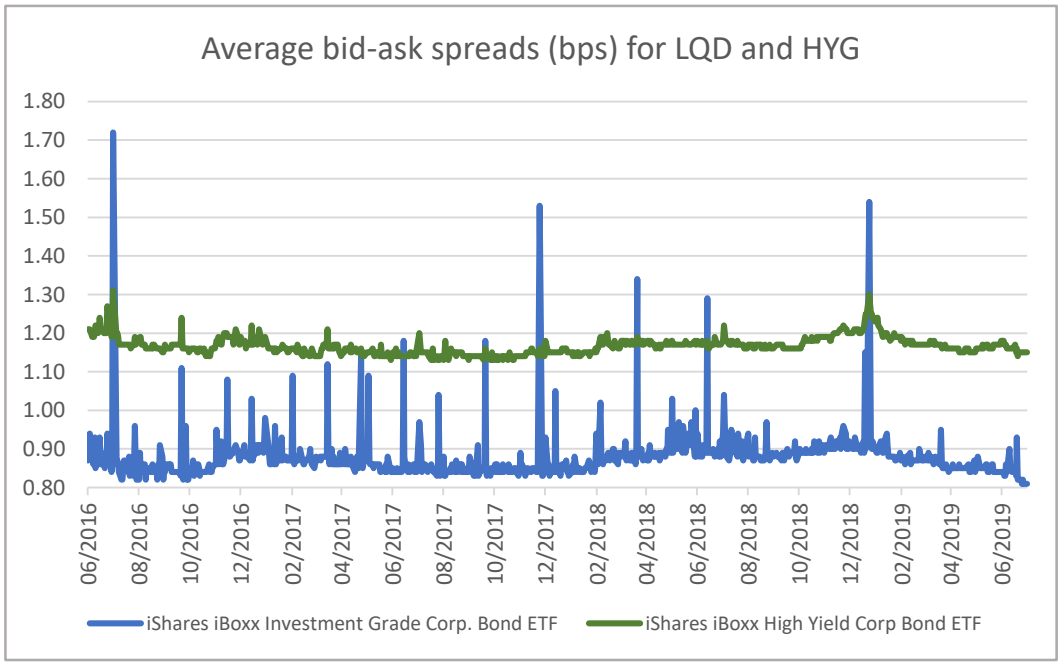
Relation between excess monthly return on NYSE stocks and their bid-ask spread, 1961-1980



Market Liquidity: Asset Pricing, Risk, and Crises, 2013

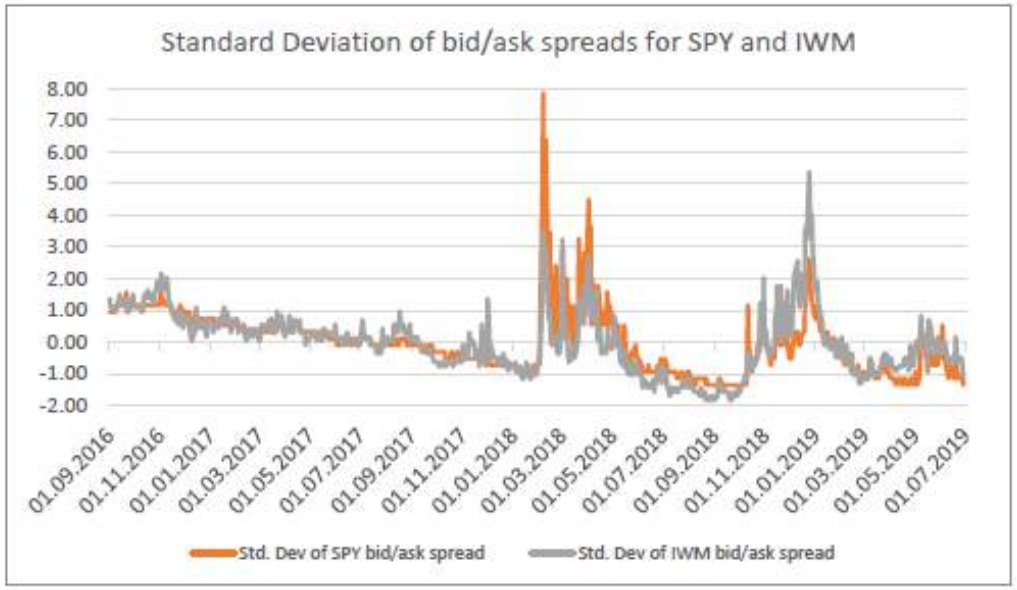
Bid-ask spreads for equity and bond ETFs with lower lows versus reset up for VIX level post Feb '18

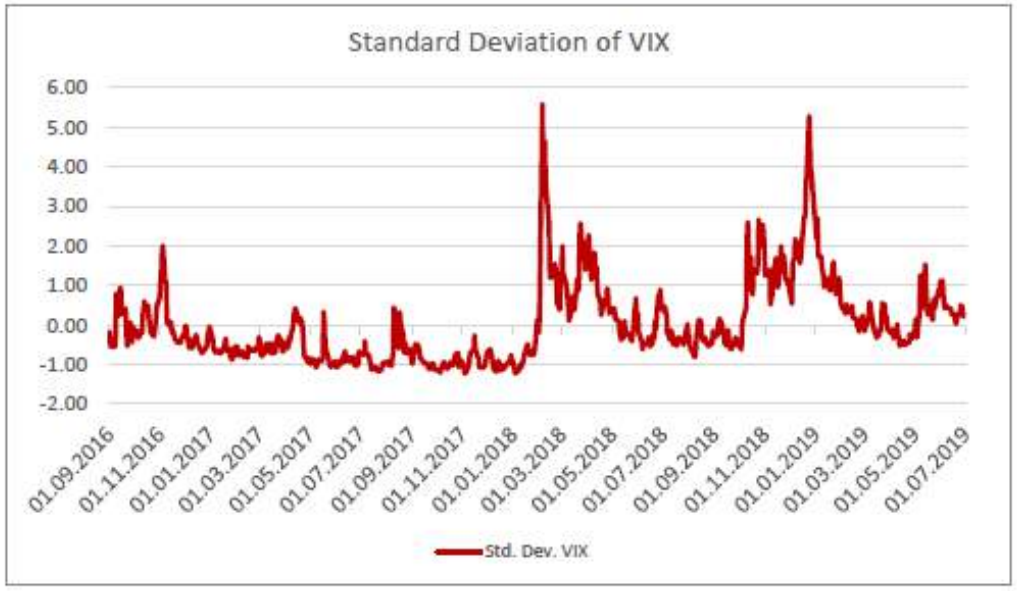




Source: Bloomberg

Bid-ask spreads provide increased granularity for source of risk not captured by VIX





Bid-ask spreads for SPY greatly impacted by inverse VIX, while IWM bid-ask spreads heavily impacted by Nov/Dec. 2018 sell-off.

2018 volatility spikes in February and December can be better defined using standard deviation of bid-ask spreads for SPY and IWM than simple observation of VIX variance.

Absolute level of risk implied by VIX can be misleading when not qualified by additional liquidity measures. Structural reset to higher level post Inverse Vix spike in Feb 2018.

Source: Bloomberg

S&P 500 e-mini liquidity

Order book depth
Quote size

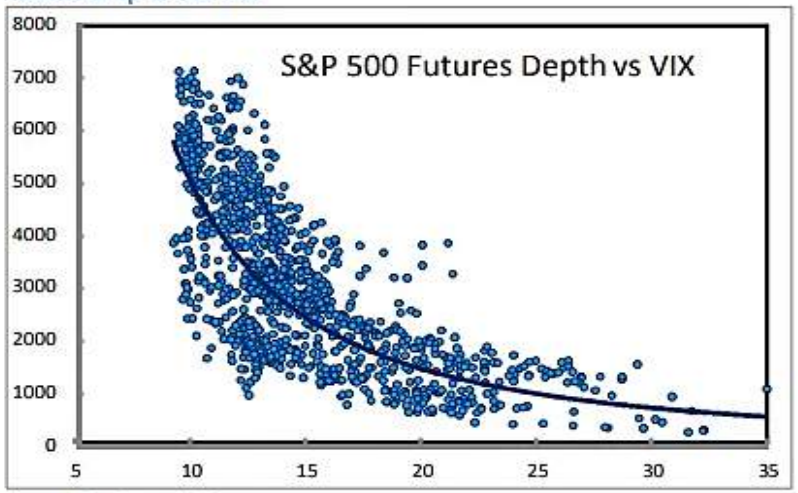
Liquidity based on order book depth Volatility

Volatility feedback loop

'Relationship between liquidity and volatility is very strong and nonlinear, SPX 500 E-mini futures market depth declines exponentially with VIX index. Given that an increase in volatility often results in systematic selling, this relationship is the key to understand market fragility and tail events.'

Marko Kolanovic, J.P. Morgan, Jan. 2019

Figure 1: S&P 500 E-mini futures depth shows a strong (exponential) relationship to the VIX



Source: J.P. Morgan QDS.

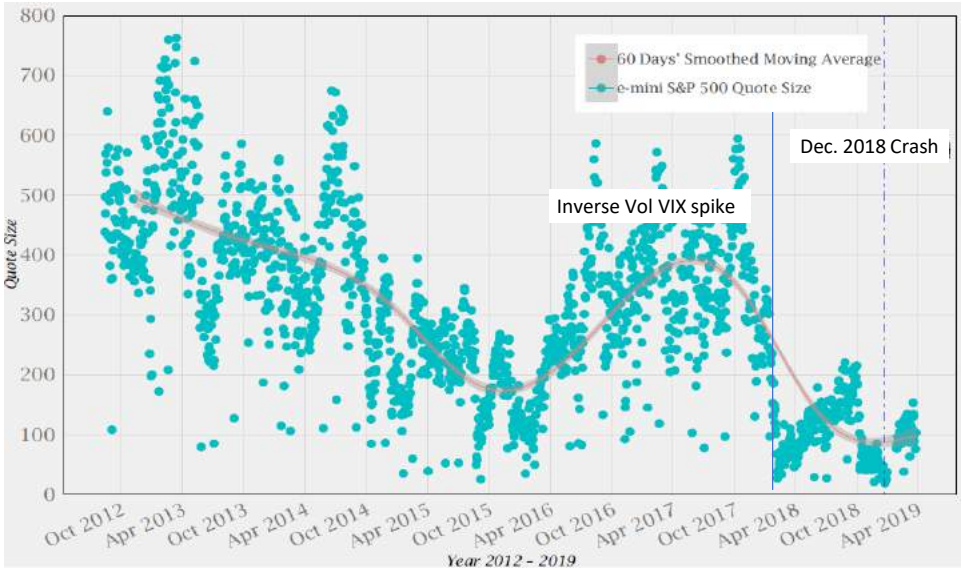
Figure 2: The regression slope between liquidity and the VIX got larger over time

Source: J.P. Morgan QDS.

Given the importance of VIX Calls as significant component of a tail hedge, VIX vs E-mini S&P futures order book depth statistical relationship could be monitored and inform hedge ratio.

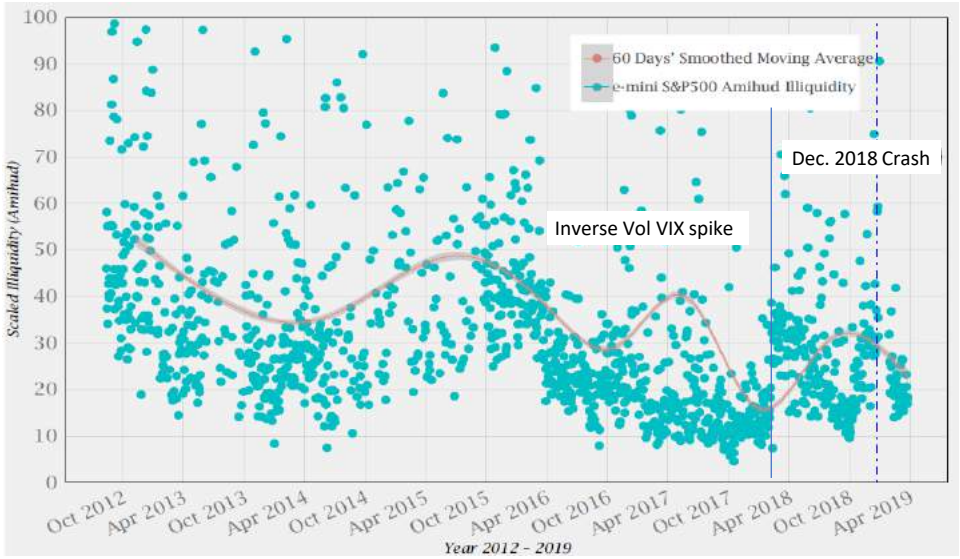
Liquidity of E-mini S&P 500 Futures based on quote size

E-mini S&P 500 Futures: Average daily quote size



Average daily quote size is at six year lows for E-mini S&P 500 futures futures.

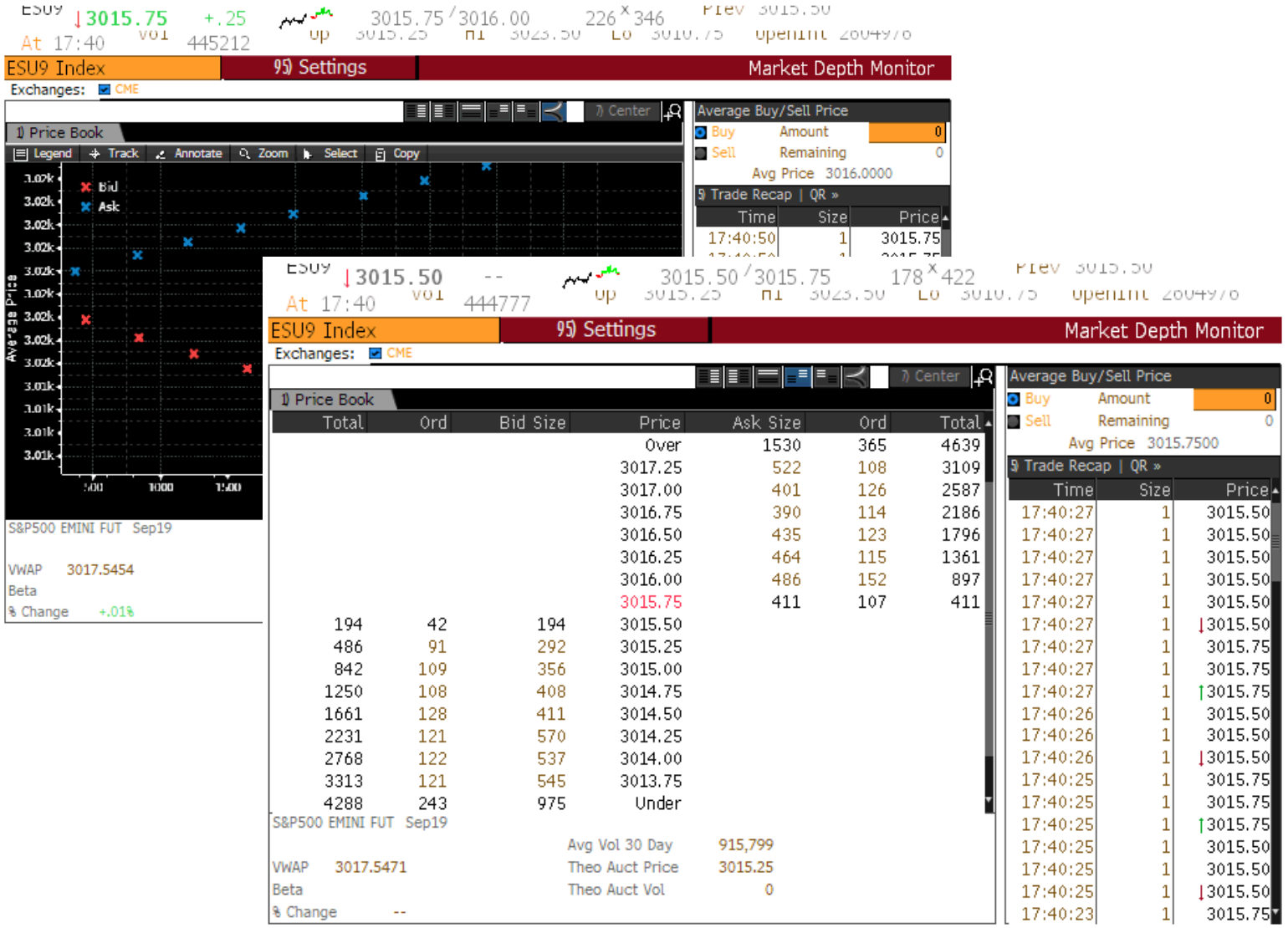
E-mini S&P 500 Futures: Average Daily Amihud Illiquidity



Amihud illiquidity indicates that E-mini S&P 500 futures are on an average somewhat more liquid (less illiquid) compared to six years ago.

Source: Quantitative brokers, April 2019

S&P 500 e-mini future order book depth – Bloomberg / CME data



Source: Bloomberg

Quant quake August 2007

Risk management implications from Quant Quake

Quant Quake analysis highlighted unwind risk of 'very liquid' equity exposure but when crowded positions were challenged by high leverage and margin constraints as per the episode in August 2007, significant losses occured.

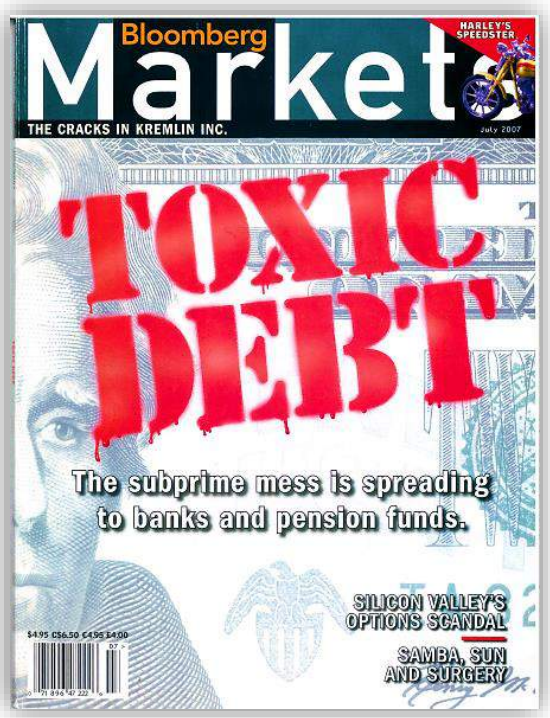
Tail hedge
In a repeat of August 2007, VIX call option exposure, assuming -3% decline to underlying indices on day 3 of the 4 day episode, can deliver only partial offset to a levered exposure. With perfect forsight, maximum return in the August 2007 episode, subject to entry and exit is a VIX range approx +10-15pts from low to high either side of the 4 day episode.

Liquidity and risk capacity
If daily mark to market can be tolerated, then simply not de-risking and waiting for normalisation on day 4, was a reasonble strategy. Moderate fund leverage and high unencumbered cash position required to prevent prime broker margin related de-risking action.

Total quant exposure
Option to limit total exposure, but alternative allocations add potentially other unwanted risk profile.

Factor exposure
Due to unwind pressure, short interest factor had an 8 standard deviation move against the position.
Option to reduce factor exposure to this variable by limiting heavily shorted names.

Pre-conditions for 2007 August Quant losses



Source: Bloomberg magazine, July 2007

- **Crowded positioning** amongst 'pure quant funds' with approx USD 250 bn AUM contributed to the losses.

- **Rapid deterioration of economic outlook and problems with mortgage origination**. Mid-2006 onwards continuously inverted yield curve until May 2007, rising volatility since March 2007, failure of two Bear Stearns credit funds in June, and rating agencies downgrade of mortgage backed securities in July.

- **Excessive leverage**

2007 Estimated Leverage in HF strategies	
Tykhe Capital	10x
Goldman HF, Global Alpha	7x
Khandani and Lo estimate of average quant fund leverage for market neutral EQ long/short.	9x

Source: A. Khandani & A.Lo, what happened to the quants in August 2007? Sept. 2007

- **De-risking of credit funds** morphed into general de-leveraging including long short quant equity, leading to substantial negative performance for specific funds/strategies.

Negative performance	
AQR	down 13% first 10 days of August 2007, recovered by month end
GSAM	Global Alpha, Global Equity Opportunities down approx. 30%
Tykhe	lost between 17-31% by August 9th (fund AUM pre event $1.8bn)
CTA HF index	lost 4.6% in the month of August

Source: Next Quant Meltdown, Michelle Celarier, Aug. 2017

Inverted yield curve 2006 and 2019

Generic US 10yr – US 3mth yield

Source: Bloomberg

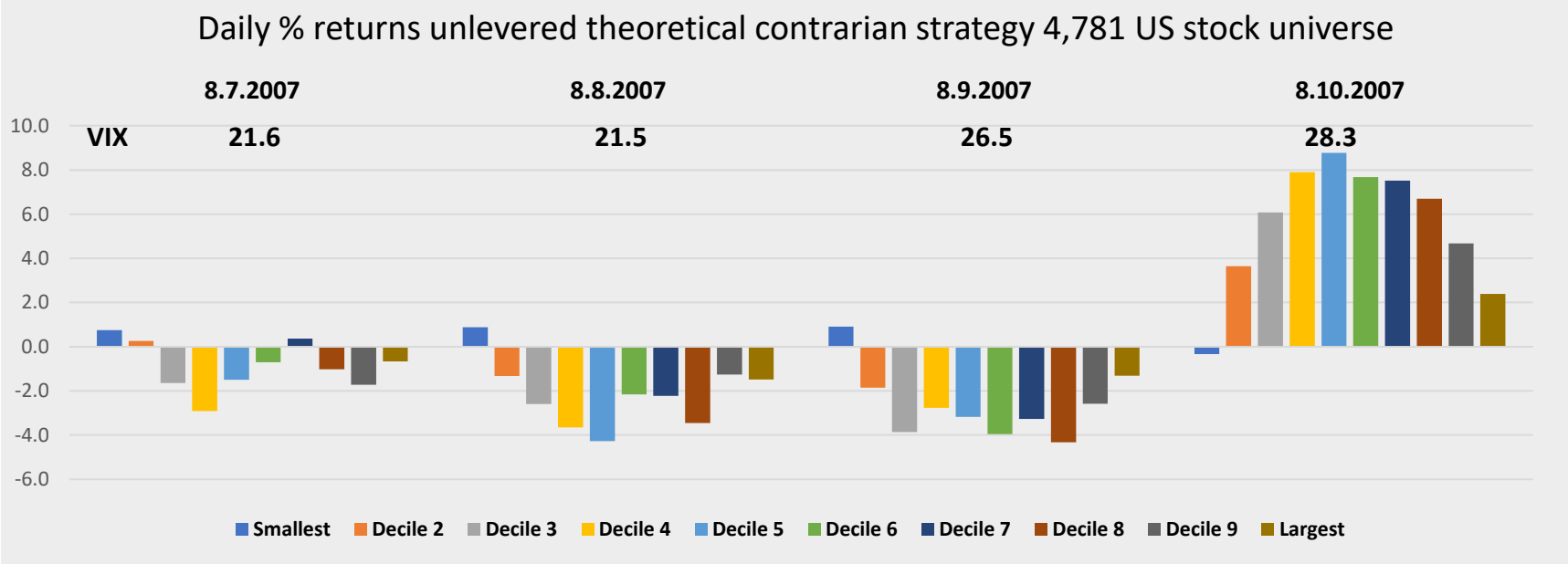
HF pressure to reduce market exposure triggered by credit market worries

Quant quake August 7th, 8th, 9th, 10th 2007

Source: Bloomberg

Daily returns of unlevered theoretical contrarian strategy

Estimated strategy returns based on 8x leverage: Aug 7th -4.6%, Aug 8th -11.3%, Aug 9th -11.4%, Aug 10th +23.6%

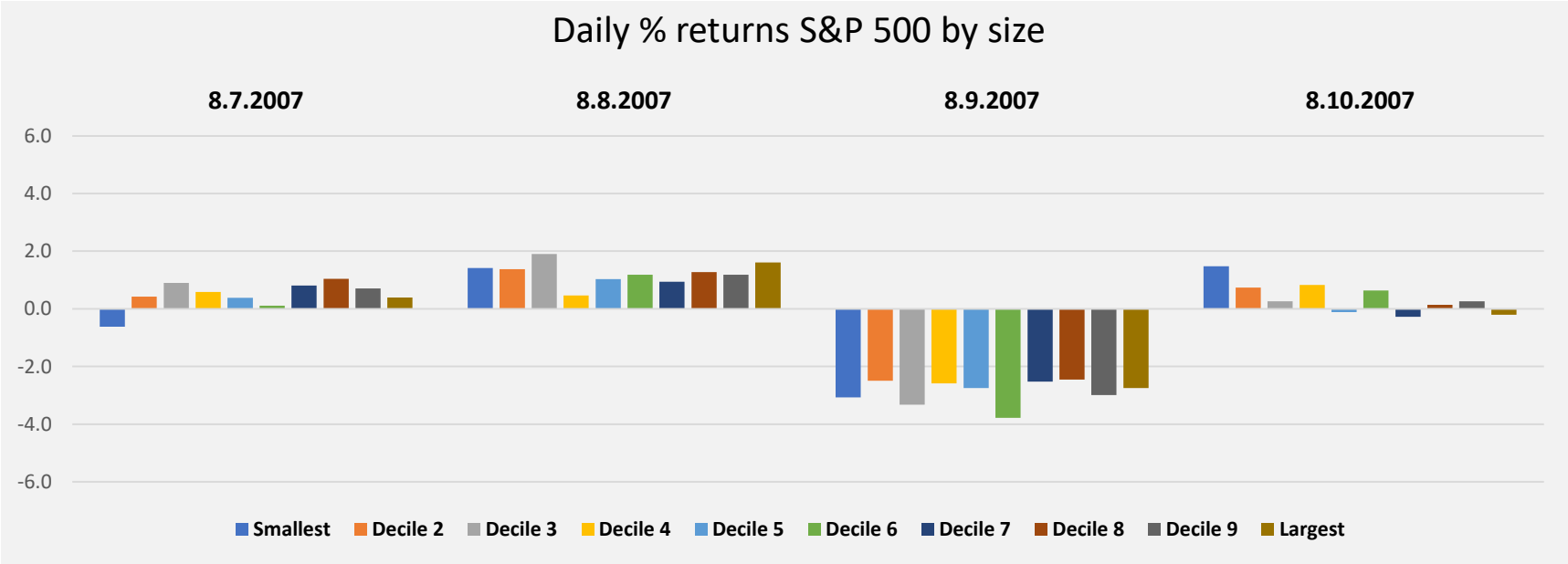


Applied strategy: Contrarian trading strategy, by buying yesterday's losers and selling yesterday's winners at each date, such a strategy actively bets on mean reversion across all N stocks, profiting from reversals that occur within the rebalancing interval. Strategy benefits from market overreaction, i.e., when underperformance is followed by positive returns and vice-versa for outperformance.

Methodology: Contrarian trading strategy applied to the daily returns of 4'781 stocks in the University of Chicago's CRSP Database, and to stocks within 10 market-cap deciles, U.S. common stocks (CRSP share codes 10 and 11) with share prices above $5 and less than $2,000.

Source: A.Khandani & A.Lo, What happened to the quants in August 2007? (September 2007)

Daily returns for S&P 500 constituents by size



S&P 500 over 4 trading days – except 9th August index levels slightly up each day.

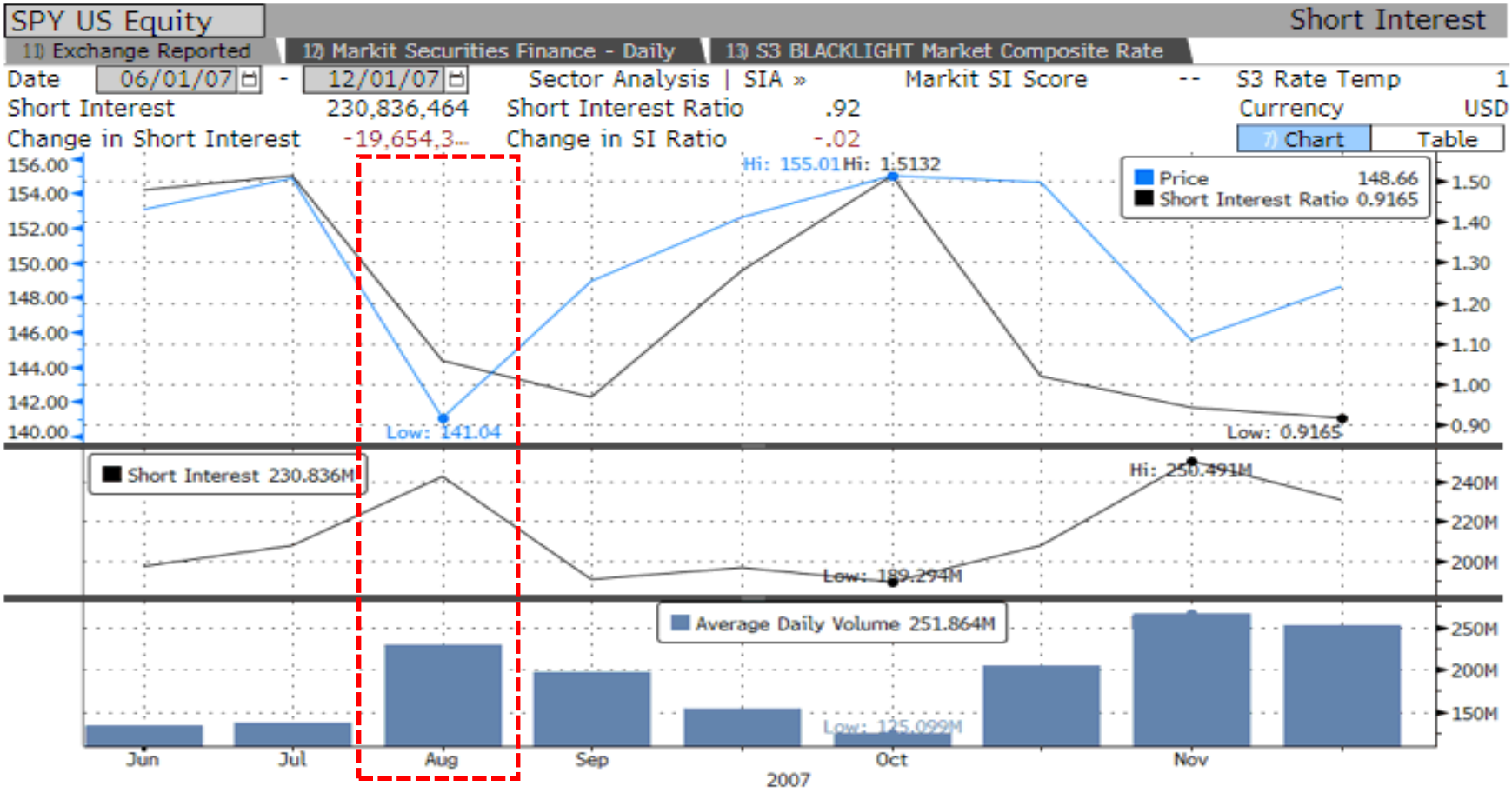
Source: Carlyon, Bloomberg, July 2019

Cross asset performance

Date	S&P 500	S&P Small Cap 600	MSCI Emerging Markets	MS World ex US	Lehman Aggregate US Gov.	Lehman US Universal Corp. HY Index	Goldman Sachs Commodity Index	Trade Weighted USD Index	VIX (Change)
7/30/2007	1.03%	0.94%	0.87%	0.14%	-0.04%	0.18%	0.11%	-0.12%	-3.30
7/31/2007	-1.26%	-0.88%	1.67%	1.36%	0.17%	0.61%	1.18%	-0.10%	2.65
8/1/2007	0.73%	0.19%	-3.42%	-1.70%	0.04%	-0.15%	-1.34%	0.13%	0.15
8/2/2007	0.46%	0.98%	0.61%	0.62%	0.04%	0.53%	0.00%	-0.20%	-2.45
8/3/2007	-2.65%	-3.48%	-0.05%	-0.37%	0.29%	0.08%	-1.10%	-0.66%	3.94
8/6/2007	2.42%	1.35%	-1.99%	-0.57%	-0.14%	-0.29%	-2.76%	0.10%	-2.56
8/7/2007	0.62%	0.71%	0.45%	0.56%	-0.04%	0.38%	0.34%	0.28%	-1.04
8/8/2007	1.44%	1.52%	2.83%	1.88%	-0.48%	0.84%	-0.20%	-0.17%	-0.11
8/9/2007	-2.95%	-1.38%	-1.28%	-1.52%	0.31%	-0.07%	-0.37%	0.54%	5.03
8/10/2007	0.04%	1.01%	-3.30%	-2.85%	0.07%	-0.29%	-0.03%	-0.12%	1.82
Net 8/7 - 8/10	*-0.85%*	*1.86%*	*-1.30%*	*-1.93%*	*-0.14%*	*0.86%*	*-0.26%*	*0.53%*	*5.70*
8/13/2007	-0.03%	-0.84%	1.01%	1.08%	0.04%	0.34%	0.27%	0.46%	-1.73
8/14/2007	-1.81%	-1.87%	-1.42%	-1.10%	0.23%	-0.10%	0.35%	0.54%	1.11
8/15/2007	-1.36%	-1.45%	-2.39%	-1.52%	0.15%	-0.56%	0.80%	0.41%	2.99
8/16/2007	0.33%	1.70%	-5.63%	-2.91%	0.58%	-0.59%	-3.01%	-0.11%	0.16
8/17/2007	2.46%	2.30%	0.12%	0.96%	-0.28%	0.24%	1.49%	-0.37%	-0.84
8/20/2007	-0.03%	0.30%	3.78%	1.23%	0.23%	0.24%	-1.65%	-0.03%	-3.66
8/21/2007	0.11%	0.21%	-0.18%	0.61%	0.24%	0.19%	-1.14%	0.11%	-1.08
8/22/2007	1.18%	1.19%	2.58%	1.27%	-0.16%	0.37%	0.04%	-0.30%	-2.36
8/23/2007	-0.11%	-1.16%	1.76%	1.16%	-0.01%	0.22%	0.96%	-0.13%	-0.27
8/24/2007	1.16%	1.44%	0.44%	0.51%	-0.10%	0.04%	1.10%	-0.59%	-1.90
8/27/2007	-0.85%	-1.07%	1.90%	0.29%	0.23%	0.17%	0.28%	0.09%	2.00
8/28/2007	-2.34%	-2.70%	-0.85%	-1.26%	0.34%	-0.07%	-0.17%	0.02%	3.58
8/29/2007	2.22%	2.28%	-0.23%	0.04%	-0.09%	-0.06%	1.40%	-0.07%	-2.49
8/30/2007	-0.41%	-0.38%	1.31%	0.80%	0.29%	0.06%	0.15%	0.12%	1.25
8/31/2007	1.12%	1.28%	2.39%	1.58%	-0.16%	0.01%	0.48%	0.00%	-1.68

Source: A.Khandani & A.Lo, What happened to the quants in August 2007? (September 2007)

Short interest, short interest ratio (days to cover), turnover volume USD



Source: Bloomberg

Factor performance – August 8th 2007 vs February 6th 2018

	Aug. 8th, 2007		Feb. 5th, 2018	
USFAST Factors	**Return**	**Z-score**	**Return**	**Z-score**
1-day Reversal	-0.51%	-2.92	-0.04%	-0.233
Beta	0.57%	1.119	-0.51%	-1.002
Dividend yield	0.36%	3.174	0.00%	0.036
Downside risk	-0.29%	-3.545	-0.04%	-0.429
Earnings quality	-0.23%	-1.814	0.04%	0.295
Earnings yield	-0.86%	-5.992	0.07%	0.467
Growth	0.03%	0.224	0.06%	0.529
Industry Momentum	-0.19%	-2.733	-0.03%	-0.396
Leverage	0.05%	0.486	-0.11%	-0.965
Liquidity	-0.40%	-3.133	0.22%	1.694
Long-term Reversal	-0.33%	-3.277	0.12%	1.179
Management Quality	-0.17%	-1.961	-0.13%	-1.563
Mid Capitalization	-0.28%	-1.555	0.02%	0.095
Momentum	-0.91%	-3.44	0.03%	0.113
Profitability	-0.43%	-3.582	-0.11%	-0.904
Prospect	0.22%	2.698	0.02%	0.228
Regional Momentum	0.22%	2.659	0.05%	0.547
Residual Volatility	0.45%	1.975	-0.08%	-0.353
Seasonality	-0.04%	-0.538	-0.04%	-0.61
Sentiment	-0.30%	-3.209	0.00%	-0.005
Short Interest	**0.71%**	**8.822**	**-0.02%**	**-0.241**
Short-Term Reversal	0.58%	3.46	0.04%	0.221
Size	-0.36%	-1.743	-0.40%	-1.927
Value	-0.44%	-3.444	-0.17%	-1.352
Market	**1.43%**	**1.203**	**-3.96%**	**-3.333**

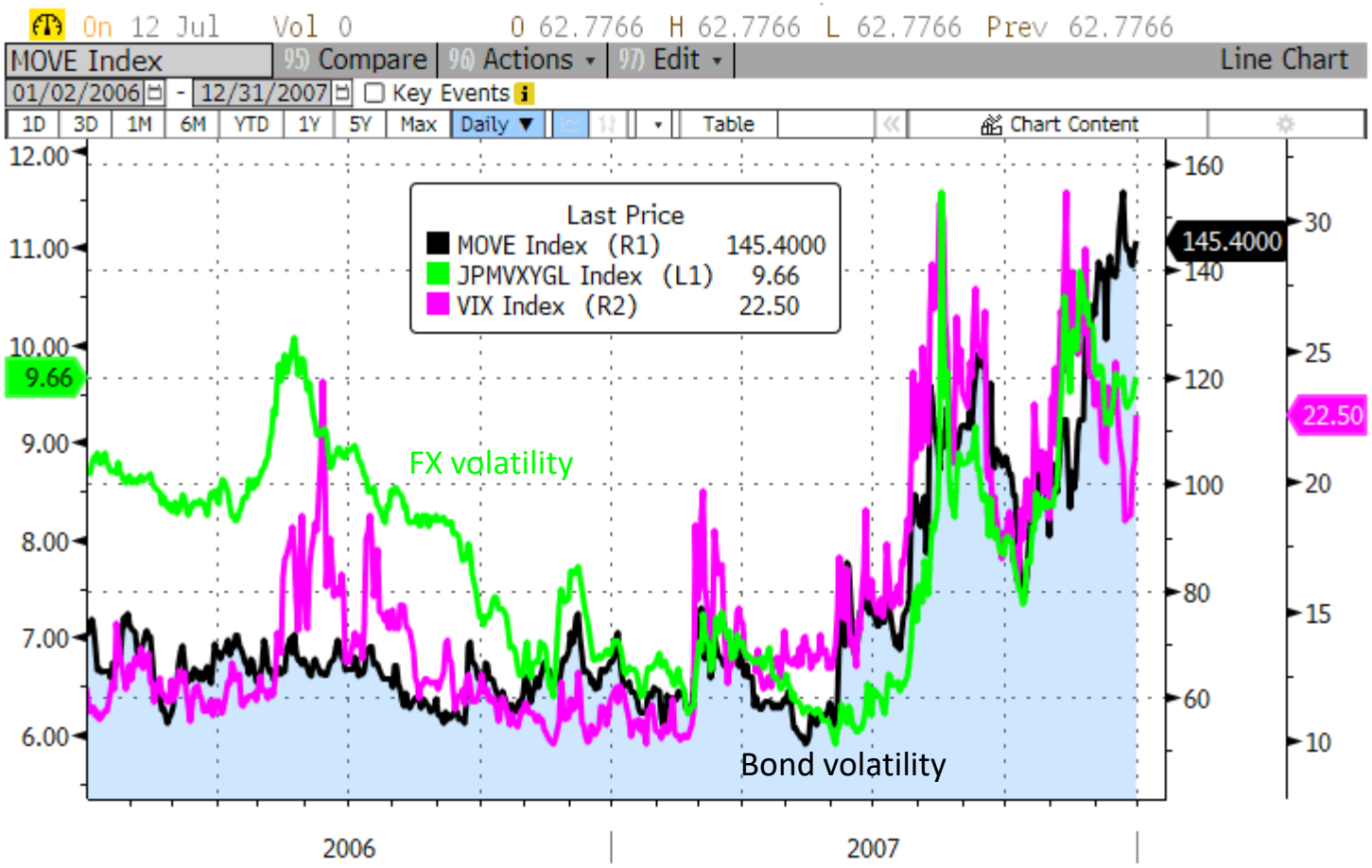
The market factor was up by just over one standard deviation on August 8th. On the other hand, traditional risk premia factors used by quantitative strategies suffered sharp drawdowns as leveraged equity hedge funds aggressively unwound positions in stocks with high exposure to these factors.

In particular, value, earnings yield, momentum and profitability were all down by more than three standard deviations. The short interest factor had a nine standard deviation positive move that day, a result of aggressive unwinding of short positions and short covering by leveraged quantitative equity funds.

On Monday, Feb. 5th 2018, the US market factor (bottom line) was the only factor that experienced an extreme drawdown of more than three standard deviations while all style factors were within two standard deviations. The worst-hit style factors were size, value, beta and management quality, with drawdowns between one and two standard deviations. The short interest factor had muted negative return that day, suggesting that covering of short positions did not play an important role.

Source: MSCI, Dissecting the stock market sell-off, Feb 6, 2018

Cross-asset volatility 2006 - 2007



Source: Bloomberg

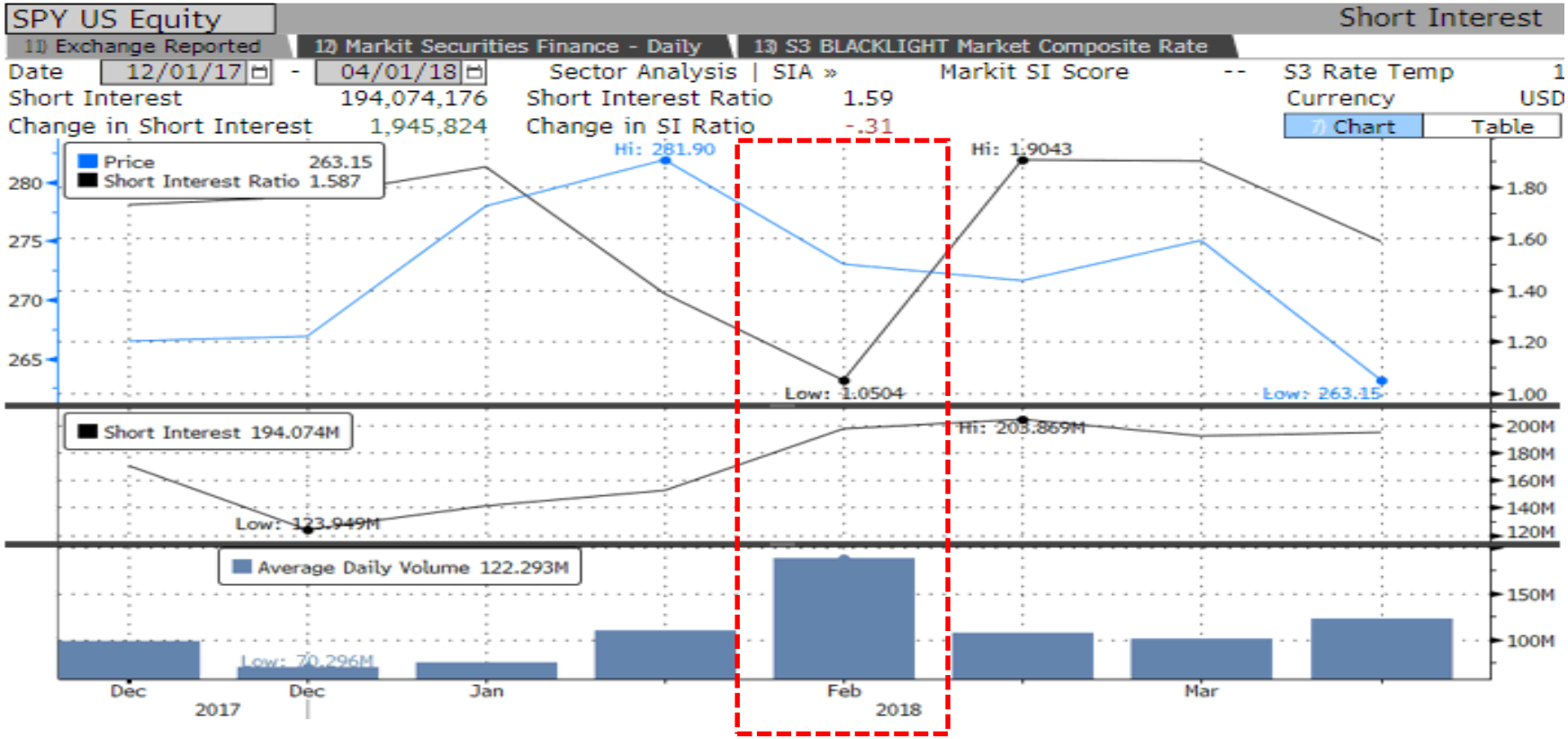
Inverse Vix – February 2018

Volatility 2017 – 2018: Volatility never returned to previous lows

Inverse VIX Volatility Jan/Feb 2018

Source: Bloomberg

Short interest, short interest ratio (days to cover), turnover volume USD



Source: Bloomberg

Quant Quake (Aug. 2007) vs Inverse Vol Spike (Feb. 2018)

	Aug. 2007	Feb. 2018
Prerequisite	Blow-up of two Bear Stearns credit strategies funds in June, mounting problems at Countrywide Financial. Crowding in highly levered quant strategies	In January 2018, the assets of crowded inverse and leveraged volatility funds had climbed to over USD 5 bn. One year later, the assets stood at USD 1bn
Volatility	VIX jumped from 21.6 (Aug. 7th) to 28.3 (Aug. 10th)	Largest ever one day gain (+116% / +20points) in history (Feb. 5th)
S&P 500 Index	-0.85% net return in 4 trading days (Aug. 7th – 10th)	-10.7% in 6 trading days (Feb. 5th delivered -4.1%)
CTA monthly perf.	-1.4% (Source: Eurekahedge) -4.6% (Credit Suisse Tremont HF Index)	-4.1% (Source: Eurekahedge)
L/S Equity monthly perf.	-1.5% (Source: Eurekahedge) -1.4% (Credit Suisse Tremont HF Index) -1.2% (BarclayHedge)	-1.5% (Source: Eurekahedge) -1.1% (BarclayHedge)

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