From the Quant Quake of August 2007 to the Flash Crash of May 2010: The Microstructure of Financial Crises

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Quantitative Equity Funds Hit Hard In August 2007

- Specifically, August 7–9, and massive reversal on August 10
- Some of the most consistently profitable funds lost too
- Seemed to affect only quants
- No real market news

Wall Street Journal
September 7, 2007

What Is The Future of Quant?

- Is "Quant Dead"?
- Can "it" happen again?
- What can be done about it?

But Lack of Transparency Is Problematic!

AUGUST AMBUSH

How Market Turmoil Waylaid the 'Quants'

Morgan Stanley Star Is Among Those Battered; No Time for Music Now

By SCOTT PATTERSON And ANITA RAGHAVAN

Peter Muller, a 43-year-old trader at Morgan Stanley, is used to markets behaving more or less as he expects. But in late July, some unusual patterns perplexed him. Certain investing strategies that historically had posted steady gains started faltering for no evident reason.

Soon, the unusual trading spread from U.S. to Japanese and European

Adding Up
Estimated assets in quant hedge funds using two common strategies, 'market neutral' and 'statistical abitrage'; quarterly data

Source: Hedgefund.net

Use Strategy As Research Tool

- Lehmann (1990) and Lo and MacKinlay (1990)

- Basic mean-reversion strategy:

$$\omega_{it} = -\frac{1}{N}(R_{it-k} - R_{mt-k}) \quad , \quad R_{mt-k} \equiv \frac{1}{N}\sum_{i=1}^{N} R_{it-k}$$

$$\sum_{i=1}^{N} \omega_{it} = 0 \quad \text{Market Neutral}$$

$$\mathrm{I}_t \equiv \frac{1}{2}\sum_{i=1}^{N} |\omega_{it}| \quad \text{Gross Long or Short Market Value}$$

$$R_{pt} \equiv \sum_{i=1}^{n} \omega_{it} R_{it}/\mathrm{I}_t \quad \text{Unleveraged Return}$$

Expected Profits $E[\pi_t(q)]$:

$$\pi_t(q) \;\equiv\; \sum_{i=1}^{N} \Big(\omega_{i,t} \sum_{k=1}^{q} R_{i,t+k} \Big)$$

$$E[\pi_t(q)] \;=\; \mathcal{M}(\mathbf{\Gamma}_1) \;+\; \cdots \;+\; \mathcal{M}(\mathbf{\Gamma}_q) \;-\; q\,\sigma^2(\boldsymbol{\mu})$$

$$\mathbf{\Gamma}_j \;\equiv\; E[(\mathbf{R}_{t-j} - \boldsymbol{\mu})(\mathbf{R}_t - \boldsymbol{\mu})']$$

$$\mathcal{M} \;\equiv\; \frac{1}{N^2}\,\boldsymbol{\iota}'\mathbf{A}\boldsymbol{\iota} \;-\; \frac{1}{N}\,\mathrm{tr}(\mathbf{A})$$

$$\sigma^2(\boldsymbol{\mu}) \;\equiv\; \frac{1}{N}\sum_{i=1}^{N}(\mu_i - \mu_m)^2 \;\;,\;\; \mu_m \equiv \frac{1}{N}\sum_{i=1}^{N}\mu_i$$

A New Microscope

Special Cases:

- Uncorrelated Returns ($\Gamma_j = 0$)

$$\mathsf{E}[\pi_t(q)] \;=\; -q\,\sigma^2(\boldsymbol{\mu}) \;\leq\; 0$$

- Idiosyncratic Mean Reversion (Marketmaking)

$$\gamma_{ii}(k) \;<\; 0$$
$$\gamma_{ij}(k) \;=\; 0$$
$$\Rightarrow\; \mathcal{M}(\boldsymbol{\Gamma}_k) \;>\; 0$$

$$\mathsf{E}[\pi_t(q)] \;=\; \underbrace{\mathcal{M}(\boldsymbol{\Gamma}_1) \;+\; \cdots \;+\; \mathcal{M}(\boldsymbol{\Gamma}_q)}_{>\,0} \;-\; q\,\sigma^2(\boldsymbol{\mu})$$

A New Microscope

Simulated Historical Performance of Contrarian Strategy

Year	Market Capitalization Deciles										All
	Smallest	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Largest	
	Average Daily Returns										
1995	3.57%	2.75%	1.94%	1.62%	1.07%	0.61%	0.21%	-0.01%	-0.02%	0.04%	1.38%
1996	3.58%	2.47%	1.82%	1.34%	0.84%	0.52%	0.19%	-0.11%	-0.04%	0.02%	1.17%
1997	2.83%	1.94%	1.34%	1.02%	0.62%	0.28%	0.04%	-0.12%	0.06%	0.14%	0.88%
1998	2.38%	1.45%	1.11%	0.62%	0.29%	0.03%	-0.04%	-0.12%	0.03%	0.10%	0.57%
1999	2.56%	1.41%	0.82%	0.38%	-0.01%	-0.11%	-0.21%	-0.35%	-0.01%	0.06%	0.44%
2000	2.58%	1.59%	0.92%	0.14%	0.03%	-0.02%	-0.14%	0.16%	0.00%	0.03%	0.44%
2001	2.15%	1.25%	0.57%	0.24%	-0.01%	0.06%	0.13%	-0.10%	-0.11%	-0.11%	0.31%
2002	1.67%	0.85%	0.53%	0.29%	0.28%	0.26%	0.28%	0.20%	0.11%	0.09%	0.45%
2003	1.00%	0.26%	-0.07%	0.04%	0.11%	0.20%	0.18%	0.15%	0.04%	0.05%	0.21%
2004	1.17%	0.48%	0.31%	0.38%	0.25%	0.29%	0.22%	0.15%	0.05%	-0.01%	0.37%
2005	1.05%	0.39%	0.13%	0.11%	0.09%	0.11%	0.05%	0.08%	0.01%	0.02%	0.26%
2006	0.86%	0.26%	0.11%	0.06%	0.05%	-0.02%	-0.02%	0.05%	0.06%	0.00%	0.15%
2007	0.57%	0.09%	0.08%	0.18%	0.16%	-0.08%	0.04%	-0.04%	0.00%	-0.04%	0.13%

A New Microscope

Simulated Historical Performance of Contrarian Strategy

Year	Market Capitalization Deciles										All
	Smallest	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Largest	
	Standard Deviation of Daily Returns										
1995	0.92%	0.88%	0.81%	0.82%	0.78%	0.77%	0.73%	0.67%	0.63%	0.65%	0.40%
1996	1.07%	1.00%	0.79%	0.81%	0.88%	0.84%	0.90%	0.90%	0.83%	0.73%	0.48%
1997	1.04%	0.98%	0.96%	0.96%	1.12%	1.00%	0.91%	0.99%	0.98%	0.77%	0.68%
1998	1.59%	1.67%	1.23%	1.22%	1.57%	1.25%	1.29%	1.43%	1.08%	1.00%	0.84%
1999	1.66%	1.82%	1.44%	1.44%	1.79%	1.57%	1.71%	1.70%	1.57%	1.07%	1.02%
2000	1.57%	1.69%	2.06%	1.89%	1.76%	2.15%	2.18%	2.29%	2.44%	2.56%	1.68%
2001	1.33%	1.26%	1.46%	1.62%	1.65%	1.64%	1.83%	1.91%	2.28%	2.29%	1.43%
2002	1.17%	0.89%	1.14%	1.07%	1.25%	1.11%	1.30%	1.42%	1.50%	1.50%	0.98%
2003	1.11%	0.81%	0.95%	0.89%	0.86%	0.81%	0.77%	0.76%	0.75%	0.56%	0.54%
2004	1.35%	1.01%	0.87%	0.76%	0.76%	0.78%	0.80%	0.74%	0.69%	0.57%	0.53%
2005	1.35%	0.80%	0.89%	0.70%	0.77%	0.77%	0.65%	0.73%	0.57%	0.56%	0.46%
2006	1.07%	0.90%	0.83%	0.84%	0.70%	1.07%	0.68%	0.68%	0.64%	0.61%	0.52%
2007	0.96%	1.02%	1.00%	0.99%	1.06%	1.44%	1.00%	0.87%	0.67%	0.56%	0.72%

Total Assets, Expected Returns, and Leverage

AUM in TASS Equity Hedge Funds and
the Profitability of the Contrarian Trading Strategy
1995 to 2007

A New Microscope
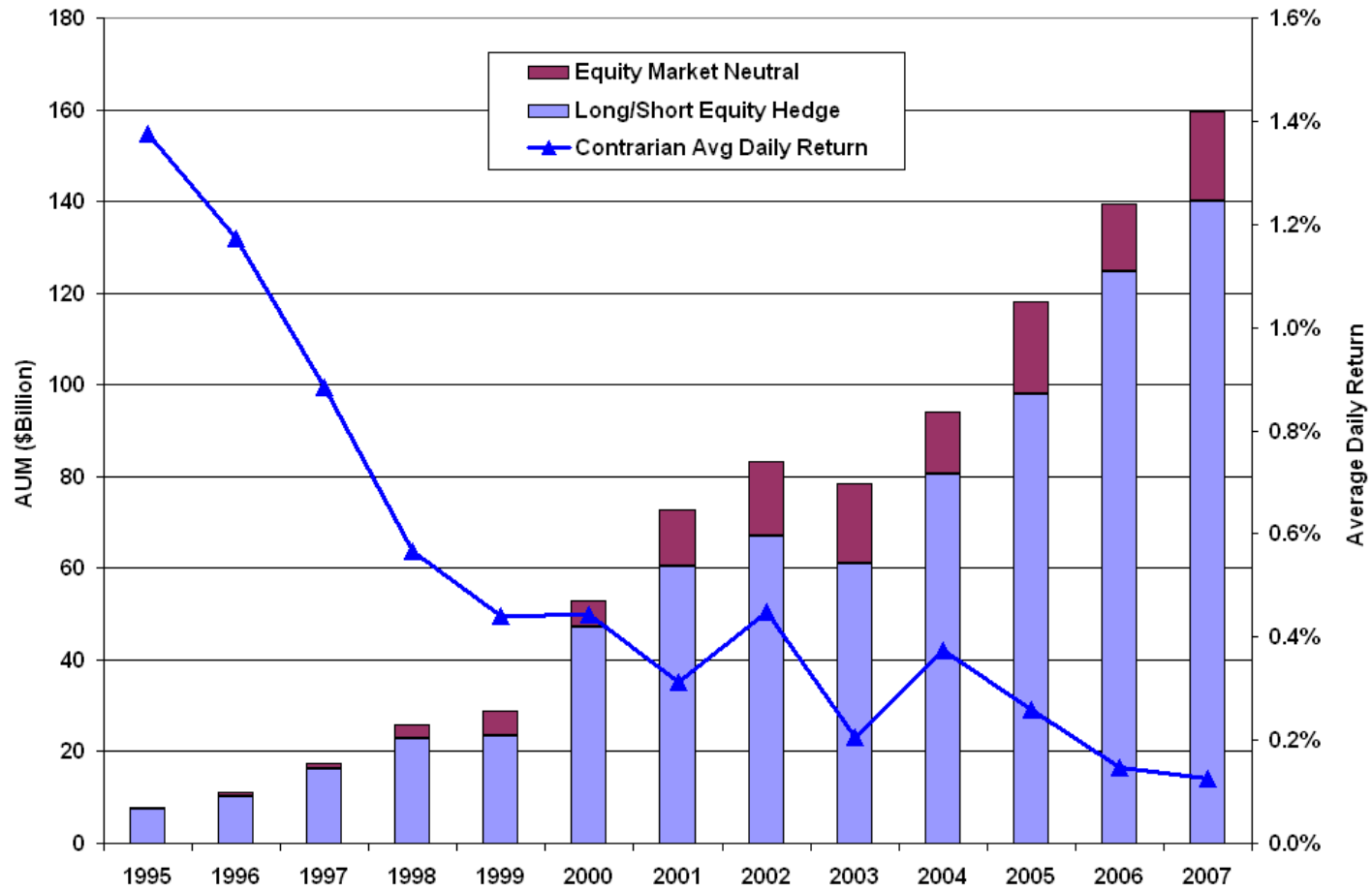
Basic Leverage Calculations

- Regulation T leverage of 2:1 implies

$$\$100\text{MM of Capital} \;\Rightarrow\; \text{Leverage} \;=\; \frac{|100| + |-100|}{100} \;=\; 2:1$$

- More leverage is available:

$$\$100\text{MM of Capital} \;\Rightarrow\; \text{Leverage} \;=\; \frac{|500| + |-500|}{100} \;=\; 10:1$$

- Leverage magnifies risk and return:

$$\theta:1 \;\Rightarrow\; \text{Leveraged Return} \;\equiv\; \frac{\theta}{2} R_{pt}$$

Total Assets, Expected Returns, and Leverage

How Much Leverage Needed To Get 1998 Expected Return Level?

- In 2007, use 2006 multiplier of 4

- 8:1 leverage

- Compute leveraged returns

- How did the contrarian strategy perform during August 2007?

- Recall that for 8:1 leverage:
  - $E[R_{pt}] = 4 \times 0.15\%$ $= 0.60\%$
  - $SD[R_{pt}] = 4 \times 0.52\%$ $= 2.08\%$

$\Rightarrow$ 2007 Daily Mean: **0.60%**

$\Rightarrow$ 2007 Daily SD: **2.08%**

Required Leverage Ratios For Contrarian Strategy To Yield 1998 Level of Average Daily Return

Year	Average Daily Return	Return Multiplier	Required Leverage Ratio
1998	0.57%	1.00	2.00
1999	0.44%	1.28	2.57
2000	0.44%	1.28	2.56
2001	0.31%	1.81	3.63
2002	0.45%	1.26	2.52
2003	0.21%	2.77	5.53
2004	0.37%	1.52	3.04
2005	0.26%	2.20	4.40
2006	0.15%	3.88	7.76
2007	0.13%	4.48	8.96

What Happened In August 2007?

Daily Returns of the Contrarian Strategy In August 2007

Date	Deciles by Market Capitalization										All
	Smallest	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Largest	
7/30/2007	-0.28%	0.08%	7.85%	-1.43%	0.29%	0.91%	1.04%	1.51%	2.05%	0.71%	1.77%
7/31/2007	0.77%	4.41%	1.12%	2.20%	-2.53%	0.09%	-3.19%	1.94%	-1.23%	0.22%	1.46%
8/1/2007	6.10%	1.78%	-5.55%	1.39%	3.79%	-3.52%	-2.83%	-2.52%	-8.06%	-0.90%	0.43%
8/2/2007	3.54%	-3.04%	-0.46%	-2.68%	-3.77%	-10.79%	8.63%	6.12%	-2.97%	-0.77%	-1.22%
8/3/2007	-3.79%	-2.49%	-3.12%	0.24%	3.52%	0.05%	-2.49%	-4.35%	-2.29%	-2.74%	-0.10%
8/6/2007	-3.33%	-7.06%	-1.57%	-4.12%	5.47%	-5.47%	-4.75%	-2.86%	1.06%	3.08%	2.01%
8/7/2007	3.00%	1.03%	-6.55%	-11.65%	-6.01%	-2.79%	1.42%	-4.08%	-6.86%	-2.67%	-4.64%
8/8/2007	3.52%	-5.30%	-10.36%	-14.58%	-17.07%	-8.65%	-8.94%	-13.85%	-5.06%	-5.91%	-11.33%
8/9/2007	3.66%	-7.42%	-15.46%	-11.08%	-12.72%	-15.78%	-13.06%	-17.33%	-10.32%	-5.22%	-11.43%
8/10/2007	-1.32%	14.62%	24.32%	31.58%	35.08%	30.67%	30.07%	26.79%	18.73%	9.55%	23.67%
8/13/2007	5.42%	-1.24%	-2.53%	-4.26%	-6.20%	-0.88%	-5.15%	-8.04%	-8.58%	-4.99%	-3.05%
8/14/2007	4.65%	3.64%	-1.02%	1.35%	2.23%	-1.12%	2.74%	-1.16%	0.66%	0.67%	0.33%
8/15/2007	3.52%	4.74%	-2.42%	-2.33%	-0.69%	-3.89%	-0.97%	-5.36%	-2.29%	-4.73%	-1.53%
8/16/2007	-5.03%	-2.16%	0.59%	-2.36%	-2.39%	-3.95%	-6.94%	-5.08%	1.08%	-7.31%	-3.24%
8/17/2007	14.30%	9.94%	0.41%	5.04%	5.32%	-2.07%	0.47%	-1.56%	1.24%	0.44%	1.53%
8/20/2007	15.02%	7.02%	1.42%	5.40%	2.03%	1.74%	4.88%	2.22%	1.57%	4.67%	4.58%
8/21/2007	4.98%	0.43%	0.02%	-1.80%	0.09%	-2.54%	-0.33%	-0.20%	0.74%	0.43%	0.24%
8/22/2007	-3.39%	-1.23%	-2.07%	-2.05%	-0.67%	-3.31%	-0.74%	-2.26%	1.57%	0.37%	-1.51%
8/23/2007	-0.14%	2.79%	2.79%	-0.64%	1.51%	4.15%	1.04%	-1.33%	1.28%	1.23%	1.31%
8/24/2007	2.47%	-1.13%	-0.26%	0.92%	3.70%	-0.23%	-0.29%	0.37%	-1.42%	2.43%	1.73%
8/27/2007	4.38%	2.80%	0.46%	0.78%	5.01%	-0.63%	1.58%	2.85%	2.84%	0.10%	2.99%
8/28/2007	1.64%	1.26%	0.34%	-2.45%	-2.56%	-1.99%	-1.33%	-1.77%	-1.88%	0.99%	-3.04%
8/29/2007	5.79%	0.31%	5.07%	8.32%	7.75%	-2.14%	5.67%	6.39%	3.63%	3.94%	7.06%
8/30/2007	4.27%	0.16%	2.46%	1.61%	3.55%	0.41%	-0.11%	-0.16%	0.47%	-0.19%	2.01%
8/31/2007	6.75%	3.86%	3.80%	-2.21%	0.21%	2.08%	-0.32%	-2.68%	0.02%	0.58%	1.46%

What Happened In August 2007?

Daily Returns of Various Indexes In August 2007

Date	S&P 500	S&P Small Cap 600	MSCI Emerging Markets	MSCI World ex. US	Lehman Aggregate US Gov. Index	Lehman US Universal Corp. High-Yield Index	Goldman Sachs Commodity Index	Trade Weighted USD Index	CBOE Volatility 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
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

Comparing August 2007 To August 1998

Daily Returns of the Contrarian Strategy In August and September 1998

Date	Deciles by Market Capitalization										All
	Smallest	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Largest	
8/3/1998	3.35%	1.75%	1.68%	0.15%	3.25%	-0.33%	0.40%	0.06%	0.62%	0.16%	1.01%
8/4/1998	-0.29%	2.16%	1.64%	-1.35%	-1.18%	-0.51%	-0.82%	-0.07%	-1.22%	-0.16%	-0.18%
8/5/1998	2.75%	1.93%	0.68%	2.60%	2.04%	0.93%	-0.57%	0.38%	-0.59%	2.56%	1.27%
8/6/1998	2.25%	1.68%	2.01%	0.36%	0.17%	-0.33%	-1.35%	0.15%	0.85%	1.34%	0.66%
8/7/1998	3.05%	2.99%	0.79%	0.26%	-0.23%	0.03%	0.12%	0.39%	2.93%	-0.10%	0.67%
8/10/1998	3.48%	1.69%	1.53%	0.91%	0.48%	2.23%	1.03%	-0.23%	0.68%	0.27%	1.27%
8/11/1998	2.34%	1.72%	0.81%	-0.24%	0.60%	1.18%	-0.36%	0.79%	-0.29%	-0.14%	0.59%
8/12/1998	4.83%	2.88%	2.71%	1.31%	0.96%	0.58%	2.01%	0.93%	1.00%	0.68%	2.04%
8/13/1998	3.74%	2.24%	0.88%	2.72%	0.37%	0.39%	1.03%	0.48%	-0.11%	0.04%	1.33%
8/14/1998	2.25%	1.64%	3.57%	1.42%	-0.46%	-0.05%	0.66%	-0.07%	0.77%	-0.42%	0.94%
8/17/1998	2.46%	2.48%	1.81%	0.11%	-0.32%	1.66%	-0.01%	-0.80%	0.11%	0.49%	0.96%
8/18/1998	4.31%	1.85%	1.75%	3.86%	0.35%	-0.16%	-2.12%	0.03%	0.29%	0.12%	0.87%
8/19/1998	2.60%	2.15%	1.16%	0.45%	-0.65%	-0.36%	0.34%	-0.80%	0.06%	-0.13%	0.63%
8/20/1998	1.60%	3.04%	1.49%	0.42%	-0.64%	0.55%	0.87%	-0.61%	-0.55%	-1.47%	0.46%
8/21/1998	2.26%	4.06%	2.18%	1.79%	1.03%	-0.06%	-0.28%	-0.51%	0.06%	-0.36%	1.04%
8/24/1998	5.35%	1.84%	4.13%	0.63%	-0.83%	0.13%	-1.57%	-1.02%	-0.68%	0.73%	0.90%
8/25/1998	2.05%	2.19%	1.76%	0.85%	-0.45%	-0.34%	0.91%	-1.46%	-0.48%	-0.56%	0.36%
8/26/1998	4.02%	1.39%	1.78%	0.81%	-0.31%	0.06%	-0.43%	1.03%	-0.65%	-0.26%	0.61%
8/27/1998	1.69%	1.15%	0.24%	-1.16%	-2.02%	-0.47%	-1.54%	-1.91%	-0.63%	-2.20%	-0.78%
8/28/1998	2.52%	2.29%	1.33%	1.35%	0.11%	1.12%	-1.29%	-1.32%	-1.18%	-0.36%	0.39%
8/31/1998	3.31%	1.79%	0.51%	-0.36%	-3.44%	-1.97%	-3.08%	-4.47%	-2.73%	-2.82%	-1.62%
9/1/1998	4.96%	4.42%	6.04%	4.67%	9.06%	6.68%	6.71%	6.67%	4.90%	6.10%	6.59%
9/2/1998	4.43%	2.74%	1.90%	0.82%	-1.33%	0.25%	0.86%	-0.39%	0.45%	0.33%	0.63%
9/3/1998	3.89%	3.78%	2.08%	2.09%	0.23%	-0.03%	0.79%	0.15%	0.51%	0.76%	1.41%
9/4/1998	5.10%	3.95%	2.09%	0.75%	-0.33%	-0.84%	-1.33%	-1.61%	-1.15%	-3.68%	0.26%

Comparing August 2007 To August 1998

Daily Returns of the Contrarian Strategy In August and September 1998

Date	Deciles by Market Capitalization										All
	Smallest	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Largest	
9/8/1998	3.53%	3.40%	3.82%	0.57%	0.60%	0.82%	1.35%	1.05%	0.97%	3.73%	2.08%
9/9/1998	1.99%	3.62%	1.38%	1.15%	1.12%	1.66%	1.70%	2.10%	2.32%	2.92%	2.42%
9/10/1998	4.26%	2.68%	0.08%	2.05%	0.96%	-0.27%	0.64%	-0.86%	-0.67%	-2.16%	0.29%
9/11/1998	3.34%	3.17%	2.15%	0.77%	0.20%	0.50%	-0.95%	1.28%	-0.18%	0.15%	1.24%
9/14/1998	3.53%	3.58%	1.54%	0.83%	-0.20%	-0.42%	-0.47%	-0.50%	0.02%	-0.23%	0.33%
9/15/1998	3.62%	2.36%	1.34%	0.77%	-0.17%	-0.98%	-0.52%	-1.15%	-0.95%	-0.63%	0.14%
9/16/1998	2.71%	3.33%	0.89%	1.48%	0.58%	0.83%	0.00%	0.05%	1.53%	-0.04%	1.01%
9/17/1998	3.70%	2.24%	1.54%	1.56%	-0.95%	0.23%	1.10%	-0.40%	-0.86%	0.38%	0.79%
9/18/1998	4.01%	3.94%	2.67%	1.27%	2.55%	1.20%	-1.17%	-1.41%	-0.51%	-0.45%	1.07%
9/21/1998	3.22%	1.28%	1.86%	-0.61%	-0.87%	-0.09%	-2.22%	1.08%	-0.47%	-0.32%	0.19%
9/22/1998	3.26%	2.15%	1.68%	1.76%	-0.21%	-0.16%	-0.62%	-2.06%	-1.46%	0.16%	0.42%
9/23/1998	4.24%	2.16%	0.78%	-1.66%	-0.34%	-2.33%	-3.08%	-3.27%	-0.60%	-0.42%	-0.71%
9/24/1998	2.54%	1.47%	3.13%	1.60%	0.63%	-0.38%	-0.06%	-0.27%	0.59%	1.63%	1.21%
9/25/1998	2.28%	3.27%	0.16%	0.86%	0.28%	-0.90%	-0.66%	0.67%	1.16%	0.36%	0.61%
9/28/1998	4.24%	1.24%	1.81%	2.64%	0.52%	-1.30%	0.47%	-1.58%	-0.59%	0.16%	0.60%
9/29/1998	2.75%	1.48%	-0.07%	0.81%	-0.83%	-1.61%	-1.58%	-0.83%	-1.19%	-0.83%	-0.29%
9/30/1998	2.98%	0.41%	0.33%	-0.96%	0.01%	-1.00%	-1.78%	-0.41%	-0.10%	-0.74%	-0.33%

The Unwind Hypothesis

What Happened?

- Losses due to rapid and large unwind of quant fund (market-neutral)
- Liquidation is likely forced because of firesale prices (sub-prime?)
- Initial losses caused other funds to reduce risk and de-leverage
- De-leveraging caused further losses across broader set of equity funds
- Friday rebound consistent with liquidity trade, not informed trade
- Rebound due to quant funds, long/short, 130/30, long-only funds

Did Portfolio Managers Use the Same Factors?

Factor-Based Strategies

Construct Five Long/Short Factor Portfolios

- Book-to-Market

- Earnings-to-Price

- Cashflow-to-Price

- Price Momentum

- Earnings Momentum

- Rank S&P 1500 stocks monthly

- Invest $1 long in decile 10 (highest), $1 short in decile 1 (lowest)

- Equal-weighting within deciles

- Simulate daily holding-period returns

Factor-Based Strategies

Cumulative Returns of Factor-Based Portfolios
January 3, 2007 to December 31, 2007
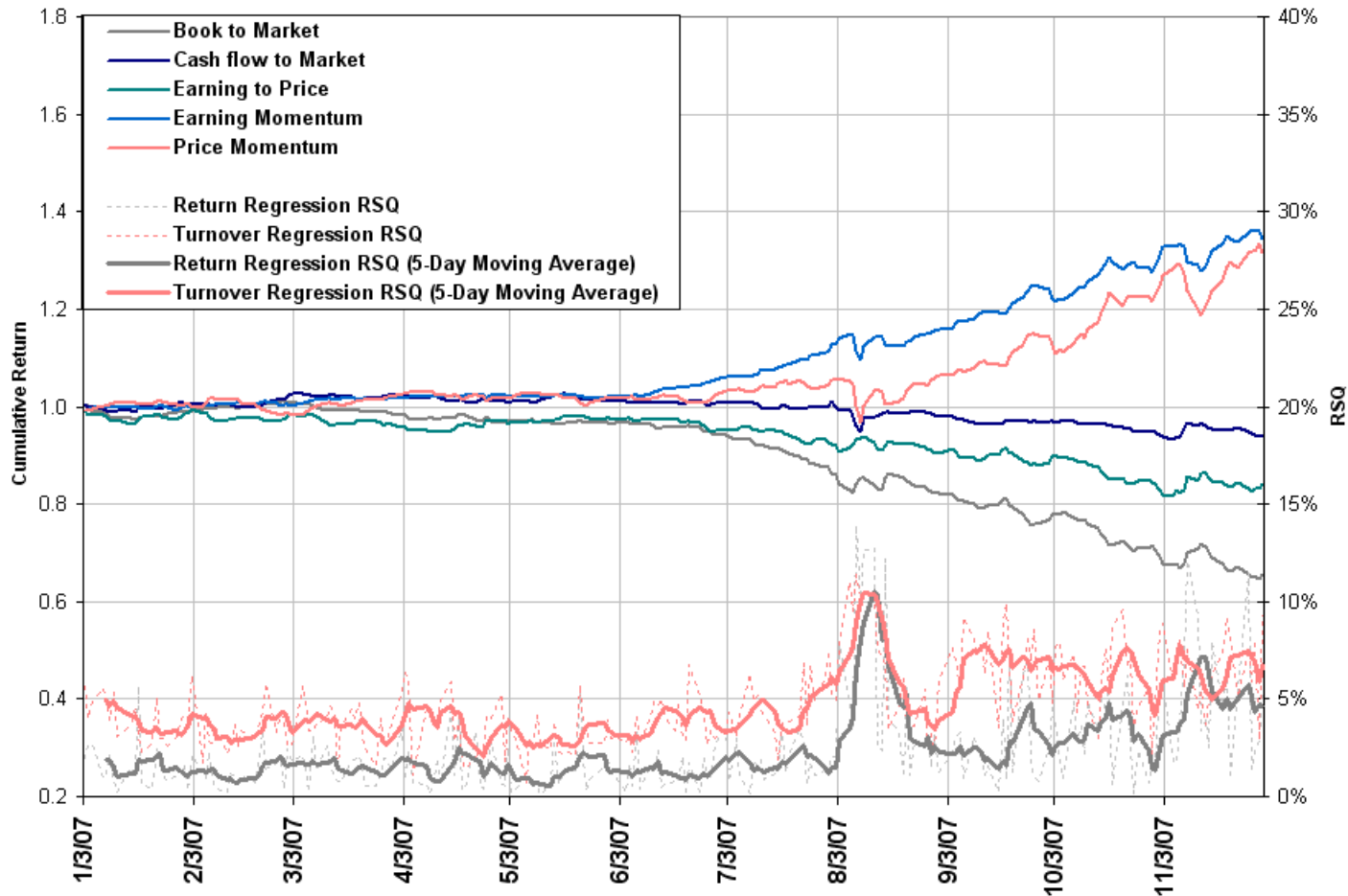
Factor-Based Strategies

Using Tick Data, Construct Long/Short Factor Portfolios

- Same five factors
- Compute 5-minute returns from 9:30am to 4:00pm (no overnight returns)
- Simulate intra-day performance of five long/short portfolios
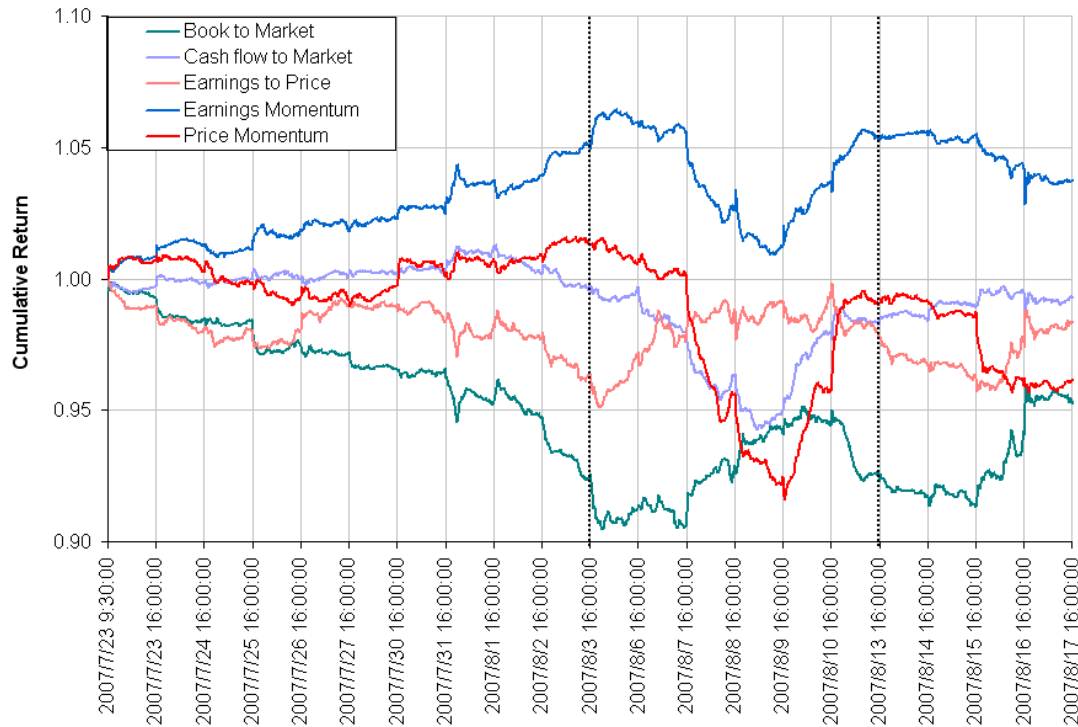
Measures of Liquidity and Price Impact

- Kyle (1985) price-impact model

Liquidity Measure

$$R_{i,t} \; = \; \widehat{c}_i \; + \; \widehat{\lambda}_i \cdot \text{Sgn}(t) \log(v_{i,t} p_{i,t}) \; + \; \widehat{\epsilon}_{i,t}$$

- Use "tick test" to determine sign of daily volume

$$\text{Sgn}(t) \;\; = \;\; \begin{cases} +1 & \text{if } R_{i,t} > 0 \\ -1 & \text{if } R_{i,t} \leq 0 \end{cases}$$

- Larger values of $\quad\Rightarrow$ less liquidity

Measures of Liquidity and Price Impact

Average Price Impact Based on Daily Data
January 1, 1995 to December 31, 2007
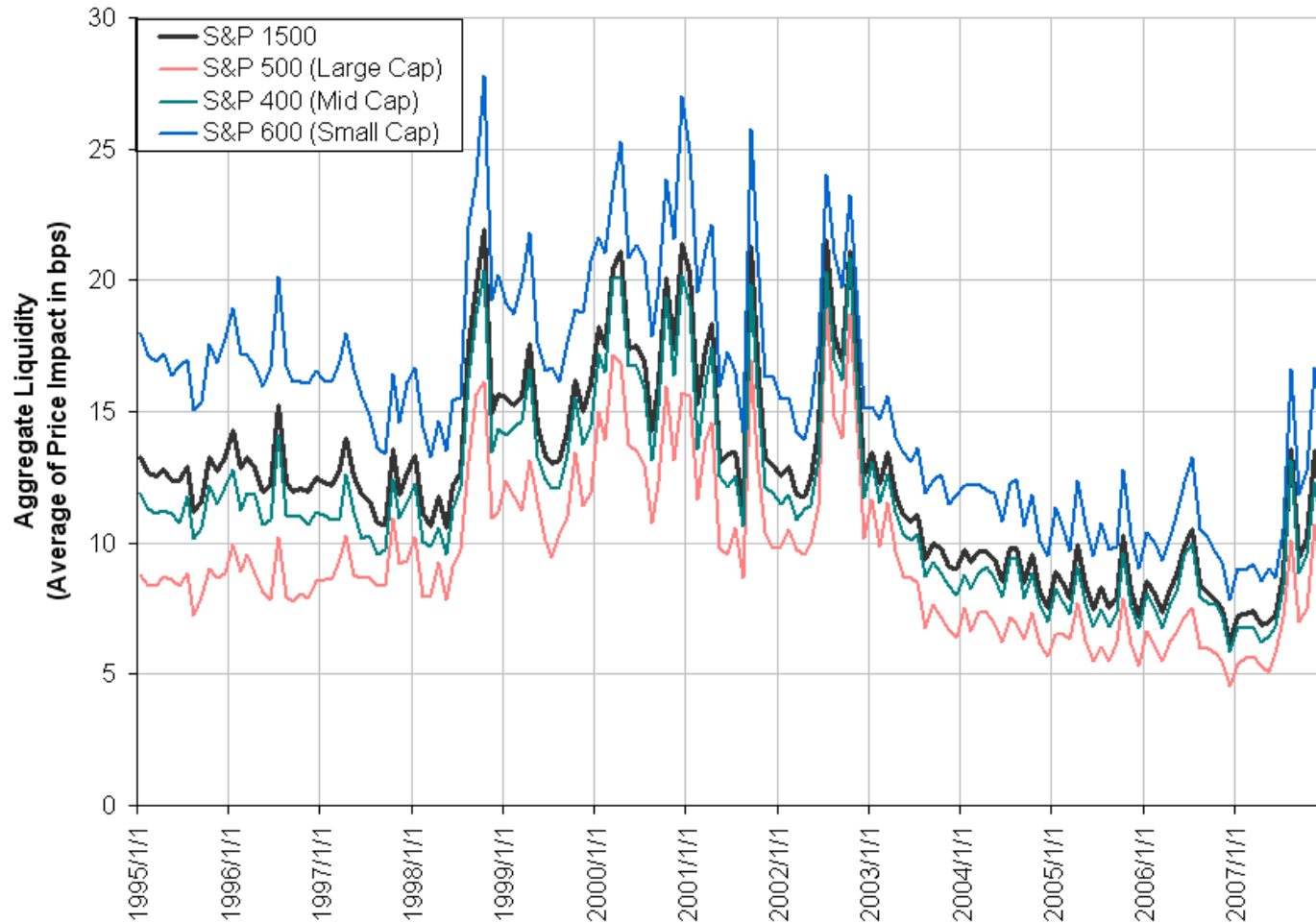
Measures of Liquidity and Price Impact

Relative Price Impact Based on Transactions Data
July to September 2007, Base Date: July 2, 2007

$$\hat{\lambda}_i \log(\$5{,}000) = 1.5 \times \hat{\lambda}_i \log(X)$$
$$X = \$5{,}000^{1.5}$$
$$= \$353{,}553$$

Proxies for Marketmaking Profits
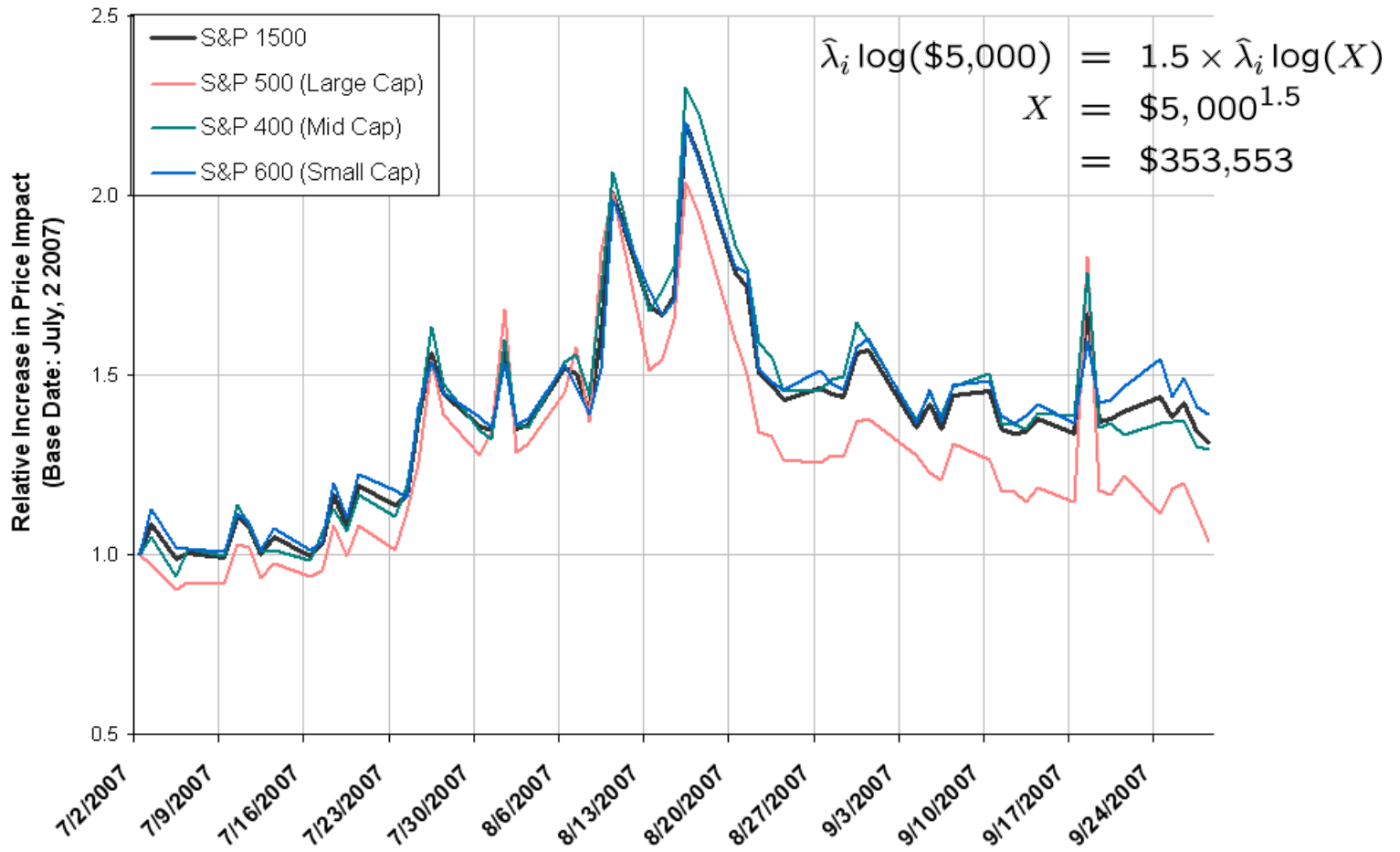
What Happened To Market-Makers During August 2007?

- Simulate simpler mean-reversion strategy using TAQ data
  - Sort stocks based on previous 5-minute returns
  - Put $1 long in decile 1 (losers) and $1 short in decile 10 (winners)
  - Rebalance every m minutes, $m = 5, 10, ..., 60$
  - Cumulate profits
- Profitability of strategy should proxy for marketmaking P&L
- Let m vary to measure the value of liquidity provision vs. horizons
- Greater immediacy $\Rightarrow$ larger profits on average
- Positive profits suggest the presence of discretionary liquidity providers
- Negative profits suggest the absence of discretionary liquidity providers
- Given positive bid/offer spreads, on average, profits should be positive

Weekly Averages of Returns to Simple Marketmaking Strategy
Using Lagged 5-Minute Returns, July to September 2007
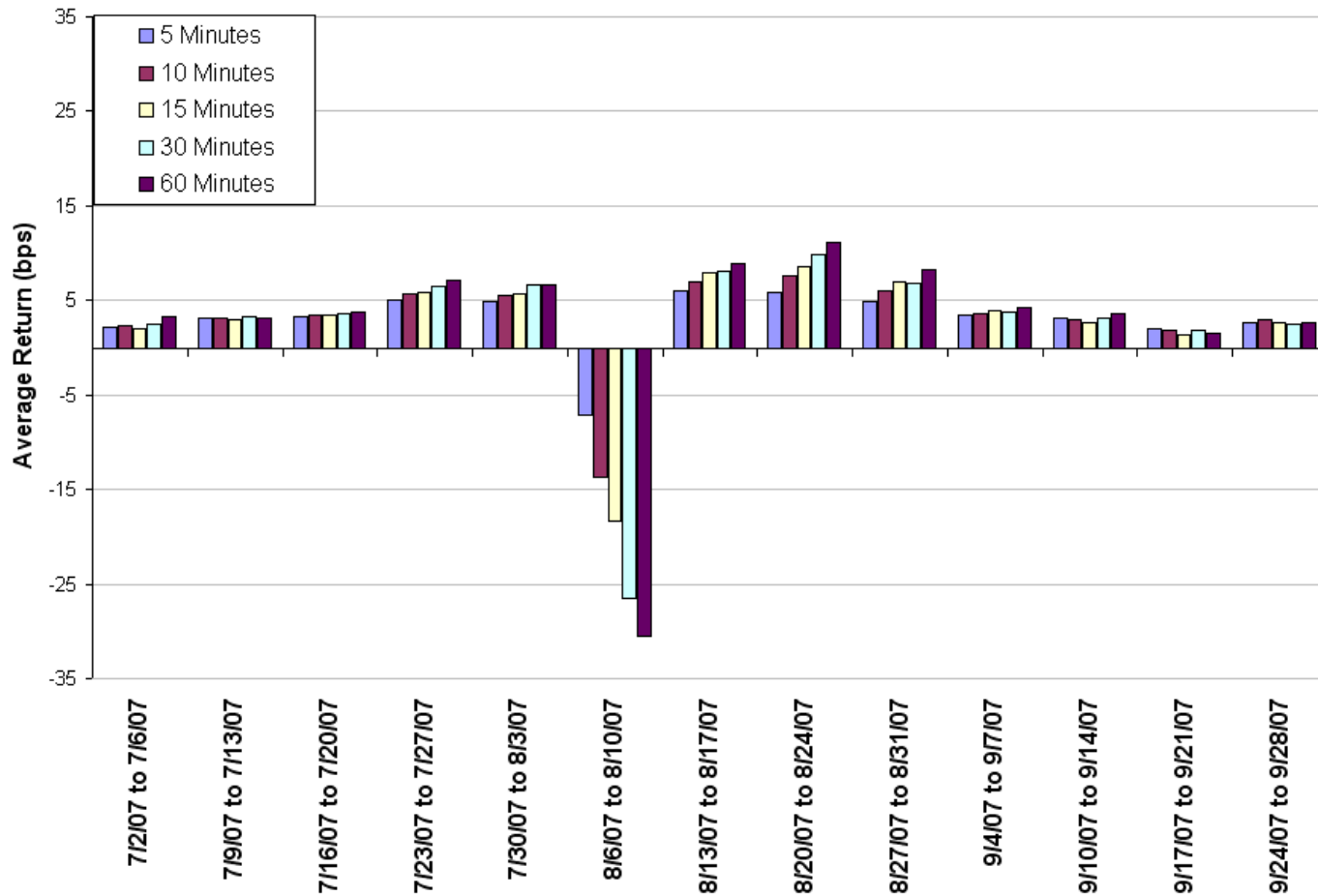
Proxies for Marketmaking Profits

Cumulative *m*-Min Returns of Intra-Daily Contrarian Profits for Deciles 10/1 of S&P 1500 Stocks July 2 to September 30, 2008
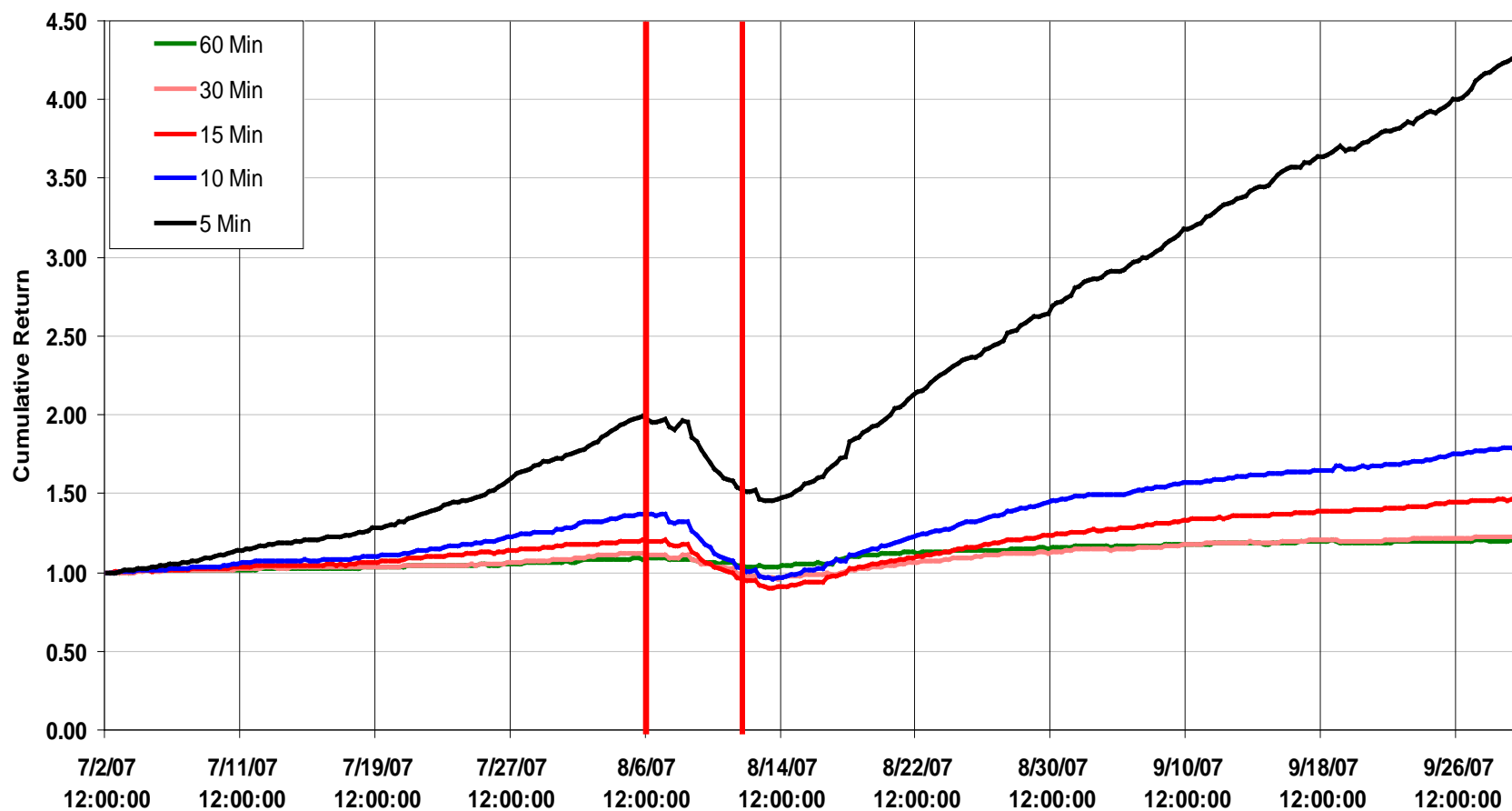
Proxies for Marketmaking Profits

Profitability of Intra-Daily and Daily Strategies
Over Various Holding Period, August 1–15, 2007

Panel A: High-Frequency Contrarian Strategy

	Average Return (bps)				
Date	5 Minutes	10 Minutes	15 Minutes	30 Minutes	60 Minutes
8/1/2007	5.06	6.81	5.15	8.02	7.37
8/2/2007	6.74	6.97	8.47	9.48	9.02
8/3/2007	4.28	2.93	1.77	1.47	-0.62
8/6/2007	-1.30	-2.57	-3.57	-8.75	-5.30
8/7/2007	-1.12	-6.32	-10.14	-14.55	-15.43
8/8/2007	-18.69	-31.60	-40.99	-56.82	-62.49
8/9/2007	-9.82	-16.86	-20.87	-27.65	-26.06
8/10/2007	-4.38	-11.41	-16.25	-25.15	-42.97
8/13/2007	-4.90	-10.29	-15.17	-23.18	-28.69
8/14/2007	5.39	7.72	8.30	10.12	10.28
8/15/2007	6.79	8.96	9.63	8.46	8.35
July Sigma	1.58	1.96	2.15	2.58	3.53

Panel B: Daily Contrarian Strategy

	Return (%)				
Portfolio Construction Date	Held 1 Day	Held 2 Days	Held 3 Days	Held 4 Days	Held 5 Days
8/1/2007	0.14%	-1.03%	-2.69%	-2.57%	-0.34%
8/2/2007	-0.76%	-1.62%	-2.57%	-2.63%	-2.79%
8/3/2007	-0.30%	-0.57%	0.65%	0.29%	2.04%
8/6/2007	-1.47%	-1.79%	-1.75%	1.24%	3.44%
8/7/2007	-2.88%	-4.49%	1.38%	4.00%	4.52%
8/8/2007	-3.99%	3.79%	7.81%	8.31%	8.20%
8/9/2007	6.85%	10.12%	9.83%	9.47%	8.96%
8/10/2007	-1.46%	-1.71%	-1.48%	-1.84%	-1.49%
8/13/2007	0.19%	0.82%	3.79%	4.61%	3.77%
8/14/2007	-0.95%	-0.83%	0.22%	0.34%	0.56%
8/15/2007	-1.34%	-0.58%	0.31%	0.76%	1.69%
January to July 2007	0.36%	0.49%	0.59%	0.66%	0.69%
2007 Sigma	0.8%	1.1%	1.2%	1.5%	1.5%

FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010

REPORT OF THE STAFFS OF THE CFTC AND SEC TO THE JOINT ADVISORY COMMITTEE ON EMERGING REGULATORY ISSUES

U.S. Commodity Futures Trading Commission
Three Lafayette Centre, 1155 21ˢᵗ Street, NW
Washington, D.C. 20581
(202) 418-5000
www.cftc.gov

U.S. Securities & Exchange Commission
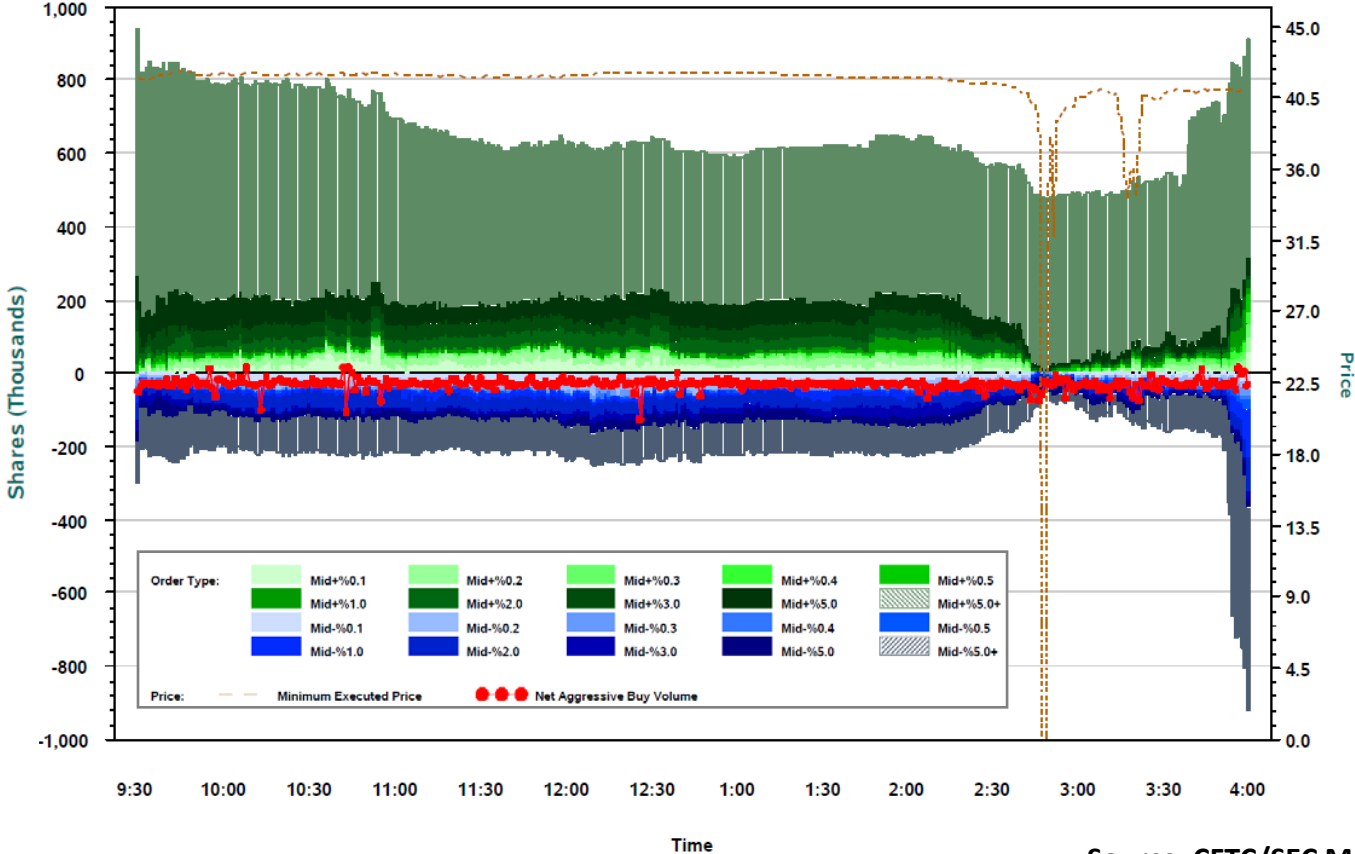100 F Street, NE
Washington, D.C. 20549
(202) 551-5500
www.sec.gov

SEPTEMBER 30, 2010

http://sec.gov/news/studies/2010/marketevents-report.pdf

Accenture plc, Market Depth, Aggressive Buys, and Price

9:30am – 4:00pm

Accenture plc, Market Depth, Aggressive Buys, and Price
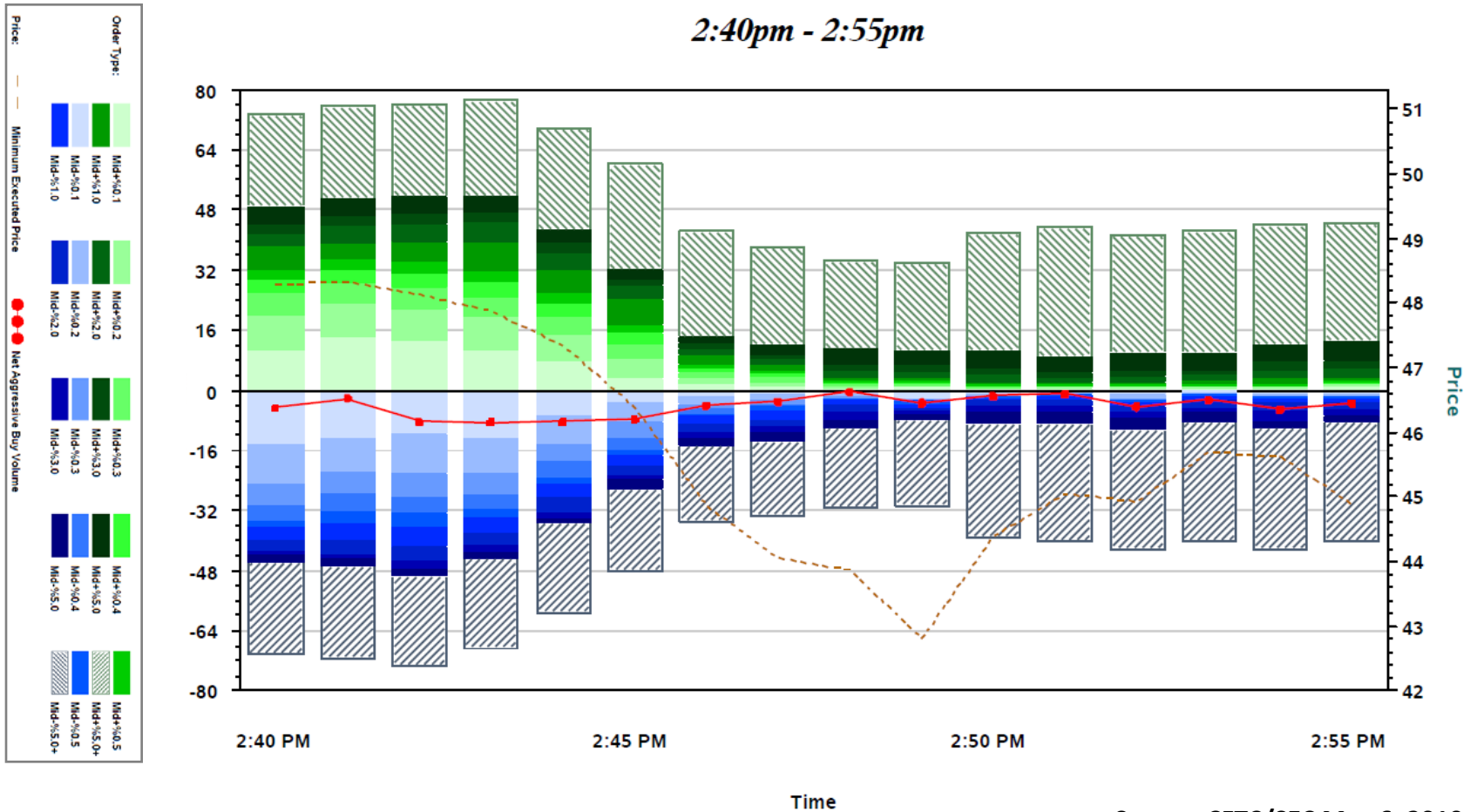
2:40pm - 2:55pm
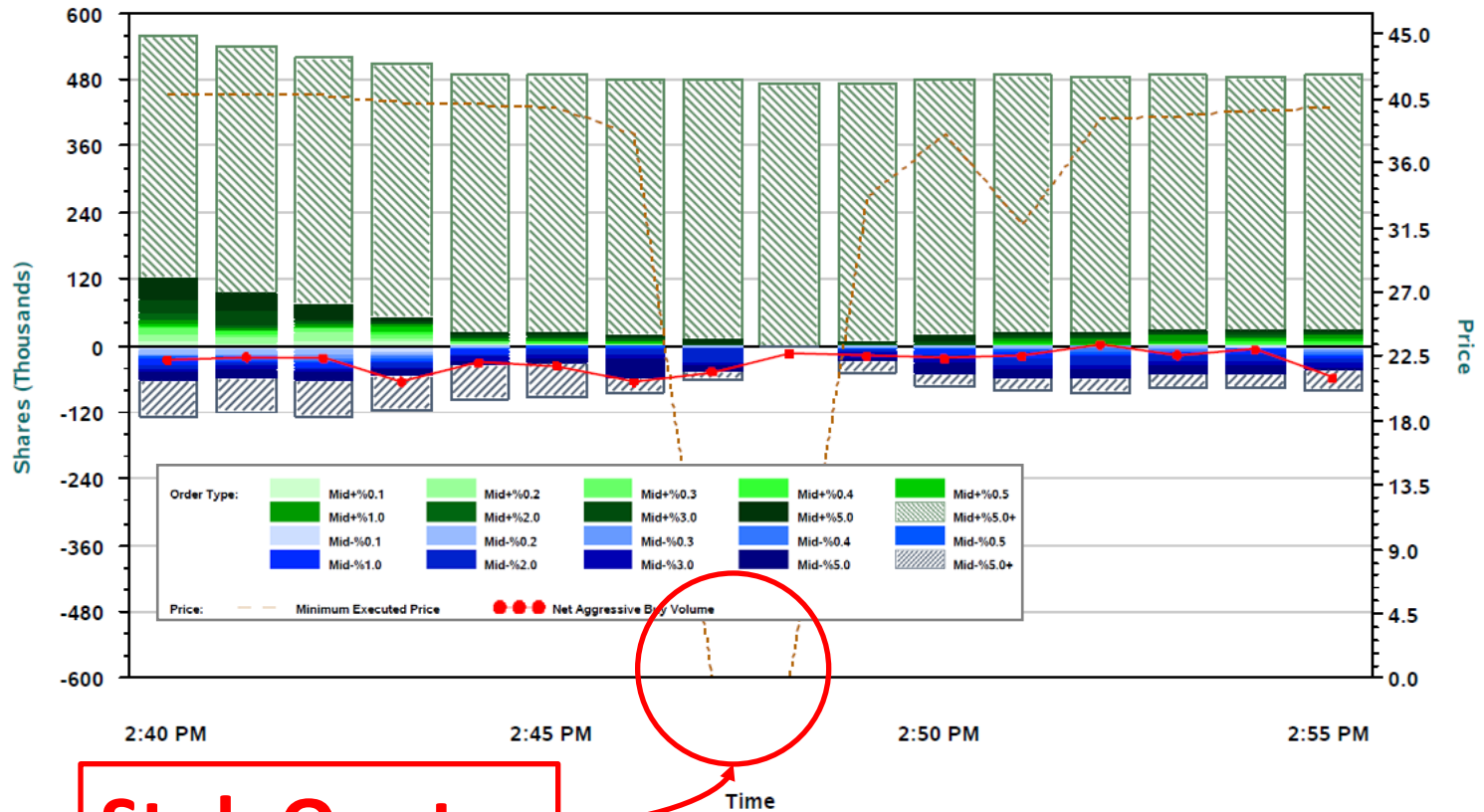
Stub Quotes

Source: CFTC/SEC May 6, 2010 Report

Top 100 ETFs' Market Depth, Aggressive Buys, and Price

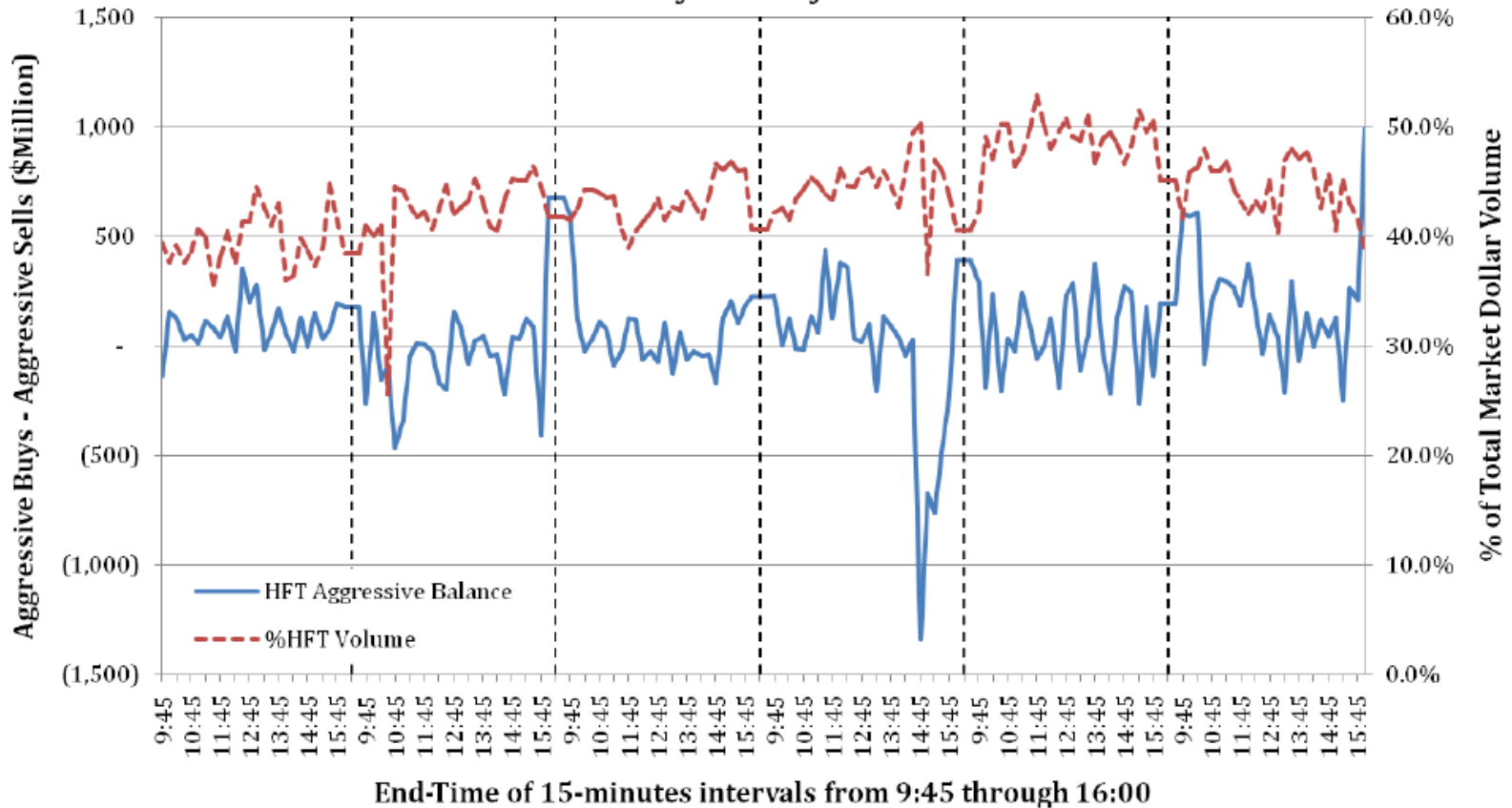*9:30am – 4:00pm*

Source: CFTC/SEC May 6, 2010 Report

May 6, 2010

Top 100 ETFs' Market Depth, Aggressive Buys, and Price

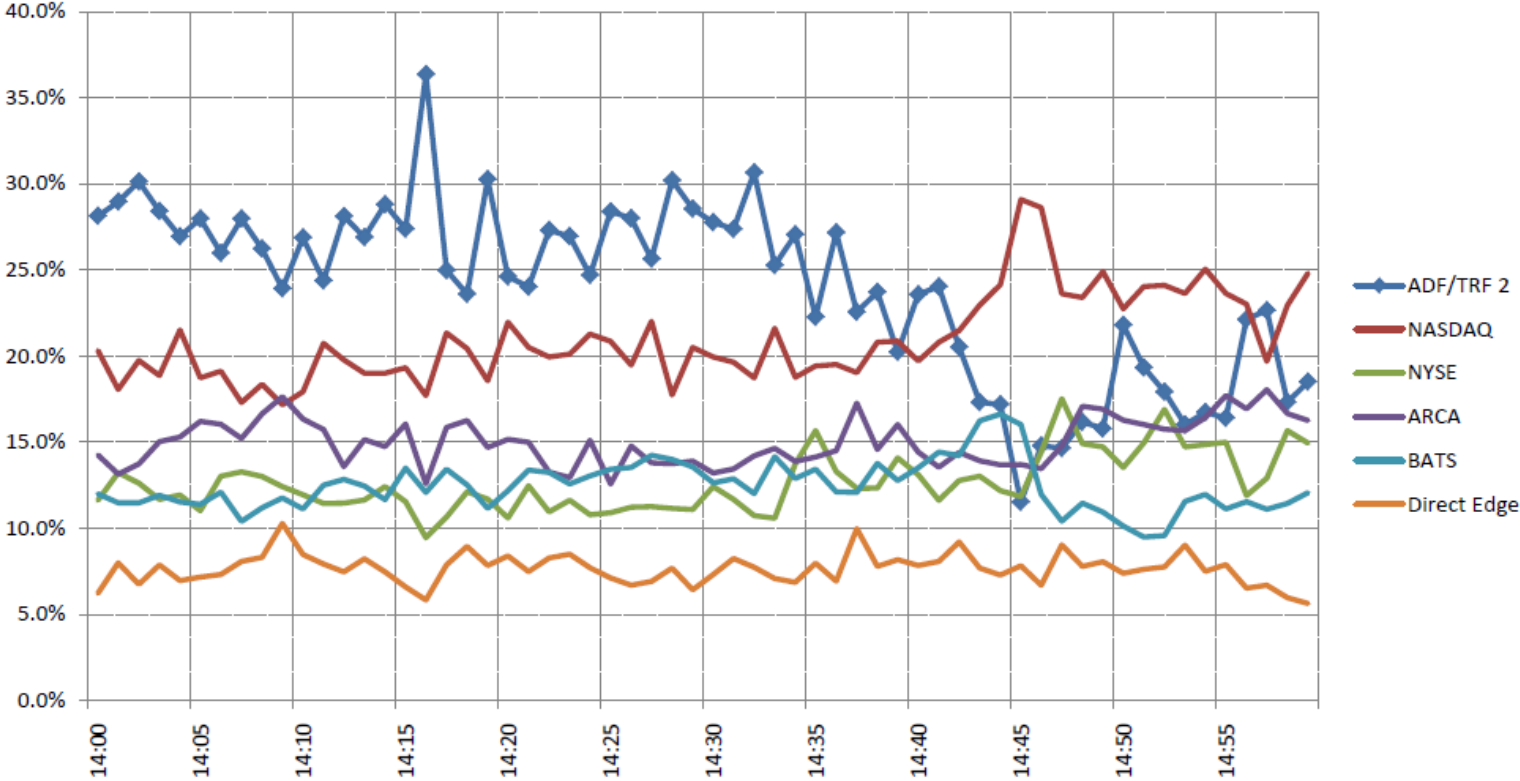Source: CFTC/SEC May 6, 2010 Report

Aggressive Order Imbalance and Volume of 17 HFT Firms
May 3 - May 10

Source: CFTC/SEC May 6, 2010 Report

Percent Shares Traded by Market Center, Adjusted for Direct Edge
One-Minute Intervals, 14:00 - 15:00

Conclusions

Lessons from August 1998, August 2007, May 2010

- Three L's of Financial Crises: Liquidity, Leverage, Losses
- All strategies are more crowded now (connectedness) relative to 1998
- Centralized exchanges vs. OTC yields different timescales for crisis
- Hold-to-maturity vs. mark-to-market accounting yields different timescales
- Hedge funds and HFTs provide more significant amounts of liquidity today
- Hedge funds and HFTs can withdraw liquidity suddenly, unlike banks
- Liquidity withdrawal can lead to market dislocations
- Financial markets are more highly connected $\Rightarrow$ **new betas**
- Systemic risk has increased

Market Microstructure Requires New Regulatory Framework

Thank You!