The Flash Crash:
The Impact of High Frequency Trading on an Electronic Market

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Commodity Futures Trading Commission

joint with

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This presentation and the views presented here represent only our views and do not necessarily represent the views of the Commission, Commissioners or staff of the Commodity Futures Trading Commission.
The Flash Crash - May 6, 2010
What did people think?

A survey conducted by Market Strategies International in June 2010 reports that over 80 percent of U.S. retail advisors believe that “overreliance on computer systems and high-frequency trading” were the primary contributors to the volatility observed on May 6.
This paper

We use audit-trail data for the E-mini S&P 500 stock index futures contract to answer three questions:

How did High Frequency Traders and others traded on May 6?

What may have triggered the Flash Crash?

What role did High Frequency Traders play in the Flash Crash?
Findings

High Frequency Traders did not cause the Flash Crash.

On May 6, HFTs traded the same way as they did on May 3-5: Small inventory, high trading volume, take more liquidity than provide.

A large, but short lived imbalance between Fundamental Sellers and Fundamental Buyers appeared.

Opportunistic Traders held it, but for a massive price concession.

Fundamental Buyers eventually stepped in and pushed prices up.
E-mini S&P 500 futures contract

Trades exclusively on the CME Globex electronic trading platform.

Highest dollar trading volume among U.S. equity index products.

Contributes the most to price discovery of the S&P 500 index: Hasbrouck (2003).

Price discovery typically occurs in the front-month contract.
June 2010 E-mini S&P 500: Trading Volume and Price
<table>
<thead>
<tr>
<th>Summary Statistics</th>
<th>May 3-5</th>
<th>May 6th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>2,397,639</td>
<td>5,094,703</td>
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<tr>
<td># of Trades</td>
<td>446,340</td>
<td>1,030,204</td>
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<tr>
<td># of Traders</td>
<td>11,875</td>
<td>15,422</td>
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<tr>
<td>Trade Size</td>
<td>5.41</td>
<td>4.99</td>
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<tr>
<td>Order Size</td>
<td>10.83</td>
<td>9.76</td>
</tr>
<tr>
<td>Limit Orders % Volume</td>
<td>95.45%</td>
<td>92.44%</td>
</tr>
<tr>
<td>Limit Orders % Trades</td>
<td>94.36%</td>
<td>91.75%</td>
</tr>
<tr>
<td>Volatility</td>
<td>1.54%</td>
<td>9.82%</td>
</tr>
<tr>
<td>Return</td>
<td>-0.02%</td>
<td>-3.05%</td>
</tr>
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</table>
Trader Categories

• High Frequency Traders (16)
• Intermediaries (179)
• Fundamental Buyers (1263)
• Fundamental Sellers (1276)
• Opportunistic Traders (5808)
• Small Traders (Noise) (6880)
Trader Categories

% of Volume

% of Trades

HFT

Opp

Fundamental

Int

Noise

Rank

0 5000 10000 15000 20000

0 5000 10000 15000 20000
Trader Categories

May 3

High Frequency Traders
Opportunistic Traders and Intermediaries
Fundamental Sellers
Fundamental Buyers

May 4

High Frequency Traders
Opportunistic Traders and Intermediaries
Fundamental Sellers
Fundamental Buyers

May 5

High Frequency Traders
Opportunistic Traders and Intermediaries
Fundamental Sellers
Fundamental Buyers

May 6

High Frequency Traders
Opportunistic Traders and Intermediaries
Fundamental Sellers
Fundamental Buyers
16 HFT accounts are responsible for almost a third of trading volume...
Net Holdings of High Frequency Traders

May 3

May 4

May 5

May 6

Yet they do not accumulate of position larger than 4500 contracts!
HFTs reduce 0.6 percent of their net holdings in 1 second.

HFTs trade in the direction of the price movement for the first 5 seconds.

Trade in the direction opposite the price movement after 10 seconds.

Interpretation: Speed or predictive ability enables HFTs to buy right when prices are about to increase and sell after the prices rose.
HFTs: Net Holdings and Prices

\[ \Delta y_t = \alpha + \phi \Delta y_{t-1} + \delta y_{t-1} + \sum_{i=0}^{20} [\beta_{t-i} \times \Delta p_{t-i}/0.25] + \epsilon_t \]

May 6

HFTs trade in the direction of the price movement for the first 2 seconds.

Trade in the direction opposite the price movement after 4 seconds.

On May 6, HFTs reverse the direction of their trading a lot faster

Follow the same strategy, but do it faster
Intermediaries: Net Holdings and Prices

May 3-5

Intermediaries reduce 0.4 percent of their net holdings in 1 second.

Intermediaries trade opposite the price movement for the first 2 seconds.

Trade in the same direction as price after 3 seconds.

May 6

Intermediaries trade opposite the price movement contemporaneously.

Reverse the direction of trade at lags 1 through 4.

Intermediaries get run over by the price move.
Profits and Losses of High Frequency Traders

Never negative.
Profits and Losses of Intermediaries

**May 3**

**May 4**

**May 5**

**May 6**
HFTs: Liquidity Provision (Passive) or Removal (Aggressive)

May 3-5

Aggressively reduce 0.5 percent of their net holdings in 1 second.

Aggressively trade in the direction of the price movement for the first 6 seconds.

Aggressively trade in the direction opposite the price movement after 10 seconds.

Passively provide liquidity at all lags, but with smaller coefficients

May 6

Same strategy, but faster

HFTs more aggressively remove liquidity, then passively supply it
Intermediaries: Liquidity Provision (Passive) or Removal (Aggressive)

May 3-5

Aggressively reduce 0.2 percent of their net holdings in 1 second.

Aggressively trade in the direction of the price movement for the first 12 seconds.

Passively provide liquidity at all lags, and with larger coefficients

May 6

Smaller coefficients

Intermediaries provide liquidity; did less of it on May 6
HFTs and Intermediaries: The Flash Crash

**DOWN (13:32:00-13:45:28 CT)**

HFTs follow the same strategy

Intermediaries get caught on the wrong side

**UP (13:45:33-14:08:00 CT)**

HFTs are less aggressive (fundamental and opportunistic buyers are)

Intermediaries close positions and about half of them withdraw
## Fundamental Traders

### Panel A: May 3-5

<table>
<thead>
<tr>
<th></th>
<th>DOWN</th>
<th></th>
<th></th>
<th>UP</th>
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<tbody>
<tr>
<td></td>
<td>Sell</td>
<td>Buy</td>
<td>Sell</td>
<td>Buy</td>
<td></td>
</tr>
<tr>
<td>HFT</td>
<td>23,746</td>
<td>23,791</td>
<td>40,524</td>
<td>40,021</td>
<td></td>
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<tr>
<td>Intermediaries</td>
<td>6,484</td>
<td>6,328</td>
<td>11,469</td>
<td>11,468</td>
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<tr>
<td>Buyers</td>
<td>3,064</td>
<td>7,958</td>
<td>6,127</td>
<td>14,910</td>
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<tr>
<td>Sellers</td>
<td>8,428</td>
<td>3,118</td>
<td>15,855</td>
<td>5,282</td>
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<tr>
<td>Opportunistic Traders</td>
<td>20,049</td>
<td>20,552</td>
<td>37,317</td>
<td>39,535</td>
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<tr>
<td>Noise Traders</td>
<td>232</td>
<td>256</td>
<td>428</td>
<td>504</td>
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### Fundamental Traders: Flash Crash

**Panel B: May 6th**

<table>
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<tr>
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<tbody>
<tr>
<td></td>
<td>Sell</td>
<td>Buy</td>
</tr>
<tr>
<td>HFT</td>
<td>152,436</td>
<td>153,804</td>
</tr>
<tr>
<td>Intermediaries</td>
<td>32,489</td>
<td>33,694</td>
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<tr>
<td>Buyers</td>
<td>28,694</td>
<td>78,359</td>
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<tr>
<td>Sellers</td>
<td>94,101</td>
<td>10,502</td>
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<tr>
<td>Opportunistic Traders</td>
<td>189,790</td>
<td>221,236</td>
</tr>
<tr>
<td>Noise Traders</td>
<td>1,032</td>
<td>947</td>
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</tbody>
</table>
Opportunistic Traders: Flash Crash

<table>
<thead>
<tr>
<th>Time</th>
<th>Opportunistic</th>
<th>Fundamental Sellers</th>
<th>Fundamental Buyers</th>
<th>Price</th>
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<tbody>
<tr>
<td>13:19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:09</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>
Cumulative Aggressiveness Imbalance

Cumulative Aggressiveness Imbalance

Aggressiveness Imbalance

[Graph showing cumulative aggressiveness imbalance over time]
Aggressiveness Imbalance: HFTs

![Graph showing HFT Buy Imbalance, HFT Sell Imbalance, and negative price points over time.](image)
Aggressiveness Imbalance: Intermediaries
\[ \frac{\Delta P_t}{P_{t-1} \times \sigma_{t-1}} = \alpha + \sum_{i=1}^{5} \lambda_i \times \frac{AGG_{i,t}}{Shr_{i,t-1} \times 100,000} + \epsilon_t \]
### Prices and Aggressiveness Imbalance: Regressions

<table>
<thead>
<tr>
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<th>May 3-5</th>
<th>May 6</th>
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<tbody>
<tr>
<td>Intercept</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(-0.19)</td>
<td>(0.31)</td>
</tr>
<tr>
<td>HFT</td>
<td>5.37</td>
<td>3.23</td>
</tr>
<tr>
<td></td>
<td>(6.43)</td>
<td>(3.37)</td>
</tr>
<tr>
<td>INT</td>
<td>0.83</td>
<td>5.99</td>
</tr>
<tr>
<td></td>
<td>(1.08)</td>
<td>(5.08)</td>
</tr>
<tr>
<td>Buyers</td>
<td>1.31</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>(4.32)</td>
<td>(2.20)</td>
</tr>
<tr>
<td>Sellers</td>
<td>1.36</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>(5.81)</td>
<td>(6.40)</td>
</tr>
<tr>
<td>Opportunistic</td>
<td>7.60</td>
<td>7.49</td>
</tr>
<tr>
<td></td>
<td>(9.74)</td>
<td>(10.61)</td>
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<tr>
<td># of Obs</td>
<td>1210</td>
<td>404</td>
</tr>
<tr>
<td>Adj-R2</td>
<td>0.36</td>
<td>0.59</td>
</tr>
</tbody>
</table>
The Flash Crash

13:32  A large fundamental seller initiates a sell program

13:42  HFTs reverse the direction of their trading (start selling)

13:45  “Hot Potato”: Lack of Fundamental and Opportunistic Buyers

13:45:28 - 13:45:33  5 second trading pause

13:45:33 – 13:45:58  Prices stabilize

13:46  Fundamental Buyers lift prices up

14:08  Prices are at the 13:32 level
The Flash Crash: CFTC-SEC Report

Large Fundamental Seller – hedges exposure in equities

Sell Algorithm – sell 75,000 E-mini’s with 9% volume participation target

Size – Largest net position of the year executed in about 20 minutes

Price Decline – sells 35,000 ($1.9 billion) contracts in 13 minutes

Cross-Market Arbitrage – buy E-mini/sell SPY or basket of equities

Across the Board Price Declines – trigger automated pauses

Lack of Liquidity in Individual Equities – systems reset to reflect higher risk

Broken Trades – retail stop loss orders executed against stub quotes
Conclusions

A large trade will always have an impact and may trigger a cascade

Volume is really not the same as liquidity

HFTs did not cause the Flash Crash, HFTS are not liquidity providers

Questions

Fundamental Buyers – why did it take so long?

How did the 5-second pause work?

More safeguards needed to prevent cascades. How dumb/smart?
I. Dealing with volatility in individual instruments:
   single stock pauses/circuit breakers;
   minimum quoting requirements for securities;
   limit up/limit down for securities;
   enhancements to pre-trade risk safeguards/pauses for the futures.

II. Dealing with market-wide volatility: market-wide circuit breakers:
   use S&P 500;
   start at 10 percent;
   pause for as low as 10 minutes;
   go as late as 3:30 p.m.
The CFTC-SEC Joint Advisory Committee (continued)

III. Restrictions on co-location/access/disruptive trading practices:
   support the SEC’s “naked access” rulemaking;
   support the CFTC’s disruptive trading rulemaking;
   look into restrictions on the executions of large orders.

IV. Liquidity Enhancements:
   “peak load” pricing;
   “reasonably related” market making quotes;
   “trade at” rule for routers/internalizers;
   order cancellation fees;
   reporting new measures of liquidity.

V. Regulators’ Access to Information:
   consolidated audit trail for the SEC;
   order book and ownership data for the CFTC.