

Algorithmic trading, high frequency finance

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The case of the flash crash

Outline

1 Introduction

- The Flash Crash
- High Frequency Trading (HFT)

2 History and Structure framework

- Structure
- Recent regulation history
- Last regulations (or not)

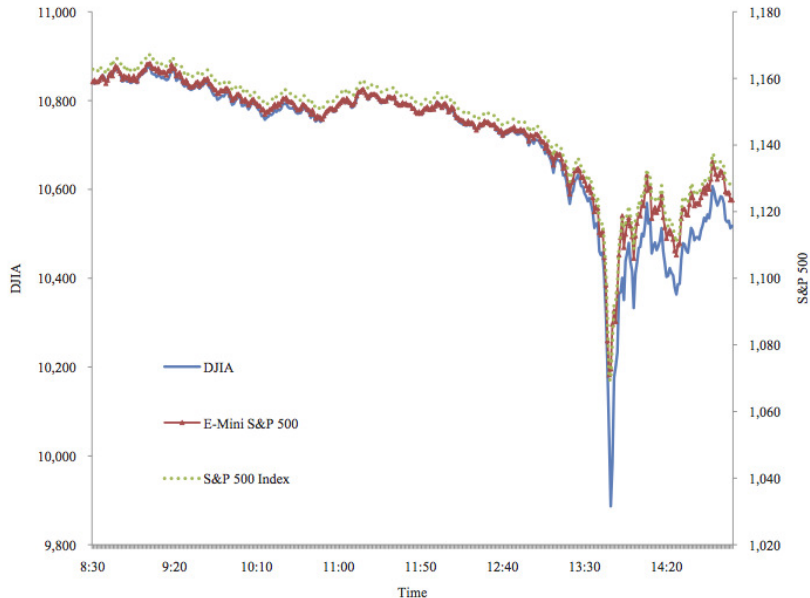
3 The new financial Markets

- New products and services
- Enriched data feed
- Algorithmic trading

4 What now?

- Market Structure
- Volatility
- Initial Public Offering (IPO)

The Flash Crash



Narative, Kirilenko et Al. (2011) I

Between 13:45 and 13:47 CT, the Dow Jones Industrial Average (DJIA), S&P 500, and NASDAQ 100 all reached their daily minima. During this same period, all 30 DJIA components reached their intraday lows. The DJIA components dropped from -4% to -36% from their opening levels. The DJIA reached its trough at 9,872.57, the S&P 500 at 1,065.79, and the NASDAQ 100 at 1,752.31. The E-mini S&P 500 index futures contract bottomed at 1,056.00.3

During a 13 minute period, between 13:32:00 and 13:45:27 CT, the front-month June 2010 E-mini S&P 500 futures contract sold off from 1127.75 to 1,070.00 , (a decline of 57.75 points or 5.1%). At 13:45:27, sustained selling pressure sent the price of the E- mini down to 1062.00. Over the course of the next second, a cascade of executed orders caused the price of the E-mini to drop to 1056.00 or 1.3%. The next executed transaction would have triggered a drop in price of 6.5 index points (or 26 ticks). This triggered the CME Globex Stop Logic Functionality at 13:45:28. The Stop Logic Functionality pauses executions of all

Narative, Kirilenko et Al. (2011) II

transactions for 5 seconds, if the next transaction were to execute outside the price range of 6 index points either up or down. During the 5-second pause, called the Reserve State, the market remains open and orders can be submitted, modified or cancelled, however, execution of pending orders are delayed until trading resumes.

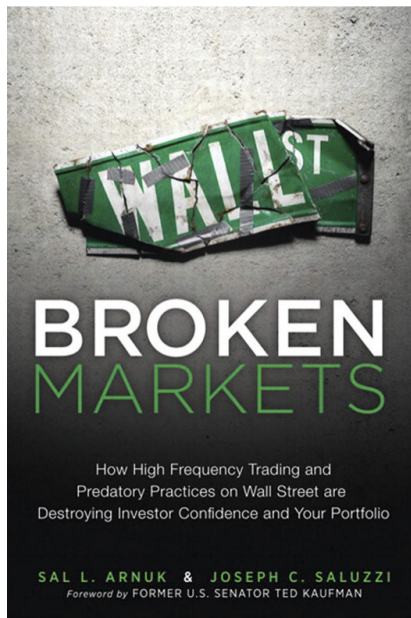
At 13:45:33, the E-mini exited the Reserve State and the market resumed trading at 1056.75. Prices fluctuated for the next few seconds. At 13:45:38, price of the E-mini began a rapid ascent, which, while occasionally interrupted, continued until 14:06:00 when the price reached 1123.75, equivalent to a 6.4% increase from that days low of 1056.00. At this point, the market was practically at the same price level where it was at 13:32:00 when the rapid sell-off began.

During the period of extreme market volatility, a large sell program was executed in the June 2010 E-mini S&P 500 futures contract. "At 2:32 p.m., against this backdrop of unusually high volatility and thinning liquidity, a large fundamental trader (a mutual fund complex) initiated a

Narative, Kirilenko et Al. (2011) III

sell program to sell a total of 75,000 E-Mini contracts (valued at approximately \$4.1 billion) as a hedge to an existing equity position...This large fundamental trader chose to execute this sell program via an automated execution algorithm (Sell Algorithm) that was programmed to feed orders into the June 2010 E-Mini market to target an execution rate set to 9% of the trading volume calculated over the previous minute...The execution of this sell program resulted in the largest net change in daily position of any trader in the E-Mini since the beginning of the year (from January 1, 2010 through May 6, 2010). Only two single-day sell programs of equal or larger size one of which was by the same large fundamental trader were executed in the E-Mini in the 12 months prior to May 6. When executing the previous sell program, this large fundamental trader utilized a combination of manual trading entered over the course of a day and several automated execution algorithms which took into account price, time, and volume. On that occasion it took more than 5 hours for this large trader to execute the first 75,000 contracts of a large sell program."

Broken Markets by S. Arnuk and J. Saluzzi (2012)



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Definition

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- ▶ Little human intervention

Four types of HFT I

Market Making Rebate Arbitrage

HFT designated market makers (DMMs) and supplemental liquidity providers (SLPs). DMMs and SLPs are the modern electronic replacements of the human specialists and market makers of yesteryear. DMMs make money not only from buying stocks and selling them higher, but also from the exchanges, which reward them with rebates for “adding liquidity.” They also are allowed parity (buy alongside other customer orders, without having to wait for the orders to be filled) by the NYSE.

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Example: Imagine you are at the grocery store

You take your cart to one of five apparently empty checkout lines. Suddenly, nine carts instantaneously appear ahead of you. You [...] move to lane two. The same thing happens. You soon find that whenever you move into a new lane, a multitude of carts appear ahead of you in line. Why? Because the supermarket has sold the right for those carts to do so. Thus, you can never be at the head of the line, no matter what you do, short of paying the exchanges a large fee to have that same right...

Four types of HFT II

Statistical Arbitrage

The type of example most often given is when IBM is trading rich in London and cheap on the NYSE, the stat arb guys will simultaneously short it in London and buy it back on the NYSE. Statistical arbitrage trading generates massive volumes in ETFs. Those massive volumes generate massive profits for the exchanges, as well as the ETF industry.

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Momentum Ignition

It tries to trick larger, institutional orders away from true supply and demand metrics. Market participants frequently hear that the reason HFT firms enter and cancel 95% of their orders without a trade is because HFTs are just “managing risk” in their market making activities. In

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NYSE and the Regionals

First exchange

The public trading of shares of corporate ownership in America dates to 1790 when the first market center, the Philadelphia Stock Exchange, opened its doors. Two years later, it was followed by the New York Stock Exchange (NYSE), as well as other regional stock exchanges.

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Business model

These regionals were member-owned by broker dealers, who bore the cost in exchange for the right to trade on them. These broker dealers were investment bankers, not trading shops. They brought companies public, issued research on them, and supported them with road shows and access to investors all of course, at a profit.

National Association of Securities Dealers Automated Quotation (NASDAQ) I

First step

NASDAQ began trading as the world's first electronic stock market in 1971. Due to less stringent listing requirements, small startups would raise money via initial public offerings (IPOs) on NASDAQ as opposed to the NYSE. For example, Intel Corp. started out as a \$6.8 million IPO and Microsoft as a \$60 million IPO.

National Association of Securities Dealers Automated Quotation (NASDAQ) II

Business model

Broker dealers competed with each other by providing two-sided quotes in each stock listed. Actual trades would predominantly be agreed to over the telephone. One broker might quote a stock as

ABCD Corp. 1,000 $17 \frac{1}{4}$ bid, $17 \frac{3}{4}$ 1,000 offered

and another broker might simultaneously quote the same stock as

ABCD Corp. 1,000 $17 \frac{1}{8}$ bid, $17 \frac{1}{2}$ 1,000 offered

As an investor, you would see that the inside market was

ABCD Corp. 1,000 $17 \frac{1}{4}$ bid, $17 \frac{1}{2}$ 1,000 offered

Your broker would get on the phone and buy your 1,000 shares from Alex Brown at $17 \frac{1}{2}$ or sell your 1,000 shares to Morgan Stanley at $17 \frac{1}{4}$.

The trigger

Why Do NASDAQ Market Makers Avoid Odd-Eighth Quotes?

Paper by William G. Christie and Paul H. Schultz, The Journal of Finance (1994). They found that odd-eighth quote are almost non existent for 70% of the 100 most actively traded stocks in the NASDAQ. That is, the minimum spread was larger than \$0.25 in most cases. "[It] raises the question of whether NASDAQ dealers implicitly collude to maintain wide spreads."

The Securities and Exchange Commission (SEC) responses

- Part I

Order Handling Rule (Jan. 1997)

- ▶ *Display Rule*: market makers and specialists should display publicly the limit orders they receive from customers when the orders are better than the market makers or the specialists quote

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- ▶ Revised definition of an exchange
- ▶ *“alternative trading systems that trade 5 percent or more of the volume in national market system securities to be linked with a registered market in order to disseminate the best priced orders in those national market system securities displayed in their systems (including institutional orders) into the public quote stream.”*

I-Only orders

Rationale

I-Only orders were one of the most popular order types that Instinet (Broker platform) offered. I-Only orders could be placed by either brokers or institutions, but only institutions could see them. They gave institutional traders an advantage and typically resulted in large trades that did not move the quote. They reduced the implicit cost of trading dramatically.

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Example

Instinet employees visited a large broker dealer client after a new hardware and software release. [...] Suddenly, the head of the brokers trading desk [...] was having trouble entering an order to buy 25,000 shares of Intel so that only institutions would see it. One of our reps ran over to assist. The next thing we heard was the head trader screaming as loud as he could, Oh my God! No! I-Only! I-Only! [The] rep had forgotten to hit the I-Only key. The order was now displayed to the entire world in the public quote. The stock immediately gapped up almost a half of dollar.

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Market Data Proposal

Market data revenue rules would be modified to reward market centers for trades and quotes

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- ▶ International Organization of Securities Commissions issued a report outlining how, “due to increased pressure to generate investment returns for shareholders, a for-profit exchange may be less likely to take enforcement action against customers or users who are a direct source of income for the exchange.”

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- ▶ Volumes began to explode
- ▶ Stocks were flickering more
- ▶ The market was becoming less personal
- ▶ HFTs were having a field day

The Flash Order Controversy

Definition

Flashing refers to the practice by exchanges of taking marketable orders and for a brief instant, showing those orders to the market centers business partners (liquidity providers) to improve on the public quote, before the exchange sends the order to the National Best Bid and Offer (NBBO).

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Consequence

Dark pools (*private trading systems in which participants can transact their trades without displaying quotations to the public*) have flourished. And yet no regulation: Flash Orders are still legal.

New rules after the Flash Crash I

Single Stock Circuit Breakers

If movement of more than 10% or 30% in a five-minute window, the trading halts.

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Elimination of Stub Quotes

Stub quotes were quotes used by market makers to create two-sided market. When Accenture was traded at \$0.01 or Sotheby's at \$100 000, these were Stub Quotes being executed. Now market maker have to quote within an 8% band around the NBBO for most securities.

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Sponsored Access Rule

requires brokers to screen orders from their sponsored access clients before sending them into the market and to perform credit and capital checks.

New rules after the Flash Crash II

Large Trader Reporting Rule

requires large traders to register with the Commission and imposes record keeping, reporting, and limited monitoring requirements on certain registered broker-dealers through whom large traders execute their transactions.

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Consolidated Audit Trail

The SEC has also proposed capturing data across different asset classes

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- ▶ Exchanges do not produce most of their revenues through corporate listings and services but from Data Services

Colocation

Cost of time

It has been estimated that a one millisecond advantage is worth up to \$100 million a year to the bottom line of a large hedge fund.

Colocation service - NYSE

“Being close to NYSE Euronexts trading engines can give your business model a competitive edge, and NYSE Technologies colocation service provides unsurpassed value. By installing your trading systems in the NYSE Euronext US Liquidity Center, our new data center located in Mahwah, New Jersey, your firm can gain extremely low latency access to NYSE Euronexts markets.”

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Fairness

Some exchanges make sure that each colocated customer receives equal amounts of connecting cable so that a server at the northeast corner of a facility has the same latency as one at the southwest.

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Essential to HFT

for modelling behaviours of institutional and retail investors. More on that in next subsection.

The Maker/Taker Model

Rebates for order flows

Liquidity “makers” get paid a rebate and liquidity “taker” pay a fee.

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But...

“...distorted order routing decisions, aggravated agency problems among brokers and their clients, unlevelled the playing field among dealers and exchange trading systems, produced fraudulent trades, and produced quoted spreads that do not represent actual trading costs.”

Hidden orders

Definition

A hidden order is placed on an exchange or dark pool, but it is not publicly visible in the quote. Investors who use this type of order are willing to give up their place in the time/price priority sequence to be more discreet about their order. Hidden orders are often used by large institutional investors who are trying to cloak themselves to not get spotted by the HFTs.

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Suppose an institutional investor was looking to buy 100,000 shares of mid cap semiconductor stock Novellus Systems (NVLS), which has average daily volume of three million shares

Say the bid price is \$46.96 and the offer is \$46.98.

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Phantom Indexes and machine-readable news

Phantom Indexes

Dow Jones Industrial Average, S&P 500, NASDAQ 100, and Russell 2000, widely followed to gauge market activity, are based on less than 30% of all shares traded because they are based only on primary market data.

Phantom Indexes and machine-readable news

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machine-readable news

Algorithms react to news being fed by data providers. On April 23, 2013, fake tweet about White House explosion and injured Obama.

From 1:08 p.m. to 1:10 p.m., the Dow Jones Industrial average plunged more than 100 points



Figure : Source: <http://www.businessweek.com>

Broker-sponsored algorithms

Volume weighted average price (VWAP)

Breaks the parent order into smaller child orders that are sent into the markets throughout the day at a rate based on the stocks historical intraday volume dispersion.

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Close-targeting-algos and Arrival-targeting-algos

Seeks to beat the days closing price or the price of the stock when the algo first starts working

Smart Order Router (SOR)

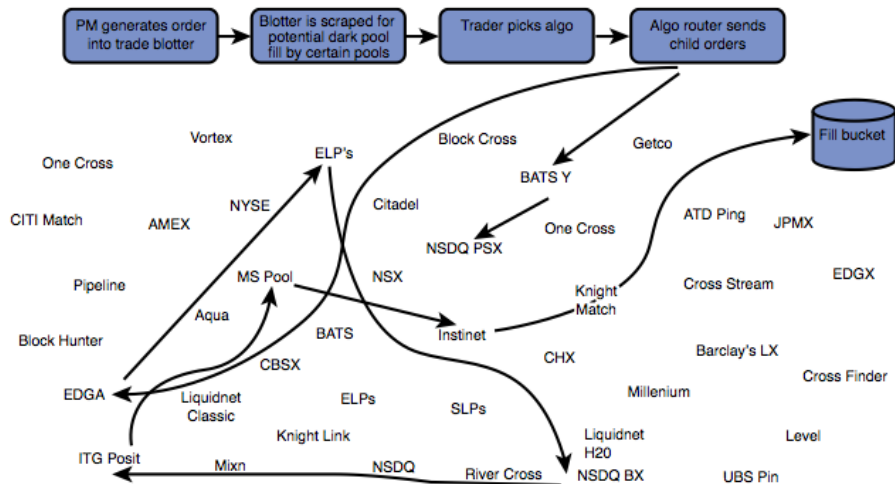


Figure 9.1 Today's convoluted buy-side order: the wandering path from order-generation to execution

Outline

1 Introduction

- The Flash Crash
- High Frequency Trading (HFT)

2 History and Structure framework

- Structure
- Recent regulation history
- Last regulations (or not)

3 The new financial Markets

- New products and services
- Enriched data feed
- Algorithmic trading

4 What now?

- Market Structure
- Volatility
- Initial Public Offering (IPO)

Topology of trading

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- ▶ Statistical arbitrage ▶ Graph

Volatility and Risk

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- ▶ But normalise volatility might also normalise abnormality [▶ Graph](#)
- ▶ Intraday and closing price volatility have increase [▶ Graph](#)

Impact on IPO

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Microsoft (1986) vs LinkedIn (2011)

On March 13, 1986, Microsoft went public, raising \$58,695,000 through a management and underwriting group led by Goldman Sachs and Alex Brown (no longer in existence) and 114 other underwriters. (Most of these investment banks are also no longer in existence.) On May 18, 2011, 25 years later, LinkedIn went public in an IPO that was six times larger (\$352,800,000) and yet was managed by an underwriting group less than one-twentieth of the size. (Only five firms underwrote LinkedIn: Morgan Stanley, Merrill Lynch, JP Morgan, Allen & Company, and UBS.)

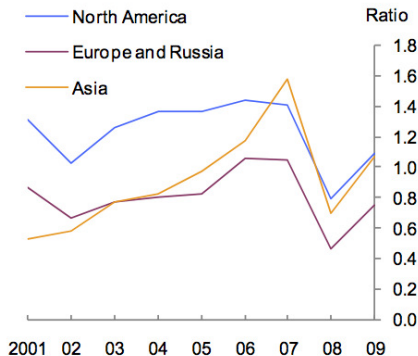
Thank you for your attention

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- ▶ Haldane, A. (2012). *The race to zero*. Speech given at: International Economic Association Sixteenth World Congress, Beijing, China, 8 July 2011.
- ▶ Kirilenko, A., Kyle, A. S., Samadi, M., and Tuzun, T. (2011). *The flash crash: The impact of high frequency trading on an electronic market*. Manuscript, U of Maryland.

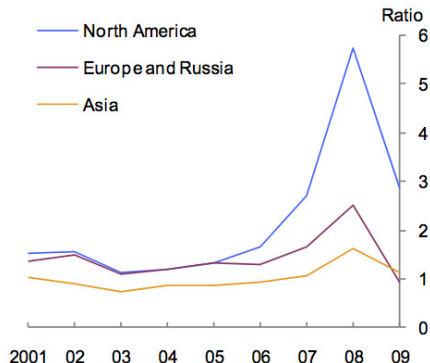
Market Structure [▶ Back](#)

Chart 1: Market capitalisation by region, relative to GDP



Source: World Federation of Exchanges.

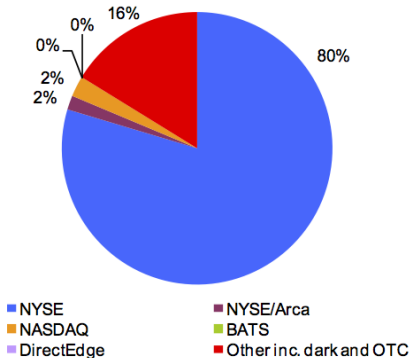
Chart 2: Equity market turnover by region



Source: World Federation of Exchanges.

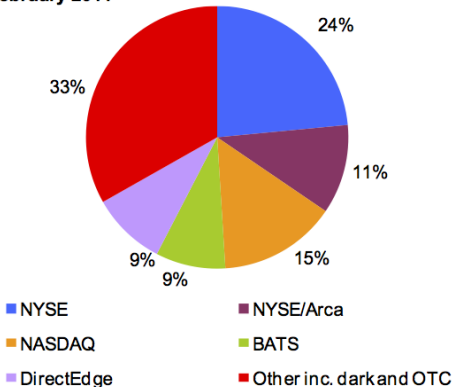
Figure : Speech 205, Bank of England (2011)

Chart 3: NYSE-listed trading volume shares, January 2005



Source: Fidessa.

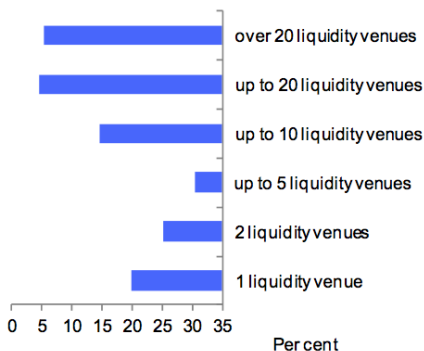
Chart 4: NYSE-listed trading volume shares, February 2011



Source: Fidessa.

Figure : Speech 205, Bank of England (2011)

Chart 7: Access to multiple trading venues by European HFTs

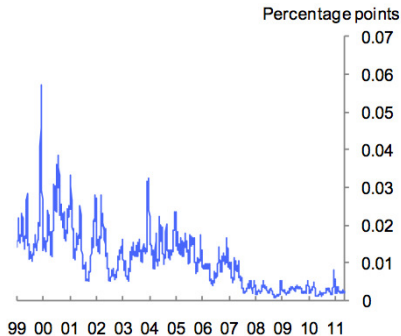


Source: Automated Trader.

Notes: Survey among 171 high frequency traders.

Figure : Speech 205, Bank of England (2011)

Chart 8: Median end-of-day bid-ask spread for largest 20 stocks in FTSE 100 as a proportion of realised volatility^(a)



Source: Thomson Reuters Datastream.

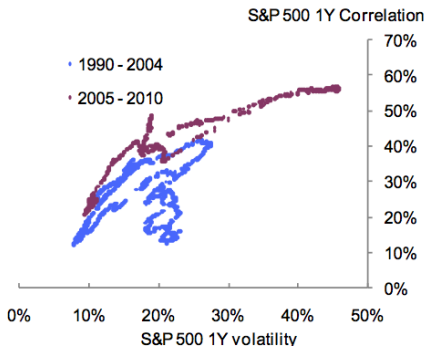
^(a) 22 day average. Largest stocks by market capitalisation. Selected stocks updated annually.

Figure : Speech 205, Bank of England (2011)

Volatility and Correlation

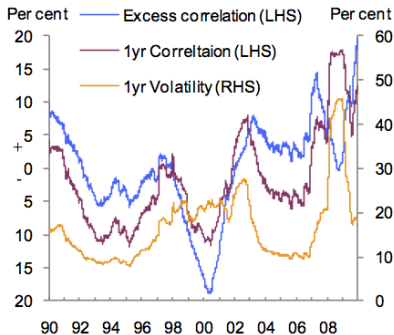
► Back

Chart 9: Volatility and correlation of S&P 500



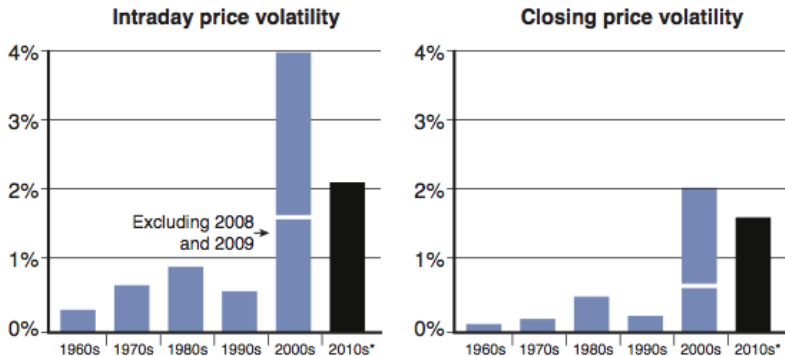
Source: JP Morgan and Bank calculations.

Chart 10: Excess volatility



Source: JP Morgan and Bank calculations.

Figure : Speech 205, Bank of England (2011)



Analysis through 9/30/11

Source: Capital Markets Advisory Partners and Capital IQ

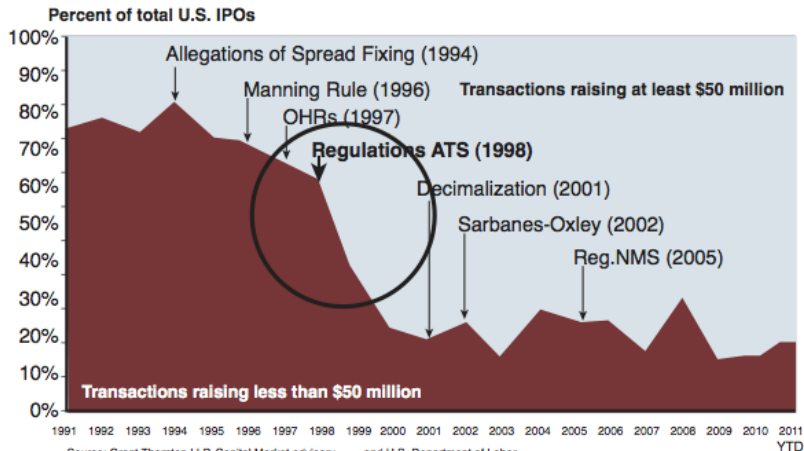
Original analysis from "Market Savings and Becoming Naav Standard," *New York Times*, September 11, 2011

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Figure 12.4 Unprecedented volatility: Standard & Poor's 500 index moves of 4% or higher

Small vs large IPO

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Source: Grant Thornton LLP, Capital Market advisory and U.S. Department of Labor
Data Includes corporate IPOs as of 9/30/11, excluding funds, RBTs, SPACs and LPs

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Figure 12.1 The small IPO market collapsed as the order handling rules and Reg ATS (electronic stock markets) cut “tolls” that were required to pay for

New listing vs delisted

► Back

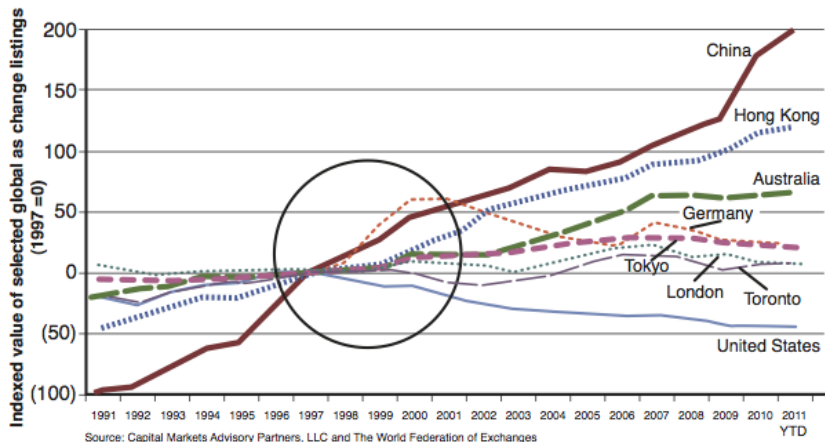


Figure 12.2 The U.S. stock market has shrunk every year since 1997 based on the number of publicly listed companies (down 43% since 1997)

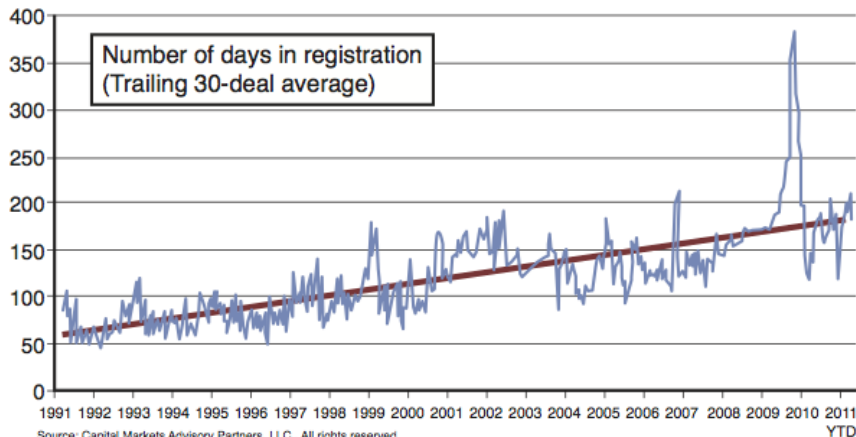


Figure 12.5 IPOs take more than 3x as long to get through the window (filing to pricing) than they did 20 years ago

IPO Success rates [▶ Back](#)

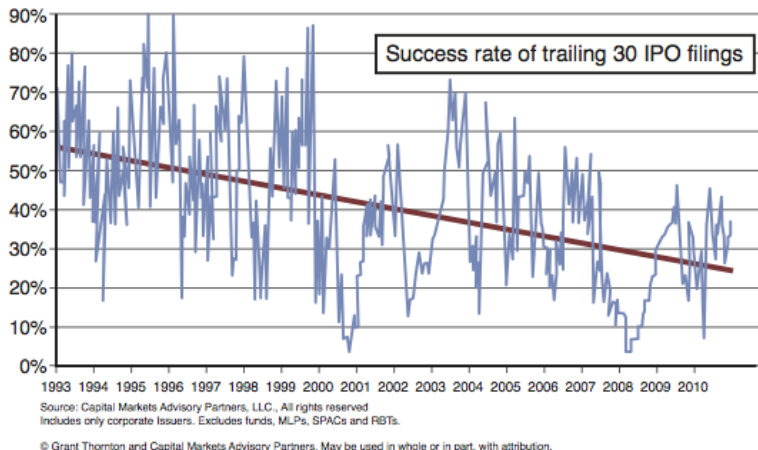


Figure 12.6 IPO success rates have been cut in half since the dawn of Reg ATS and electronic markets

Figure : Broken Markets, p. 207

IPO Success rates > \$500 million [▶ Back](#)



Figure 12.7 IPOs > \$500 million have demonstrated the steepest decline of all