Flash Crash of May 6, 2010
Why Did It Happen? Can It Happen Again?

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Algoritmik İşlemler: Teori ve Pratik Paneli
Istanbul, Turkey

Outline

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I. Introduction: NYSE

GOOD OLD DAYS

OLD DAYS

YESTERYEARS

# TODAY: NYSE DATA CENTER (Mahwah, NJ)

OLD JPM HQ (23 Wall)

New York Stock Exchange

- Founded on March 8, 1817 (traced back to May 17, 1792)

- Number of Listings: Over 2,400 (May 2016)

- Listed Market Cap: $19.69Trillion (May 2015)

- Monthly Dollar Volume: $1.5Trillion (Jan 2015)

- 169 Member Firms (2012): 97 Electronic + 7 DMM + 65 Brokerage & 274 Floor Brokers

- NYSE is the world's largest exchange (listings & volume)

- Financial services account for more than 35% of the employment income of New York City

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II. Financial Services in GDP of USA [1]

Figure 1: Financial Sector as Percentage of U.S. GDP: 1850–2009
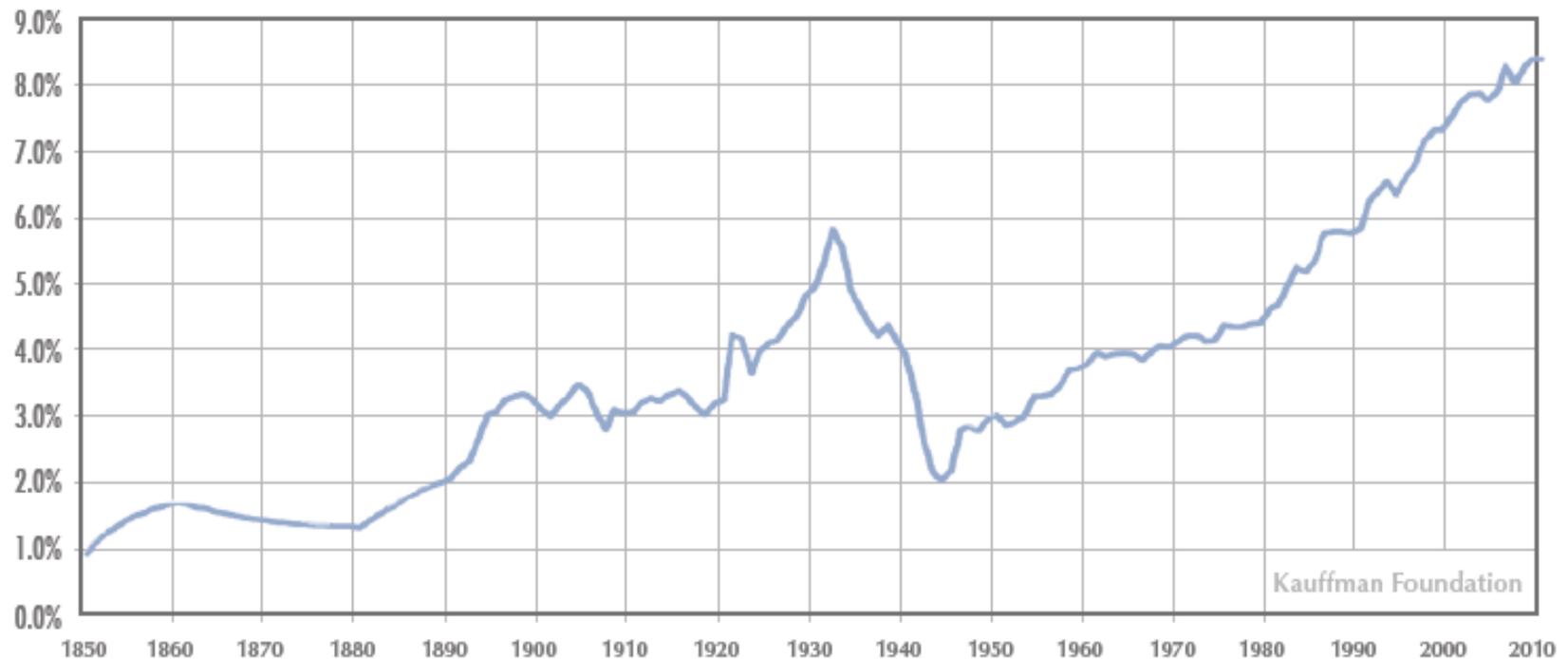
Source: The Evolution of the US Financial Industry from 1860 to 2007: Theory and Evidence. NBER.
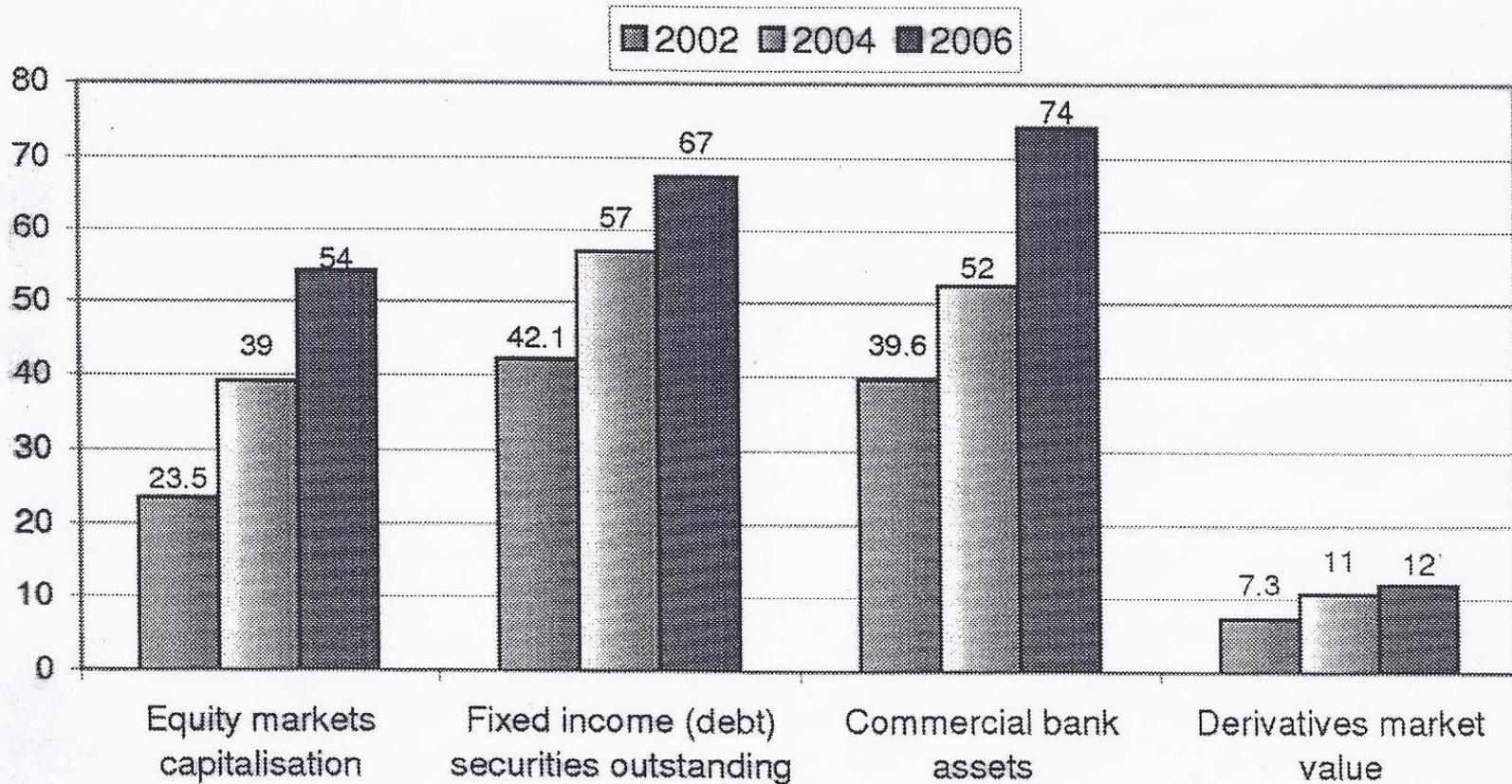
The Big Picture

Fig. 1: Global Capital Market Values ($Trillion) [1,2]

The Big Picture
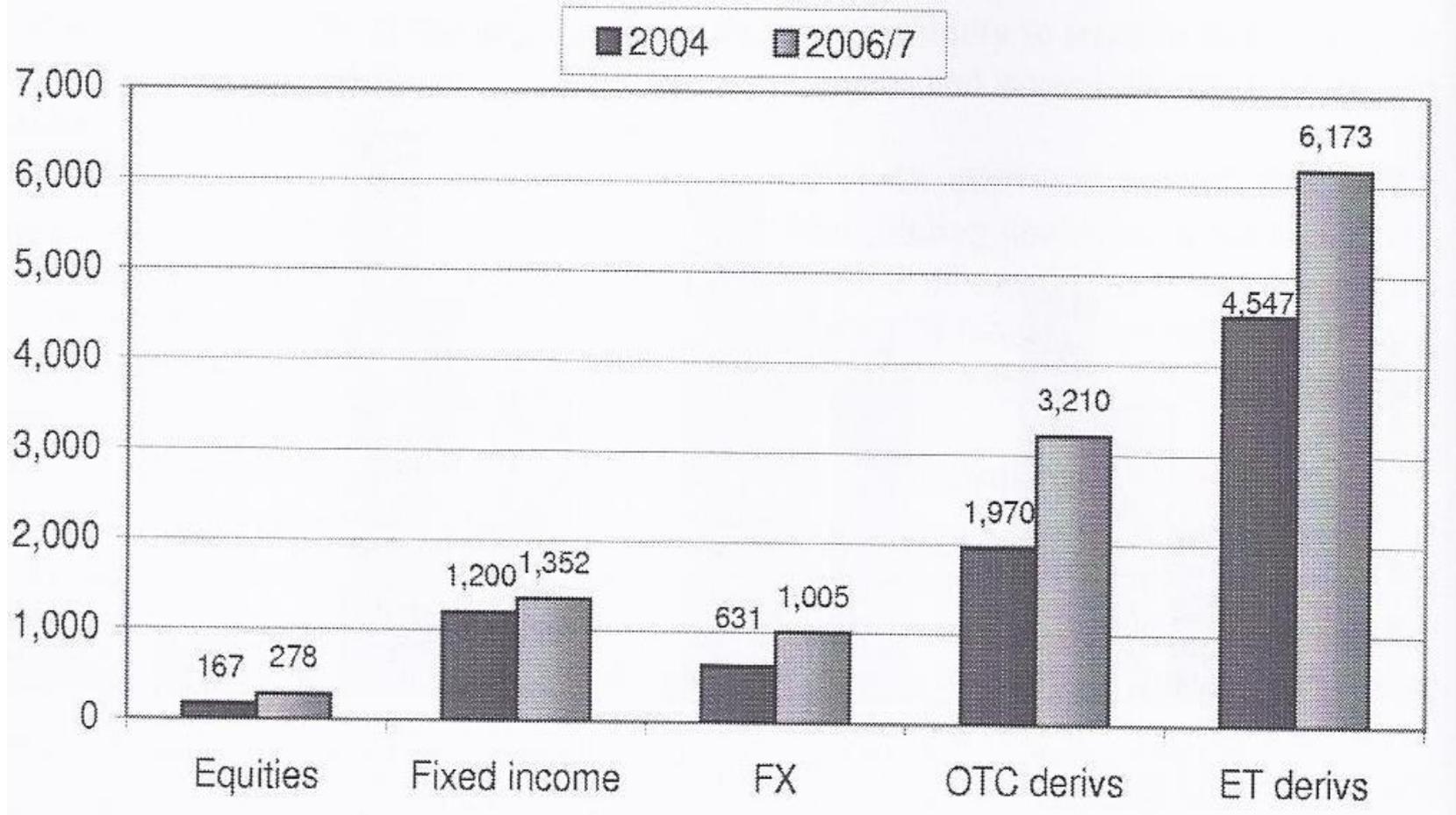

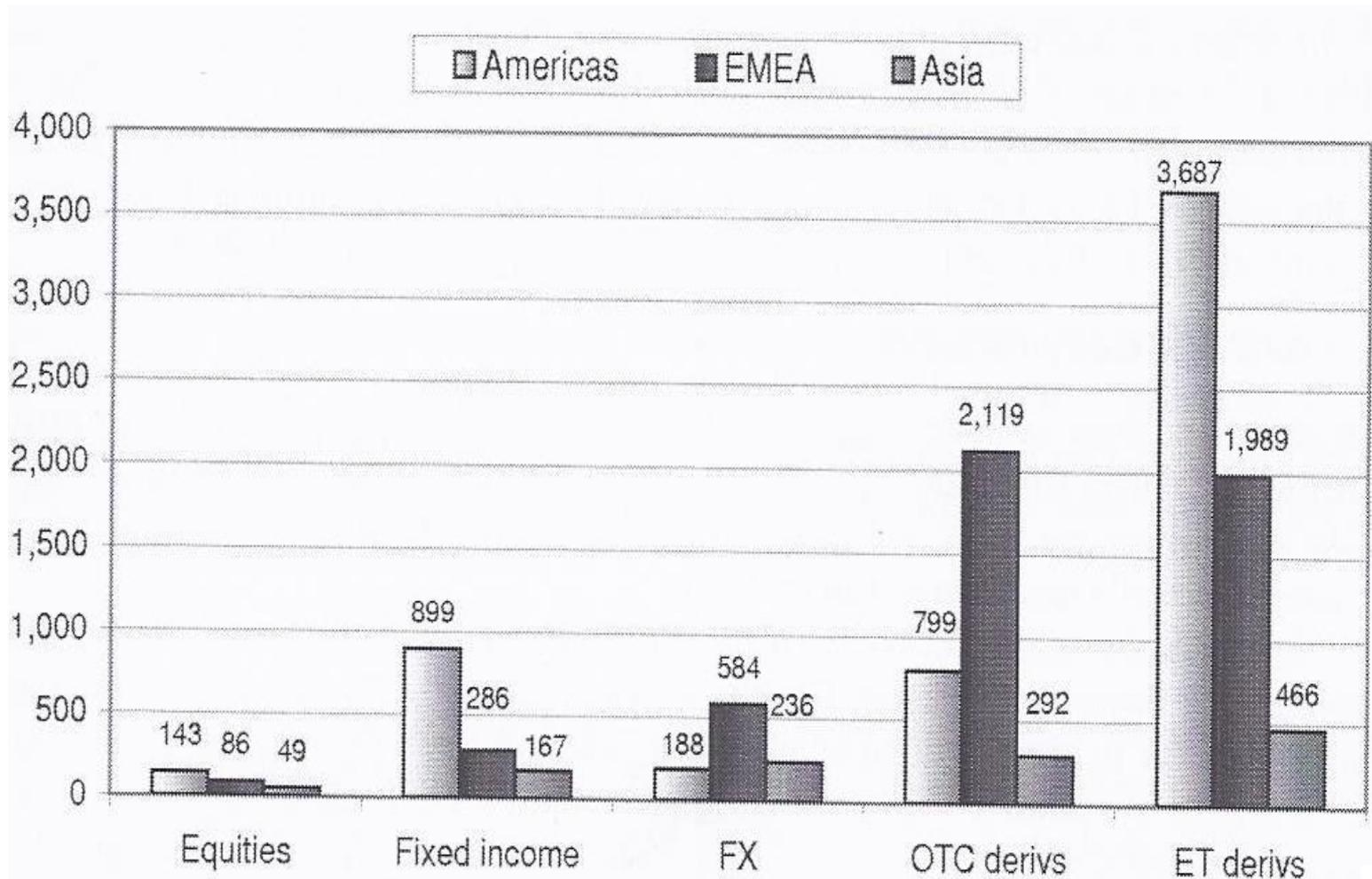Fig. 2: Average Daily Turnover ($Billion) [1-4]

The Big Picture

Fig. 3: Regional Daily Turnover ($Billion) [1-4]

III. Electronic Trading
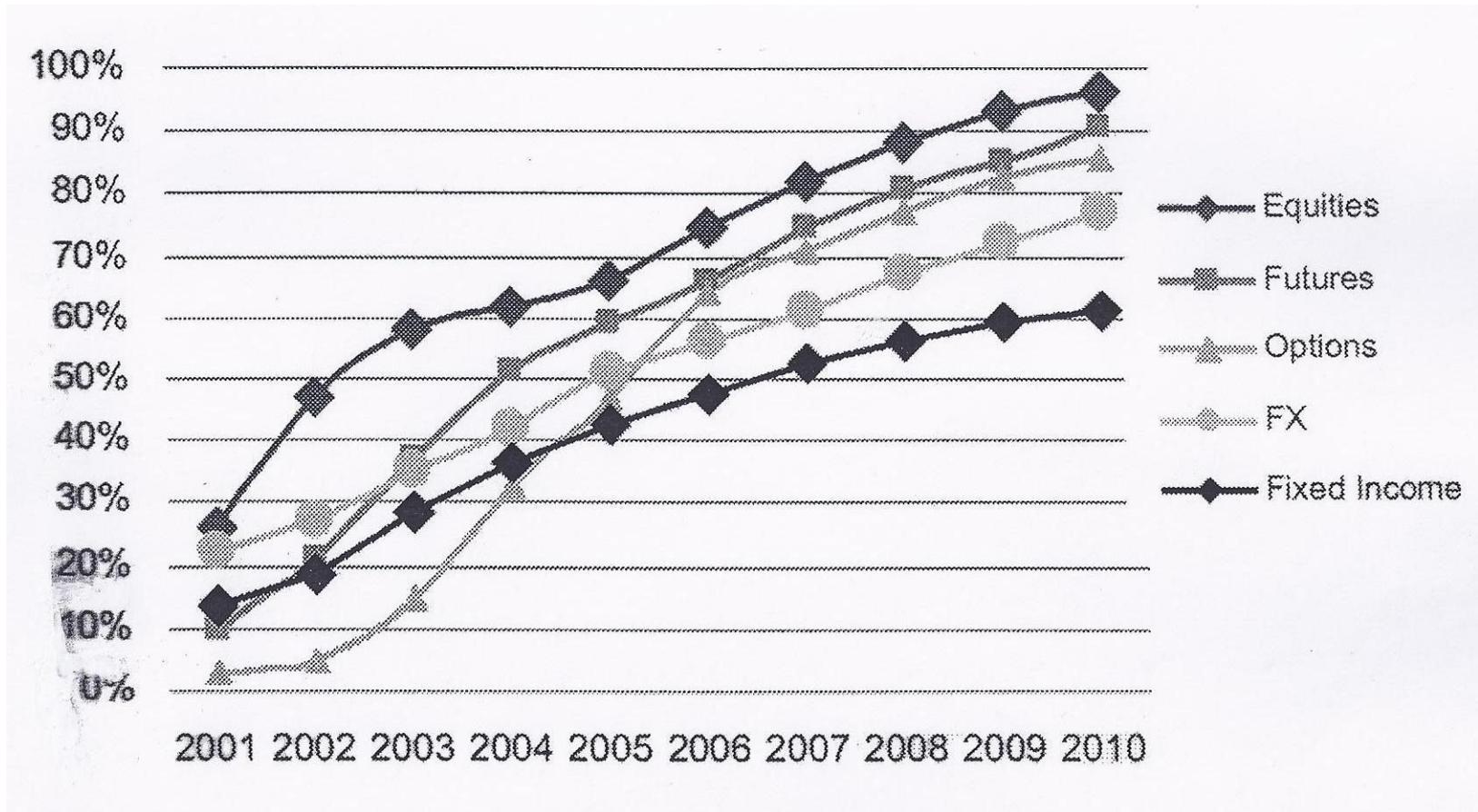
Fig. 4: Adoption of Electronic Trading in Major Asset Classes [2]
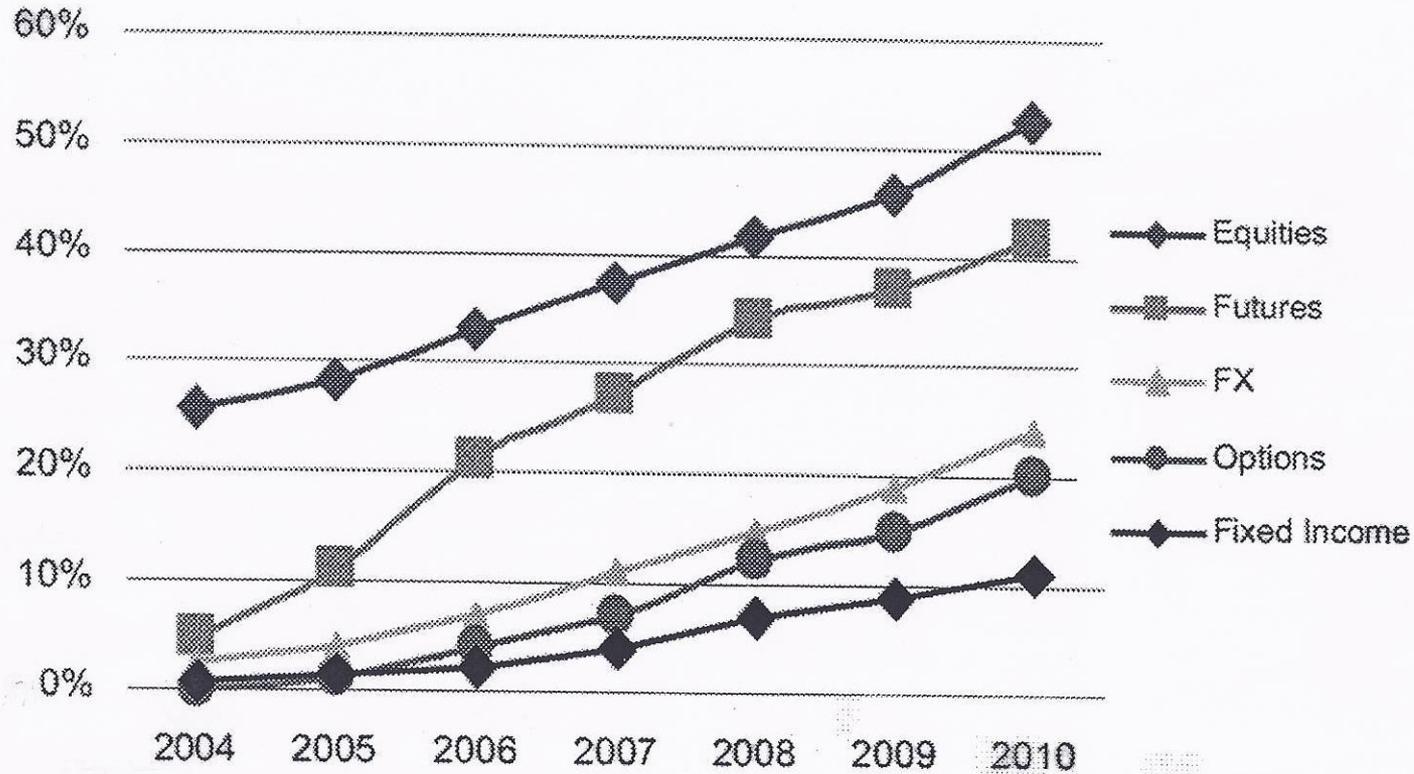
III. Electronic Trading

Fig. 5: Algorithmic Trading in Major Asset Classes [2]
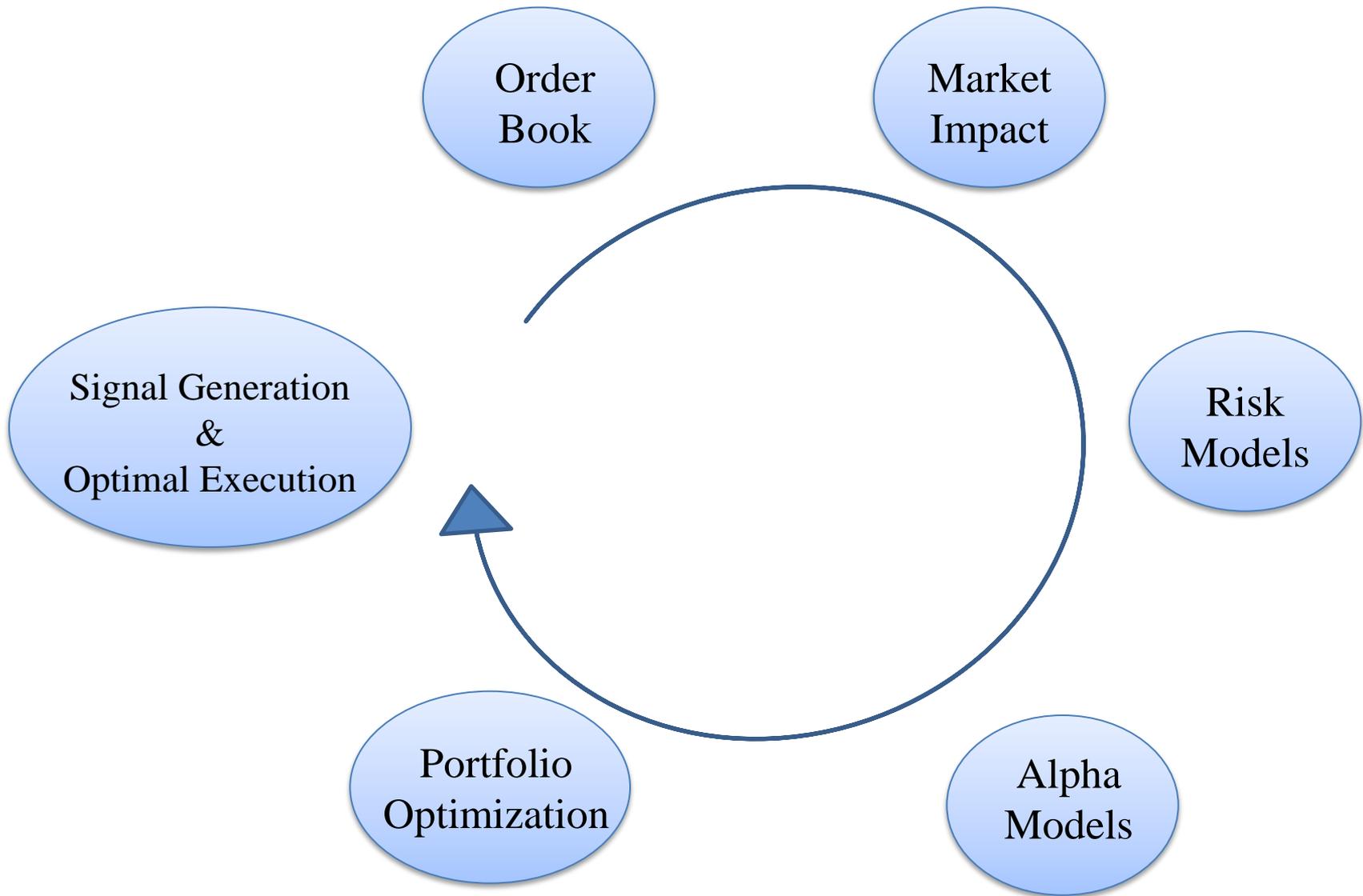
Fig. 6: A Rough Picture

III. Electronic Trading

- Limit Order Book
- Market Making
- Discrepancies of Exchanges
- Statistical Arbitrage
- Risk Analysis
- Alpha
- Portfolio Optimization
- Maintenance Cost of Portfolio
- Rebalancing & Optimal Execution
- Market Impact
- and many more

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III. Electronic Trading

- **Buy-Side** (Portfolio Manager): Desires to maximize portfolio return with minimized risk & maintenance cost
- Alpha
- Risk Management
- Market Impact
- Optimal Rebalancing & Execution Cost
- **Sell-Side** (Trader): Desires to minimize risk adjusted cost of execution
- Direct Market Access
- Trade Analytics
- Smart Order Routing
- Optimal Execution

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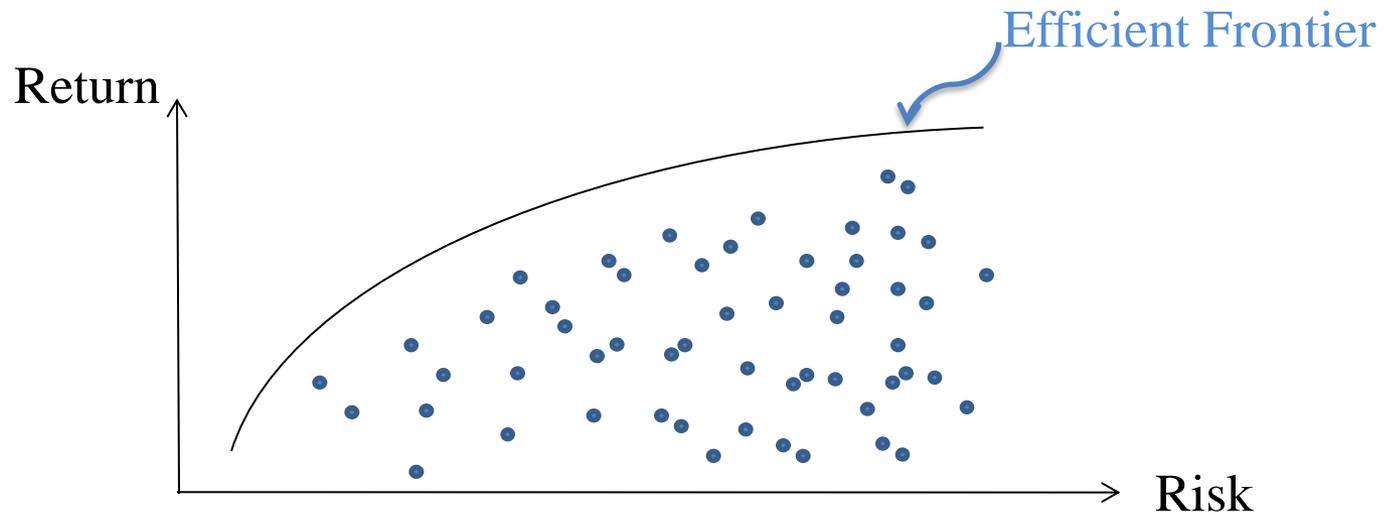
Fig. 7: Efficient Frontier (Buy-Side)
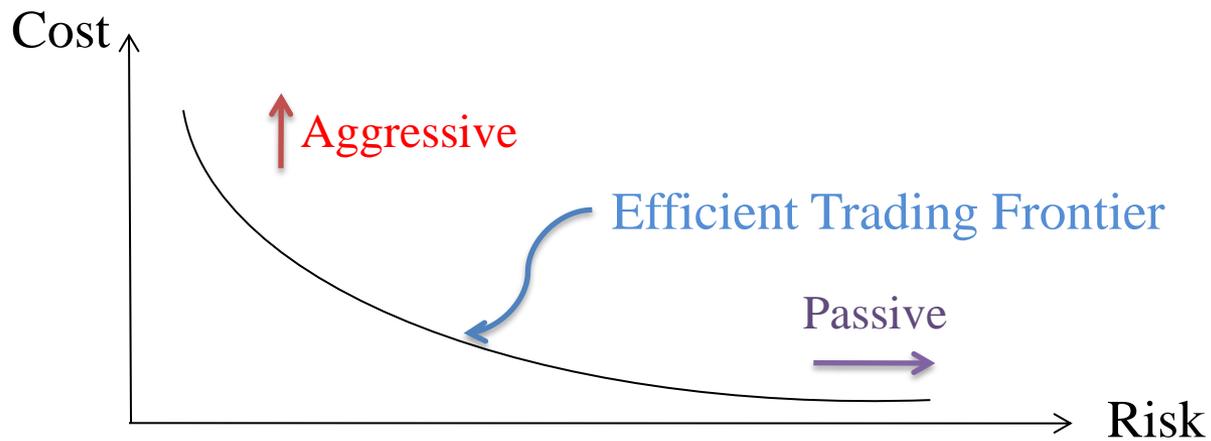
Fig. 8: Efficient Trading Frontier (Sell-Side)

IV. Market Makers

- A market maker quotes both a buy and a sell price in a financial instrument in inventory

- Market maker makes a profit from the ask-bid spread

- Exchanges have Designated Market Makers (specialists) acting as the official market maker for a given security

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IV. Market Makers

- Market makers take other side of trades when there are short-term imbalances in buy-side & sell-side orders

- Market makers have various informational and trade execution privileges

- There are over 2,000 market makers in USA

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V. Limit Order Book

- What is a Market Order? [7]

- A market order is an order to buy or sell a stock at the best available price.

- Generally, this type of order will be executed immediately. However, the price at which a market order will be executed is not guaranteed.

http://www.sec.gov/answers/limit.htm

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V. Limit Order Book

- What is a Limit Order? [7]

  - A limit order is an order to buy or sell a stock at a specific price or better. A buy limit order can only be executed at the limit price or lower, and a sell limit order can only be executed at the limit price or higher.

  - A limit order is not guaranteed to execute.

  - A limit order can only be filled if the stock's market price reaches the limit price.

  - While limit orders do not guarantee execution, they help ensure that an investor does not pay more than a pre-determined price for a stock.

  http://www.sec.gov/answers/limit.htm

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V. Limit Order Book

- A record of unexecuted limit orders which is maintained by specialists. These orders are treated the same as other orders in terms of priority of execution.

- Limit orders provide information about public intentions of traders

- Actual intensions and publicly stated intensions of traders are not always in accord as expected

- Dynamics of Limit Order Book is extremely sophisticated even for a simple case

- High Frequency Trading is a form of techno-quant arts

V. Limit Order Book
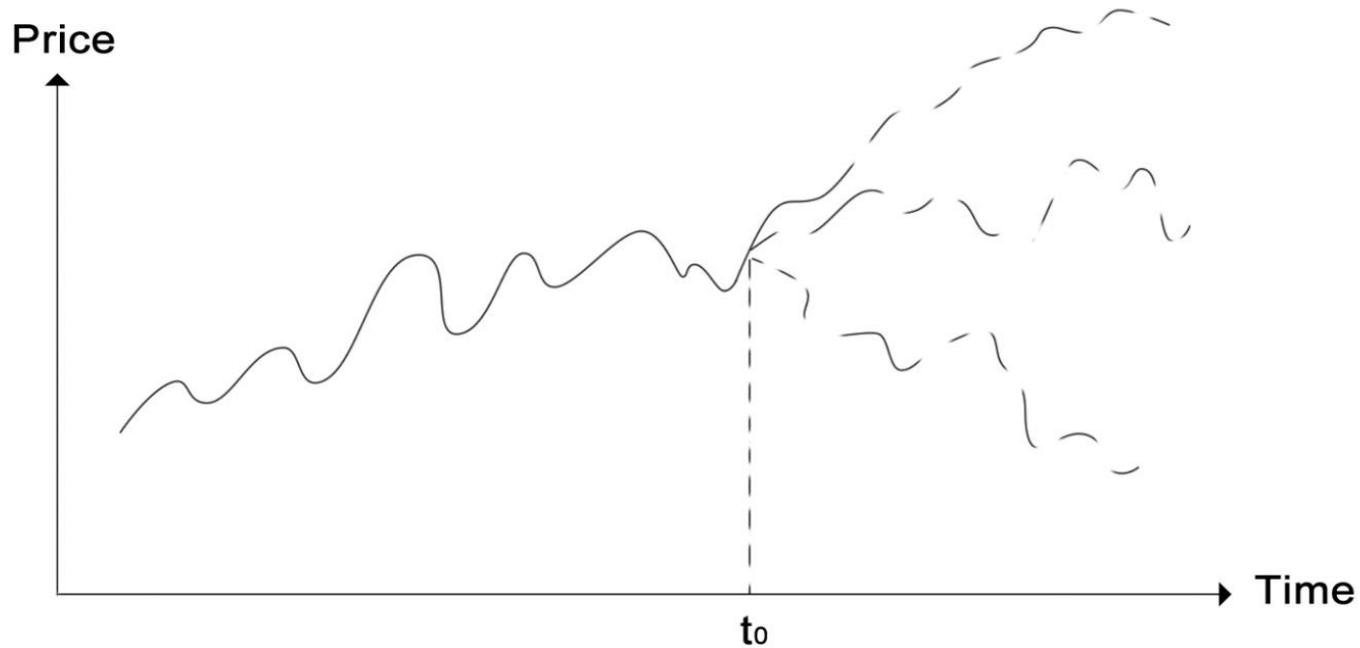
Fig. 9: Limit orders at t_0 intend to profit from future price trends for $t > t_0$

V. Limit Order Book

Fig. 10: Market impact (100 shares) [6].

Permanent Impact : $P_{PI} = P_{t_0^-} - P_{t_0^+}$

Temporary Impact : $P_{TI} = P_{t_0^-} - P_{t_0}$

V. Limit Order Book
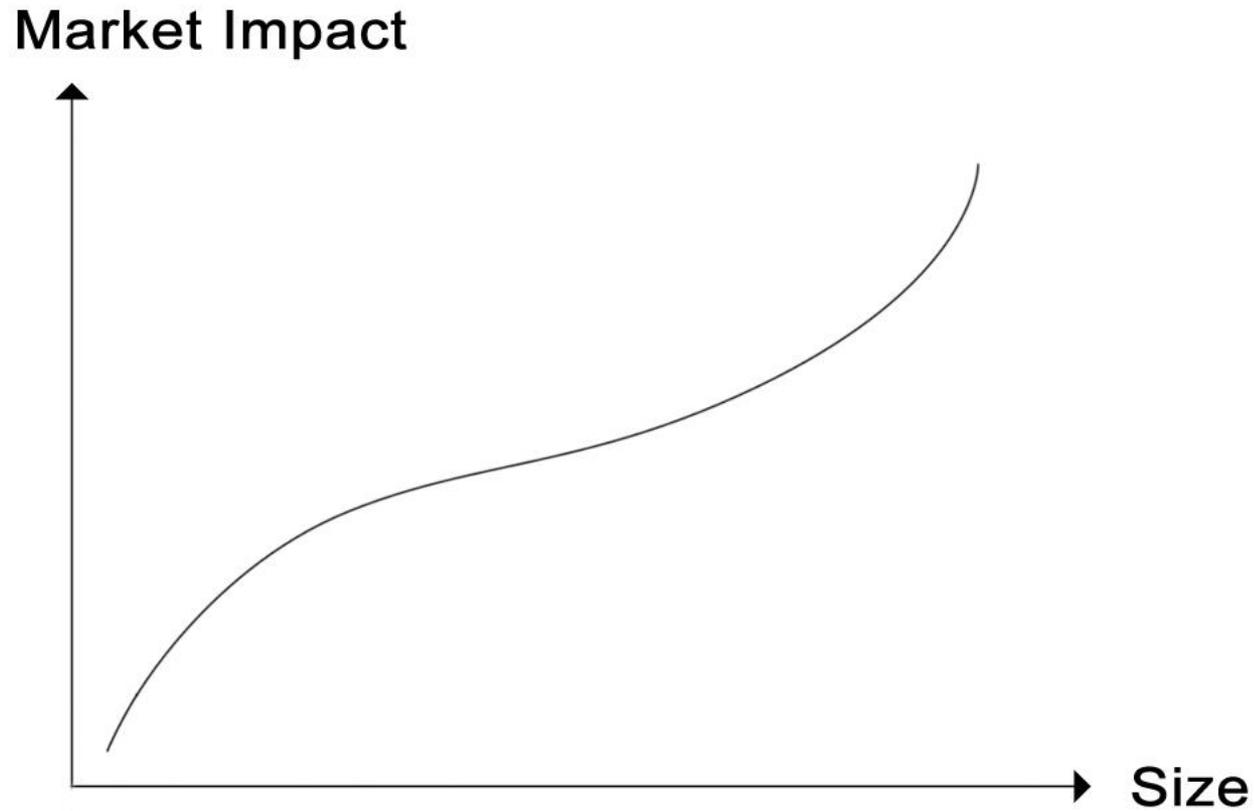
Market Impact

Fig. 11: Market impact of Trade Size

V. Limit Order Book
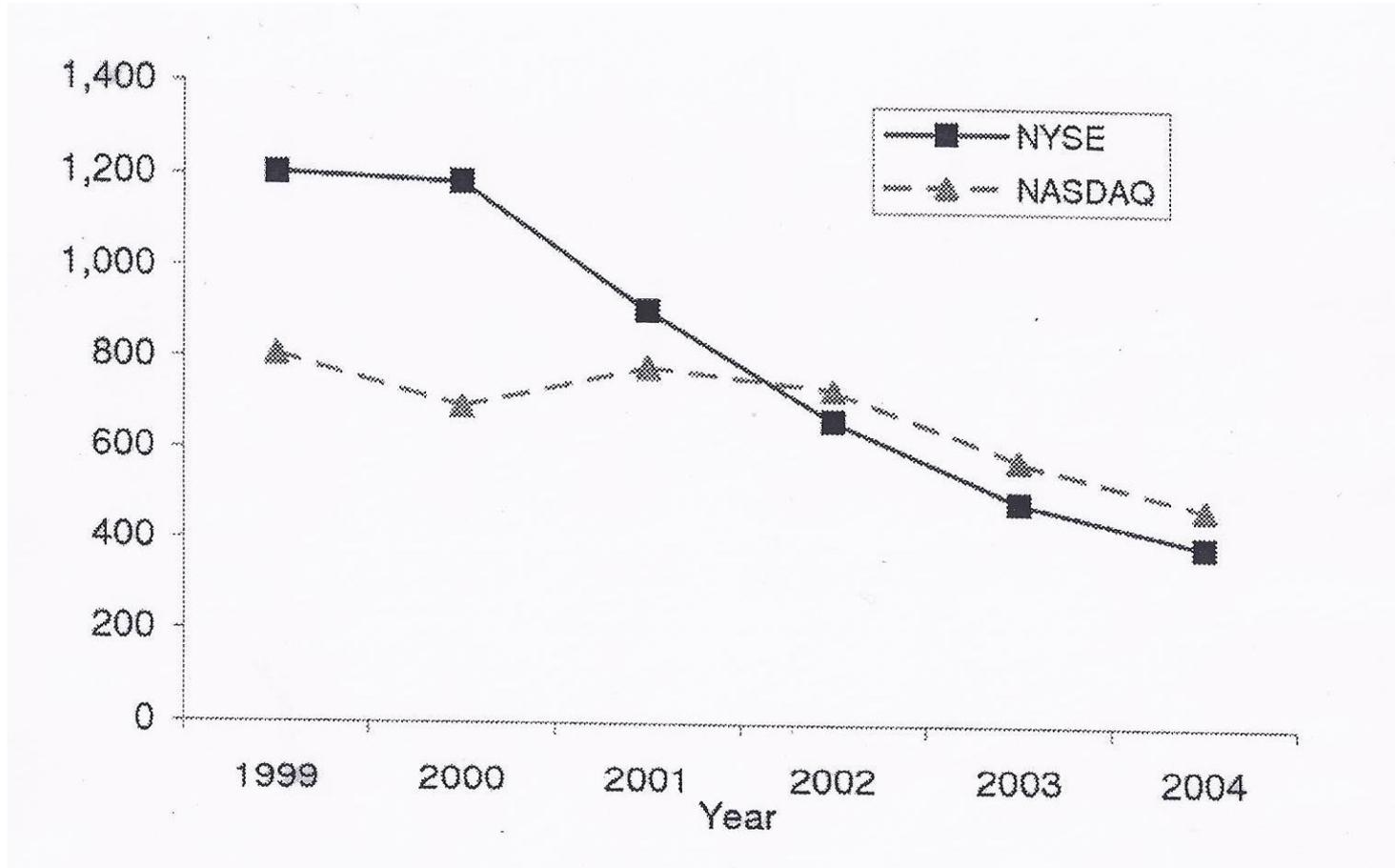
Fig. 12: Average Trade Sizes for US Equities [2,7]

V. Limit Order Book (Video 1)

09:29:16.004

Bid-Ask Spread
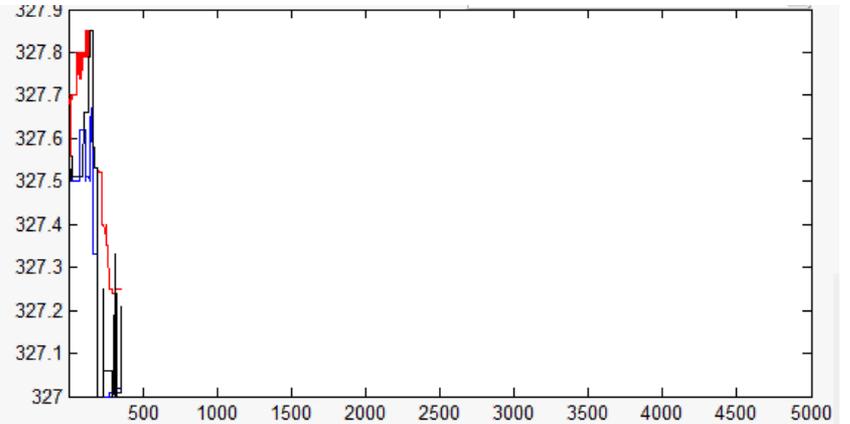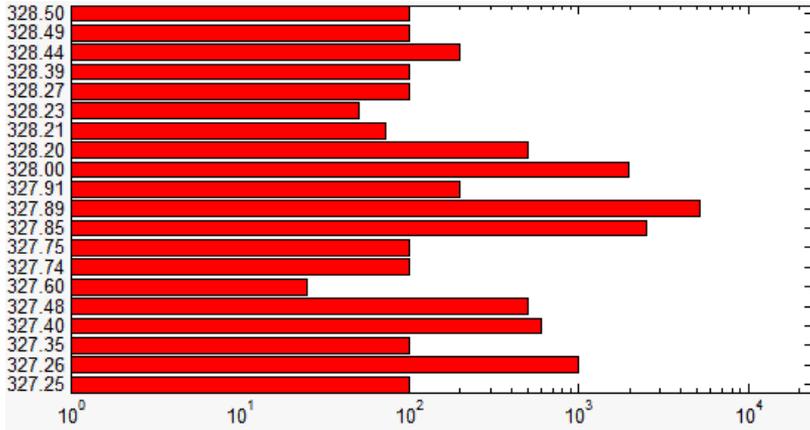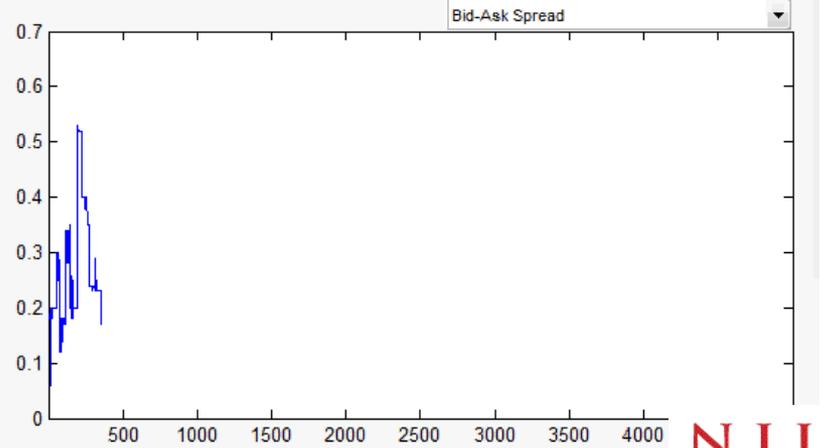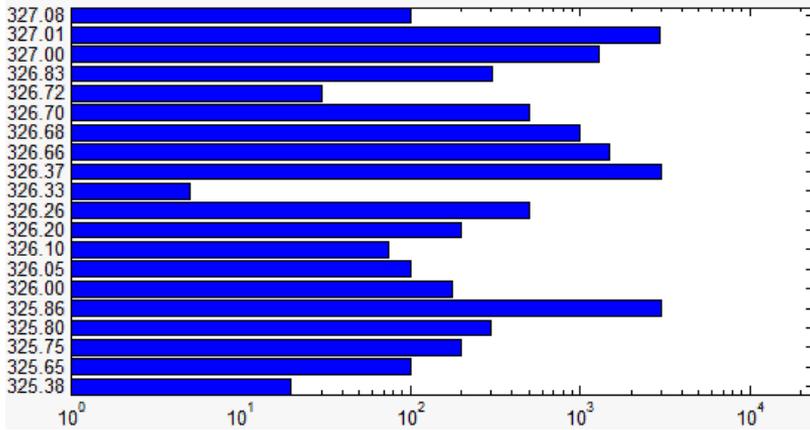
VI. HIGH FREQUENCY TRADING (HFT)

- HFT is not possible without Technology & Infrastructure (Typical tick-to-trade times are between 15-100 microseconds. Although some report 200 nanoseconds or less)
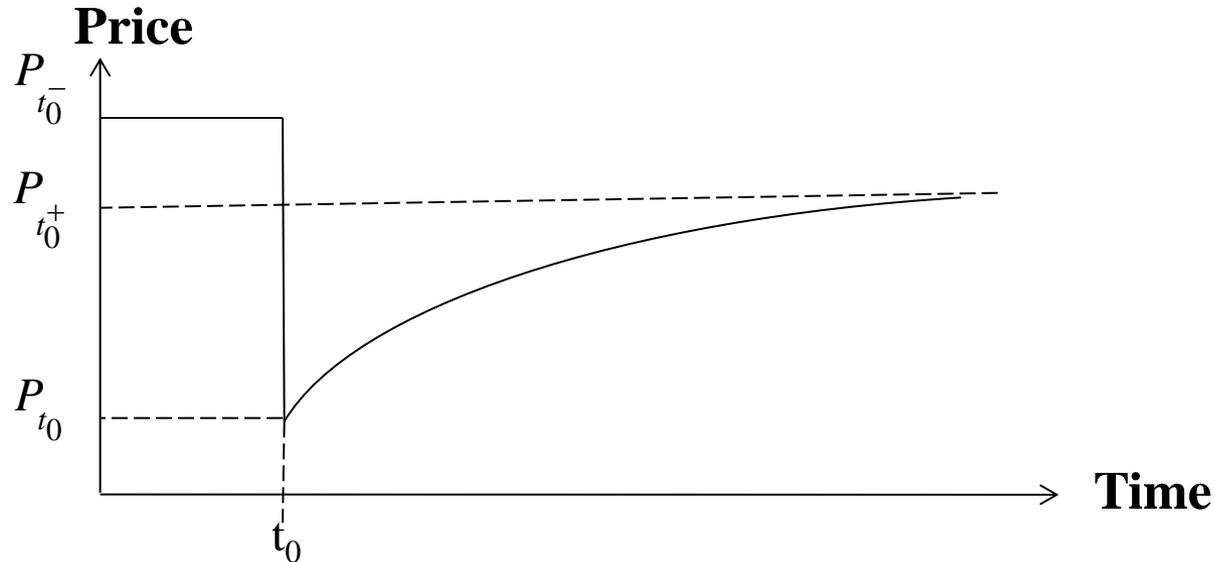
- Some HFT Strategies

- Market Making

- Latency Arbitrage

- Arbitrage (Statistical & Information)

- Market Structure Based Trading

- <u>Street saying</u>: *1 millisecond* (microsecond) reduction in latency is worth about *$100M/year* for a brokerage firm

VII. FLASH CRASH OF MAY 6, 2010

- The biggest one-day point decline, 998.5 points, on an intraday basis in DJIA history (since May 26, 1896)

- For a few minutes, $1Trillion in market value vanished

VII. FLASH CRASH OF MAY 6, 2010

- The combined selling pressure from the Sell Algorithm, HFTs and other traders drove the price of the E-Mini down approximately 3% in just four minutes from the beginning of 2:41 p.m. through the end of 2:44 p.m.

- During this same time cross-market arbitrageurs who did buy the E-Mini, simultaneously sold equivalent amounts in the equities markets, driving the price of SPY [an exchange-traded fund (ETF) which represents the S&P 500 index] also down approximately 3%.

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VII. FLASH CRASH OF MAY 6, 2010

- Still lacking sufficient demand from fundamental buyers or cross-market arbitrageurs, HFTs began to quickly buy and then resell contracts to each other – generating a "hot-potato" volume effect as the same positions were rapidly passed back and forth.

- Between 2:45:13 and 2:45:27, HFTs traded over 27,000 contracts, which accounted for about 49 percent of the total trading volume, while buying only about 200 additional contracts net.

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VII. FLASH CRASH OF MAY 6, 2010
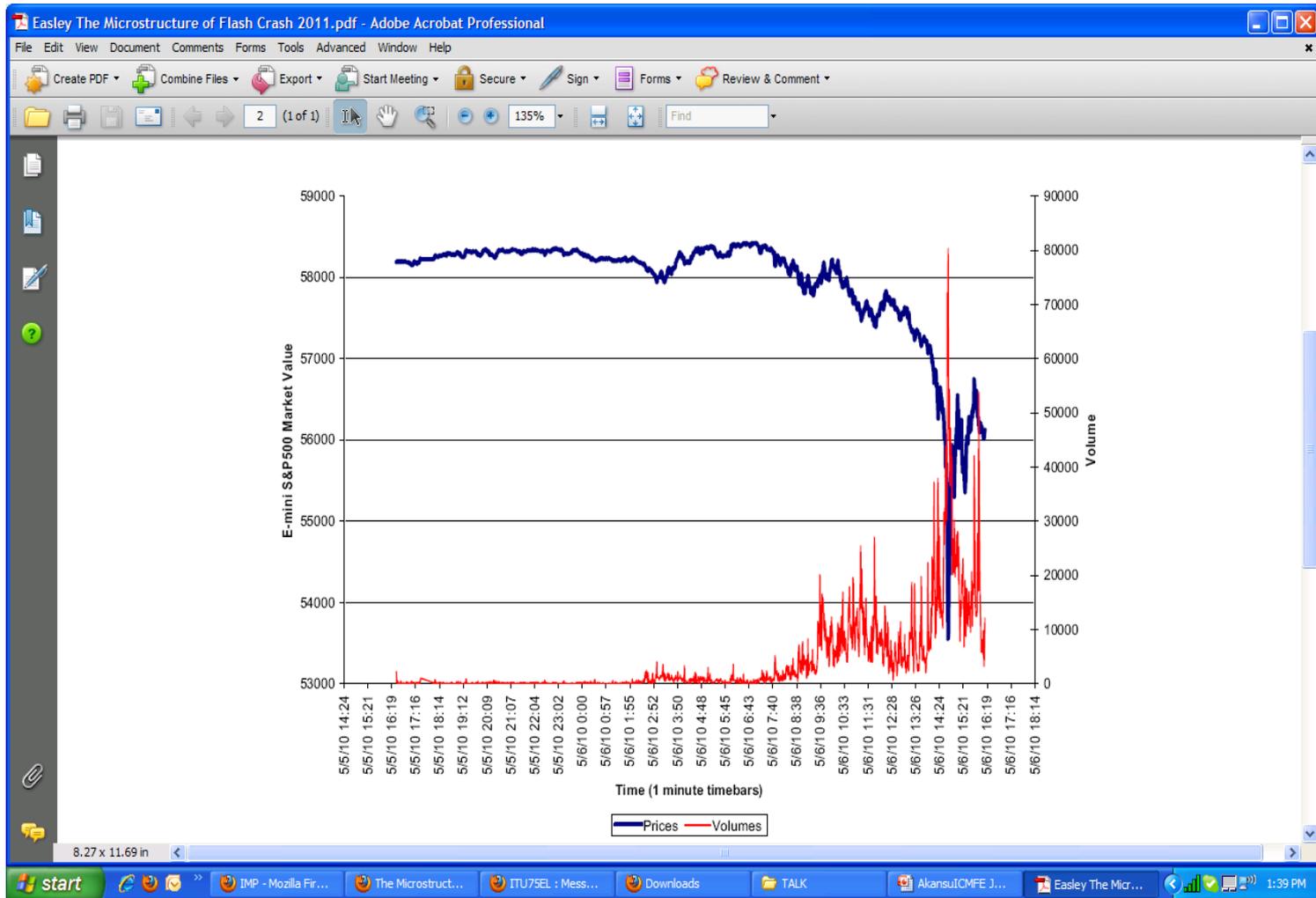
IMPACT OF FLASH CRASH

- It created tremendous public backlash for HFT

- Regulators recognized their lack of attendance to the issue

- HFT has become an expertise area within trading

- Academics got involved to study the impact of speed trading

- All big players in the market accepted HFT as "the new normal" and have been making their business moves

CAN WE HAVE ANOTHER FLASH CRASH?

- The technical answer is "Yes"

- There have been "Baby Crashes" since the issue is more judiciously handled by all now

- Flash Crashes will stay with us and all players need to have their strong expertise on market microstructure and its inner-workings

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VII. FLASH CRASH OF MAY 6, 2010

- ANOTHER LOOK AT ORDER BOOK OF MAY 6, 2010 (Video 2)

VIII. THE DUDE

- Let's remember the Dude (Video 3)

WHAT DID DUDE DO?

- I did not study what happened in detail.

- It is guessed that the Dude arbitraged various Brokers since there is only one exchange in Turkey

- In such a scenario, Brokers are treated like exchanges and BIST functions as National Best Bid and Offer (NBBO)

- Easily traceable trading strategy

IX. LOOKING FORWARD

LOB MUST BE WATCHED FOR HEALTHY MARKETS

- Limit Order Book (LOB) is the center of trading activity for each asset (ticker)

- LOB is organically linked to the publicly traded company of the ticker

- The robustness of ticker's LOB dictates the health of its trading activity

- The depth of LOB (strength of ticker) is the source of volatility and must be monitored closely for healthy markets

Market Structure Requirements [8]

- Transparency

- Low latency

- Designated Market Makers (DMM) affirmative obligations

- Price improvement

- Deep liquidity

- Competitive pricing/quoting

Designated Market Makers [8]

- The cornerstone of the NYSE market model is the Designated Market Maker (DMM). Formerly known as "Specialists"

- DMMs have obligations for maintaining fair and orderly markets for their assigned securities.

- They operate both manually and electronically to facilitate price discovery during market openings, closings and during periods of substantial trading imbalances or instability.

- DMMs apply keen judgment to knowledge of dynamic trading systems, macroeconomic news and industry specific intelligence, to make their trading decisions.

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Designated Market Makers [8]

- Have true obligations to maintain a fair and orderly market in their stocks, quote at the NBBO a specified percentage of the time, and facilitate price discovery throughout the day as well as at the open, close and in periods of significant imbalances and high volatility

- Provide price improvement and match incoming orders based on a pre-programmed Capital Commitment Schedule, which has been added to the NYSE Display Book, minimizing order latency. DMMs and their algorithms do not receive a "look" at incoming orders. This ensures that an intermediary does not see orders first, and that DMMs compete as a market participant

Designated Market Makers [8]

- Are on parity with quotes from floor brokers and those on the Display Book, encouraging DMM participation and higher market quality.

Designated Market Makers [8]

- It is a serious business to be DMM

- Exchanges cannot function without DMMs

- DMM Rights & Responsibilities must be thoroughly described

- DMMs are the backbone of trading sector

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DMM: A Case Study [8]

- DMMs regularly commit capital to add liquidity to the market to reduce the gap between supply & demand.

- For example, on the close of a recent Russell rebalancing day (a Friday), a DMM published to the market 13 million shares of a large cap DJIA stock to buy.

- Just prior to the close, an influx of sell orders caused the imbalance to swing to a 4 million share sell imbalance.

- In this situation, the DMM decided to commit $63 million in capital to support the stock at the close, avoiding a 2% drop in the price and $3 billion loss in market cap.

Supplemental Liquidity Providers (SLPs) [8]

- SLPs are electronic, high volume members incented to add liquidity on the They are primarily found in more liquid stocks with greater than 1 million shares of average daily volume.

- SLPs trade only for their proprietary accounts, not for public customers or on an agency basis.

- SLPs that post liquidity in an assigned security that executes against incoming orders are awarded a financial rebate by the exchange.

Circuit Breakers [8]

- NYSE instituted circuit breakers to reduce volatility and promote investor confidence.

- By implementing a pause in trading, investors are given time to assimilate incoming information and the ability to make informed choices during periods of high market volatility.

- DJIA with the S&P 500 as the benchmark index for measuring a market decline.

Circuit Breakers [8]

- the circuit-breaker halt for a Level 1 (7%) or Level 2 (13%) decline occurring after 9:30 a.m. Eastern and up to and including 3:25 p.m. Eastern, or in the case of an early scheduled close, 12:25 p.m. Eastern, would result in a trading halt in all stocks for 15 minutes.

- If the market declined by 20%, triggering a Level 3 circuit-breaker, at any time, trading would be halted for the remainder of the day.

- A Level 1 or Level 2 halt can only occur once per trading day.

CONCLUDING REMARKS [9,10]

- Financial sector will continue to reinvent itself by adopting State-of-the-Art Technologies to harvest global market data

- The term Big Data Finance is already coined

- Currently, Financial Intelligence & Analytics and Electronic Trading are at their infancy

- Technology-centric Major Exchanges will continue to acquire local exchanges to boost Efficiency of Global Markets to facilitate trading anything anywhere anytime

- Information-centric Hedging will progress to its next level of sophistication

- Exciting opportunities for bankers, finance professionals, technologists, social engineers & policy makers and academics

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