# การประชุมวิชาการ

# “*ศาสตราจารย์สังเวียน อินทรวิชัย* ด้านตลาดการเงินไทย”

# ครั้งที่ 24 ประจำปี 2559

## การบรรยายเรื่อง

## “High-Frequency Algorithmic Trading: Invading Now”

**ผู้บรรยาย ดร.ธนานันต์ ศิวโมกษธรรม**

**วันศุกร์ที่ 25 พฤศจิกายน 2559 เวลา 10:45 – 12:15 น.**

**ห้อง 205 คณะพาณิชยศาสตร์และการบัญชี**

**มหาวิทยาลัยธรรมศาสตร์ ท่าพระจันทร์**

# High-Frequency Algorithmic Trading

**Thananun Siwamogsatham Ph.D., CFA, FRM**

**Head of Risk Management**
**Phatra Securities Public Company Limited**

## Agenda

I **Overview of High-Frequency Trading**

- Definition and Characteristics of HFT
- Workflow of High-Frequency Operation
- Growth of HFT
- Impacts of HFT on the Market and its criticism
- Role of Technology

II **Trading Strategies**

- Automated Liquidity Provision
- Market Microstructure Trading
- Event Trading
- Statistical Arbitrage

III **Future of High-Frequency Trading**

- Challenges faced by HFT Industry
- HFT in Thailand

# High-Frequency Algorithmic Trading

## I. Overview

**Definition**

Type of algorithmic trading where orders are rapidly and frequently submitted by fast and sophisticated computer algorithms, resulting in very short holding periods

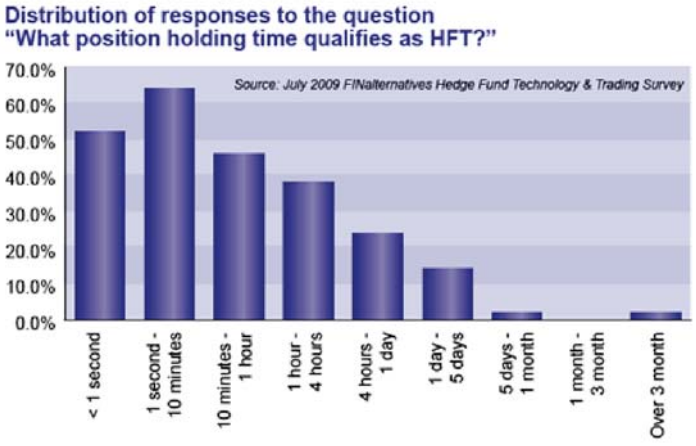
### Characteristics of HFT (by U.S. Securities and Exchange Commission)

- Use of high-speed algorithms to analyze and exploit short-lived trading opportunities, and also to route and execute orders
- Use of raw data feed and co-location service provided by exchanges to maximize speed
- Maintaining very short periods for establishing and liquidating positions, resulting in the frequent turnover of many small positions
- Submission of numerous orders that are cancelled shortly after submission
- Holding position in short periods, usually with no positions held overnight

# High-Frequency Algorithmic Trading

## I. Overview

- The term “High-Frequency” itself refers to fast entry and exit of trading positions.
- A survey by *FINalternatives.com* in 2009 concluded that "86% of the 201 asset managers believed that high-frequency trading referred strictly to holding periods of only one day or less.”




*Source: Aldridge (2010)*

# High-Frequency Algorithmic Trading

## I. Overview

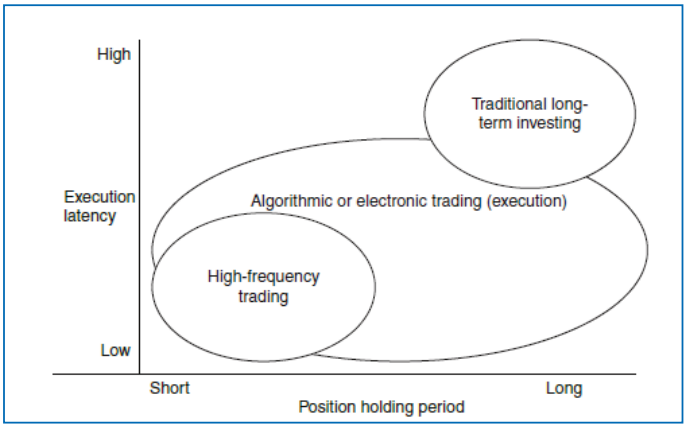
### Financial Market Evaluation

| | | |
|---|---|---|
| 1960s | • Broker –Dealer | Trading was carried out almost entirely manually. |
| 1970s | • Electronic Quotation System | NASDAQ became the world's first electronic stock market, allowing electronic transmission of orders to buy/sell securities. |
| 1980s | • Program Trading | Program trading was first developed to buy/sell basket of stocks and futures. |
| 1990s | • Electronic Communications Networks (ECNs) | ECN allows trading of securities outside of regular exchange. It employs algorithms to quickly transmit orders and to optimally match buyers and sellers. |
| 1990s onwards | • Algorithmic Trading | Algorithmic trading has gained immense popularity due to technological advances, including the emergence of high-frequency trading. |

# High-Frequency Algorithmic Trading

## I. Overview

### Algorithmic Trading vs. High-frequency Trading



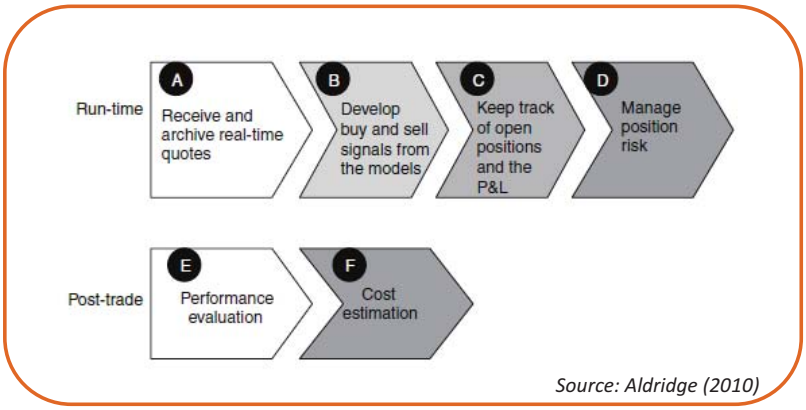

*Source: Aldridge (2010)*

- **Electronic Trading** -> Ability to transmit orders electronically as opposed to via telephone, mail, or in person.
- **Algorithmic Trading (AT)** -> The use of computer algorithms to automatically make certain trading decisions based on predetermined set of rules , submit orders, and manage those orders.
- **High-frequency Trading (HFT)** -> Subset of algorithmic trading where a large number of orders are sent to the market at high speed and extremely low latency (time between entry of an order until it is executed).

# High-Frequency Algorithmic Trading

## I. Overview

### Workflow of High-Frequency Operation




*Source: Aldridge (2010)*

"Alert System"

These functions are built within the alert system to notify monitoring personnel in case of unforeseen market behavior, market disruption, order submission failure, unusual high trading costs, etc.

- HFT makes a full range of decisions from generation of trading signals, through best execution of trading decisions
- HFT encompasses six tasks which are operated in unison

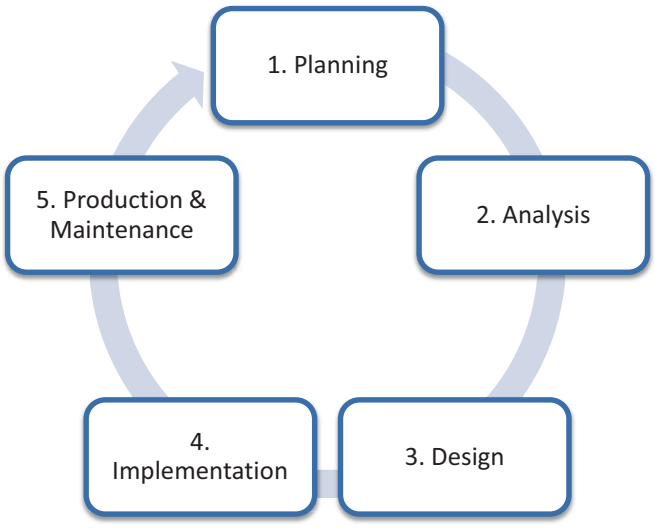
  A -> get real-time information
  B -> construct trading signals based on pre-defined algorithm
  C -> submit orders and keep track of open positions and P&L
  D -> monitor trading behavior and manage run-time trading risks
  E -> evaluate performance relative to predetermined benchmarks
  F -> ensure that trading costs are within acceptable ranges


# High-Frequency Algorithmic Trading

## I. Overview


### HFT Development Cycle

- Given the complexity of the HFT algorithms, standard iterative development cycle should be deployed.



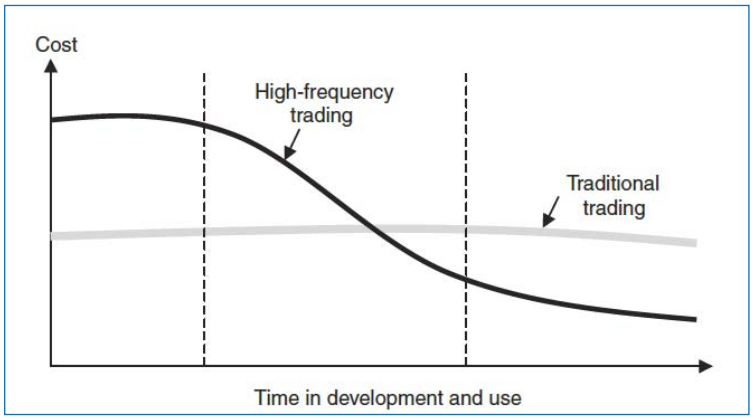

- Development begins with careful planning, scope determination and feedback aggregation from stakeholders.
- Then in the design stage, system is broken into manageable modules with detailed functionality.
- The program is then implemented as planed and back-tested.
- Finally, the program moves into production.
- Performance is constantly monitored and new iteration process begins for program enhancement.

# High-Frequency Algorithmic Trading

## I. Overview

### Development Cost and Time

- Development of HFT trading systems requires large up-front investment in terms of labor and time.
- However, the costs decline as the system moves into production and ultimately require only a small number of support staffs.
- This is in contrast with traditional trading where costs remain fairly constant through time.



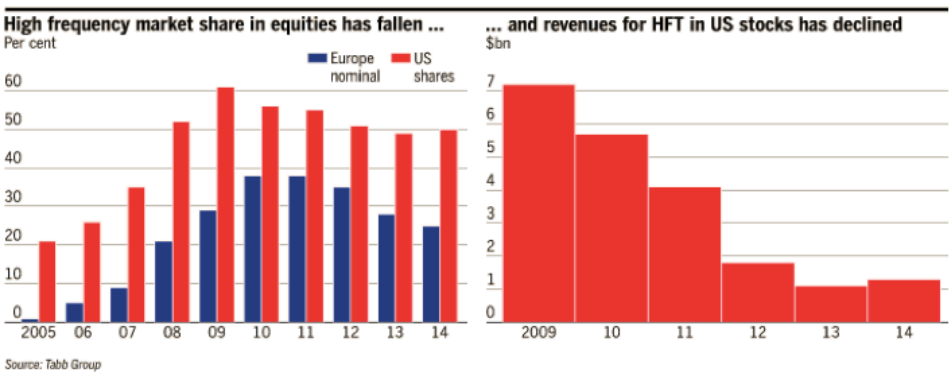

*Source: Aldridge (2010)*

# High-Frequency Algorithmic Trading

## I. Overview

### Growth of HFT

- HFT has grown substantially over the past few years due to the easy access to modern technology
- In 2009, HFT was accounted for 61% by volume of total equity turnover in the U.S.; and 29% by value of total equity turnover in Europe
- However after many traders rushed into the market, profits are way down and there have been slightly less high-frequency trading in recent years. Nevertheless, HFT is still account for half of the market share in U.S. equity market.



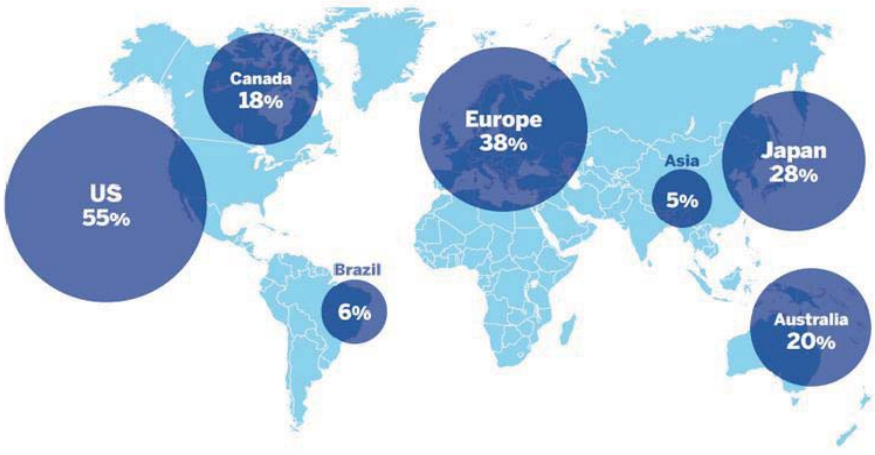
# High-Frequency Algorithmic Trading

## I. Overview

### Growth of HFT

- The popularity also has spread to the other regions of the world, including Asia and Australia

**HFT Share of Equity Trading by Region, 2010**



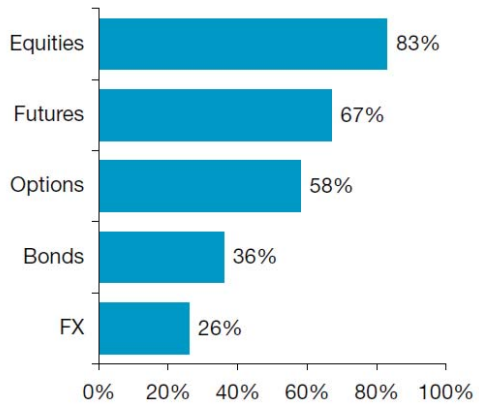

*Source: Tabb Group*


# High-Frequency Algorithmic Trading

## I. Overview

### Growth of HFT


**Asset Classes Traded by Proprietary High Frequency Trading Firms (% of Firms), U.S., 2009**




Source: *Advancedtrading.com*, accessed November 2011

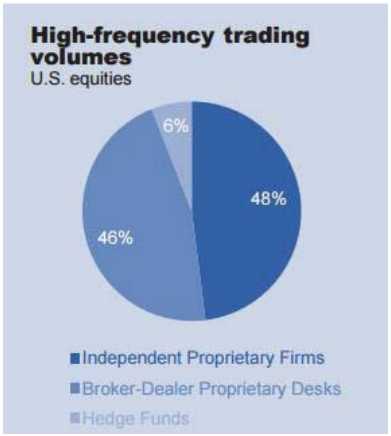
- HFT also has grown across various asset classes
- In 2009, 83% of HFT firms in the U.S. traded equity which is the most commonly traded asset class
- However, the other asset classes including futures, options, bonds, and FX are gaining popularity in HFT trading

# High-Frequency Algorithmic Trading

## I. Overview

### Big Players in U.S. Equity Market

- Research from TABB Group shows the main players in high-frequency trading of U.S. equity market.
- 48% of the HFT volume comes from dedicated HFT houses, 46% from investment banks and just 6% from hedge funds.
- The major trading firms include *Chicago Trading, Virtu Financial, Timber Hill, ATD, GETCO, Tradebot and Citadel LLC.*




*Source: Tabb Group, 2010*

# High-Frequency Algorithmic Trading

## I. Overview

### Big Players in U.S. Bond Market

- High-frequency traders are now dominating the U.S. Treasury bond market.
- Risk.net has published a confidential list ranking the top 10 firms by volume traded on BrokerTec, *an ICAP-owned trading platform for US Treasury that is believed to make up 65% -70% of interdealer market volumes.*

Top 10 firms by volume on BrokerTec (May–June 2015)

| Rank | Firm | Volume (millions) | Market share |
|---|---|---|---|
| 1 | Jump Trading | 2,291,000 | 28% |
| 2 | Citadel Securities | 1,004,000 | 12% |
| 3 | Teza Technologies | 905,000 | 11% |
| 4 | KCG | 798,000 | 10% |
| 5 | JP Morgan | 649,000 | 8% |
| 6 | Spire-X | 564,000 | 7% |
| 7 | XR Trading | 554,000 | 7% |
| 8 | Barclays | 483,000 | 6% |
| 9 | DRW | 400,000 | 5% |
| 10 | Rigel Cove | 400,000 | 5% |
| Total | | 8,048,798 | 99% |

*Source: Risk.net*

# High-Frequency Algorithmic Trading

## I. Overview

### Impacts of HFT on the Market

| Positive Impact | |
|---|---|
| **Increased Liquidity** | HFT provides large order flows, resulting in higher liquidity level in the market |
| **Narrowing Spreads** | HFT traders provide competitive prices, resulting in the decrease in bid-ask spreads |
| **Improved Market Efficiency** | HFT helps information to reflect in price more quickly and accurately |
| **Increase Exchange Fee** | HFT significantly increases trading volumes, leading to higher fee for exchange |

| Negative Impact | |
|---|---|
| **Increased Volatility** | HFT involves rapid intra-day trading that may result in high price fluctuation |
| **Impact on Institutional Investors** | HFT may front-run institutional investors by detecting incoming order flows |
| **Impact on Retail Investors** | HFT uses sophisticated algorithm so smaller investors have lost trust and confidence and believe that they cannot compete with HFT traders |
| **Impact on Listed Firm** | HFT may enter trades without fundamentally consideration, making the stock price to adjust away from its fundamental value |

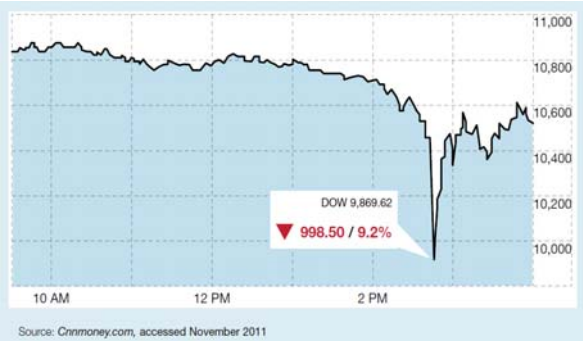
# High-Frequency Algorithmic Trading

## I. Overview

### Criticism of HFT

- The nature of high-frequency strategy which is short-term, high-speed and high-volume may adversely affect the market stability.
- It is believed that the May 6, 2010 **"Flash Crash"** – when Dow Jones collapsed by 998.5 points and rebounded within few minutes – was primarily caused by HFT.

**The Dow Jones Industrial Average, May 6th, 2010**




**"Flash Crash"**

Mutual fund trader entered sell order of 75,000 E-mini futures contracts

↓

HFT firms bought but then sold contracts aggressively, exacerbating the price decline

↓

As volatility increased, long-term traders withdrew from the market

↓

HFT firms started trading contracts among each other, generating looping effect that resulted in prices plummeted within few minutes

↓

Trading pause was automatically activated for 5 seconds

↓

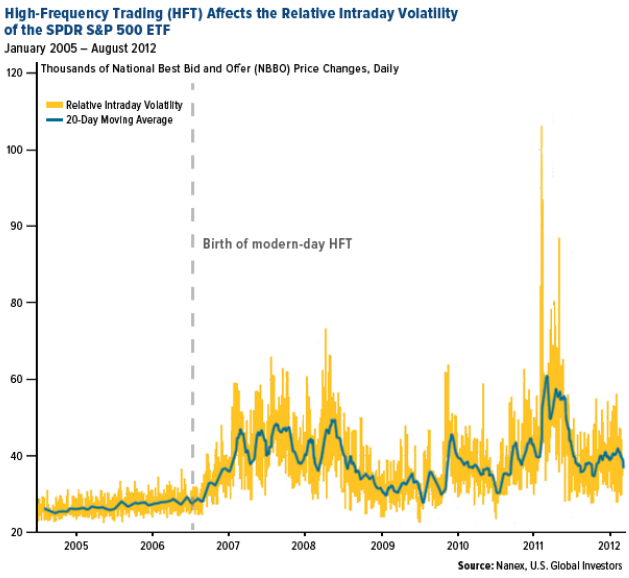
After trading resume, long-term traders re-entered market and prices stabilized

# High-Frequency Algorithmic Trading

## I. Overview

### Criticism of HFT

- HFT has been blamed for the increase in market volatility.
- The chart below shows that HFT has dramatically heightened intraday volatility in the SPDR S&P 500 ETF.
- Since 2007 when HFT has emerged and gained popularity, the volatility has risen sharply.




# High-Frequency Algorithmic Trading

## I. Overview

### Criticism of HFT and Recent Regulation

- Some HFT strategies have triggered concern from regulators since they may be associated with *front-running* and *spoofing* actions, which are illegal.

**Momentum Ignition**

HFT traders intend to rapidly submit and cancel many orders, in order to spoof other traders to buy (or sell) more aggressively. Traders subsequently liquidate the position and get profit after spurring price movement.

**Order Anticipation**

HFT traders use algorithm such as pattern recognition to identify hidden large orders. This enable traders to front-run other investors and make profit from the advanced knowledge.

- On November 24, 2015, the Commodity Futures Trading Commission (CFTC) released ***Regulation Automated Trading (Reg AT)*** to govern certain HFT strategies.
- "According to the CFTC Chair Timothy Massad, new regulation is aimed at minimizing the potential for disruptions and operational problems that may arise from automated trade order originations and executions, or malfunctioning algorithms"[1]

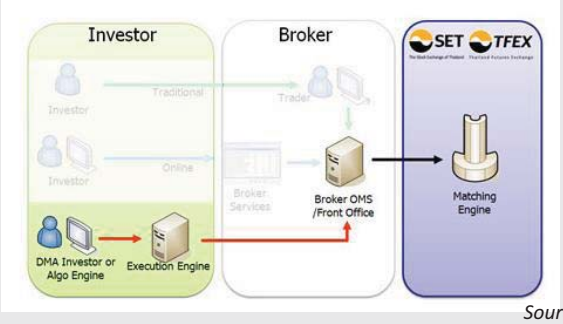
[1] Miller, Rena S. & Shorter, Gary. High Frequency Trading: Overview of Recent Developments. Washington D.C.. UNT Digital Library. http://digital.library.unt.edu/ark:/67531/metadc847719/. Accessed November 9, 2016.

# High-Frequency Algorithmic Trading

## I. Overview

### Role of Technology

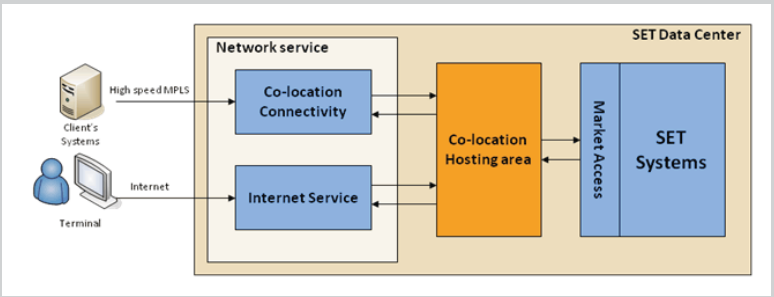
- The success of HFT is largely attributed to technology when each firm tries to become faster and smarter than the others
- Technological advancements that are most critical for the success of HFT are:

| | |
|---|---|
| **Raw Data Feeds** | Some exchanges offer real-time data feeds, which allow HFT to receive and process information faster than competitors |
| **Ultra-Low Latency Direct Market Access (ULLDMA)** | ULLDMA is mean of executing trading flow by bypassing broker discretion. Order flows pass directly through DMA market gateway and onto the venue while passing though risk checking and position keeping algorithms. For HFT, speed of execution is key so ULLDMA must incur no delay greater than milli- or micro-second.   *Source: set.or.th* |

# High-Frequency Algorithmic Trading

## I. Overview

### Role of Technology (cont.)

| | |
|---|---|
| **Co-Location** | Co-located server is machine that is placed in rented rack of the trading center with the intention to minimize potential latency and maximize data transfer speed between trading server and exchange server.   *Source: set.or.th* |
| **High Speed Analytics** | HFT is carrier out by automated series of algorithm to analyze information and detect trading opportunities. The speed and intelligence of the algorithm are critical to the success of the strategy. |

# Agenda

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III **Future of High-Frequency Trading**

- Challenges faced by HFT Industry
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## II. Trading Strategies

### Classification of High-Frequency Strategies[2]

HFT traders employ a diverse range of trading strategies, which can be classified into the following primary categories:

**A. Automated Liquidity Provision**

Involve buying and selling securities to smooth out imbalance in supply and demand and profit from bid-ask spreads

Holding Period: < 1 minute

**B. Market Microstructure Trading**

Observe patterns of quotes by market participants to reverse-engineer information and future price movement

Holding Period: < 10 minutes

**C. Event Trading**

Capture trading opportunities from certain events (e.g. earning announcement) or economic figures and generate profit from soon-to-be public news

Holding Period: < 1 hour

**D. Statistical Arbitrage**

Exploit temporary discrepancies in prices of similar and correlated financial instruments which is a result of market inefficiency

Holding Period: < 1 day

[2] Aldridge, I., 2010, High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems, Wiley.

## A. Automated Liquidity Provision

- Automated liquidity provision strategies use information on shape of order books to predict order arrival rates which are supposed to influence the future price movement.

### Birth-Date Chain Model[3]

- Stochastic model has been proposed to describe dynamics of order book, where occurrence of different order types - market orders, limit orders and cancellation orders - are modeled as independent Poisson process.
- The state of order book is modeled as Birth-Date process where arrivals of limit buy/sell orders increase the quantity of order book while cancellation and market buy/sell orders decrease the quantity.

$$X_t \sim x_0 + B[\lambda(p)]_t + D[\mu + \theta(p)]_t$$

B[…] -> Birth process which is a function of arrival rate of limit orders at each price, $\lambda(p)$
D[…] -> Death process which is a function of cancellation rate, $\theta(p)$, and market orders arrival rate, $\mu$

- Arrival rates of each order types (λ,μ,Θ) can be calibrated from market order book.
- Once the order arrival rates are estimated, probability of stock price movement can be predicted and trade can be submitted accordingly.

[3] Cont, R., Stoikov, S., and Talreja, R., 2010, A stochastic model for order book dynamics. *Operations Research.* Volume 58, No. 3, 549-563.

High-Frequency Algorithmic Trading
II. Trading Strategies

## B. Market Microstructure Trading[4]

- Market microstructure trading strategies employ the model to reverse-engineer trade flows to discover the information impounded in price and make the forecast about the future price movement.
- When market participant observes an order, the market participant updates his beliefs about the true value of the security based on parameter of the order, e.g. buy/sell, limit price, order quantity
- Bayes Rule is used to update the prior belief upon the arrival of new order.

$$\Pr(event|seeing\ data) = \frac{\Pr(seeing\ data|event)\,.\,\Pr(event)}{\Pr(seeing\ data|event)\,.\,\Pr(event) + \Pr(seeing\ data|no\ event)\,.\,\Pr(no\ event)}$$

- *Pr(event) = probability of security price increasing / decreasing*
- *Pr(seeing data) = probability of observing buy/ sell order*

[4] Aldridge, I., 2010, High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems, Wiley.

## B. Market Microstructure Trading - Example

Suppose that current mid-price of stock A is **5.10**. According to the Bayes rule, market participant should set the new ask price after observing a buy order.

Assumptions:
- Informed trader will place buy order only if he could make 4 bps and there is no other transaction costs
- Average bid-ask spread is 1 bps
- Therefore, informed trader will buy stock A only if he believes that its true value is at least 5.10+0.04+0.01 = **5.15**
- We cannot distinguish between informed and uninformed traders so we assign 50:50 probability that the buy order will arrive from each type of trader -> *Pr(informed trader) = Pr(uninformed trader) = 0.5*
- We have no indication where the price is going -> *Pr(V=5.10) = Pr(V=5.15) = 0.5*

The probability of true value of stock A being worth 5.15 after arrival of a buy order is calculated as follows:

If true value of stock A is indeed 5.15, informed trader will buy it with certainty, while uninformed trader may buy it with probability 50%
Pr($buy\ order|V$=5.15) = [Pr(informed trader) x 100%] + [Pr(uninformed trader) x 50%]
= [50% x 100%] + [50% x 50%] = 75%

$$\Pr(V = 5.15|buy\ order) = \frac{\Pr(buy\ order|V = 5.15)\,.\,\Pr(V = 5.15)}{\Pr(buy\ order|V = 5.15)\,.\,\Pr(V = 5.15) + \Pr(buy\ order|V = 5.10)\,.\,\Pr(V = 5.10)}$$

High-Frequency Algorithmic Trading
II. Trading Strategies

B. Market Microstructure Trading - Example

The probability of true value of stock A being worth 5.15 after arrival of a buy order is calculated as follows:

$$\Pr(V = 5.15|buy\ order) = \frac{\Pr(buy\ order|V = 5.15)\,.\,\Pr(V = 5.15)}{\Pr(buy\ order|V = 5.15)\,.\,\Pr(V = 5.15) + \Pr(buy\ order|V = 5.10)\,.\,\Pr(V = 5.10)}$$

$$= \frac{75\%\ x\ 50\%}{75\%\ x\ 50\% + (1 - 75\%)\ x\ 50\%} = 75\%$$

Market participant then set the new price based on this updated probability

$$New\ Price = E(v|buy\ order)$$

$$= [5.10\ x\ \Pr(V = 5.10|buy\ order)] + [5.15\ x\ \Pr(V = 5.15|buy\ order)]$$

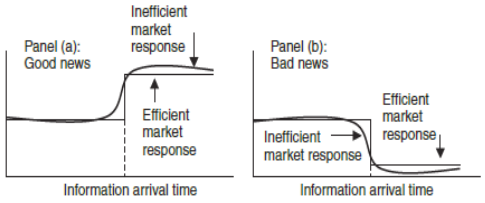
$$= [5.10\ x\ 25\%] + [5.15\ x75\%] = 5.1375$$

# High-Frequency Algorithmic Trading

## II. Trading Strategies

### C. Event Trading

- Event trading is an arbitrage strategy that profit from market inefficiency.
- When information is impounded into securities slowly or market under/over reacts to events , then arbitrage opportunities exist.
- The strategies utilize high-frequency trading since the faster the response to news , the higher the probability of making the profit.




**Forecasting Models:**

- **Directional Forecast**
  Estimate whether securities price persistently go up or down in response to specific event
  Test is conducted on historical data around the release of news. If the response is statistically significant, we can construct profitable trading strategies.

- **Point Forecast**
  Predict level of new price when market reacts to news
  Event study is performed on trading data surrounding event announcement of interest. The impact of event is then estimated by simple linear regression.

$$R_t = \propto + \beta \Delta X_t + \varepsilon_t$$

; $R_t$ : abnormal returns around the announcement
$\Delta X_t$ : surprise component of the announcement

Automated trading systems can be implemented to capture news and match events to securities based on historical analysis.


# High-Frequency Algorithmic Trading

## II. Trading Strategies


### D. Statistical Arbitrage

- Statistical arbitrage strategies exploits temporary discrepancies in prices of similar and correlated securities.
- The statistical relationship of securities is identified on historical data. If this relationship is violated, the trading is conducted and will make profit once the relationship mean-revert to its natural historical level.
- Numerous strategies can be deployed on a variety of asset classes. The examples are:

| Asset Class | Statistical Arbitrage Strategy |
|---|---|
| **Foreign Currency** | Exploit violation in Uncovered Interest Rate Parity (UIP) - difference in interest rates between two countries is equal to expected change in exchange rates between the countries' currencies |
| **Equity** | Exploit profit opportunity when correlation of highly correlated stocks temporary weakens (market neutral pairs trading) |
| **Index and ETF** | Exploit mispricing between index and its underlying components |
| **Futures** | Exploit mispricing between futures and spot instrument |
| **Options** | Exploit mispricing between a pair of options written on the same underlying but having some different features such as different in maturity date or strike |

- Statistical arbitrage is powerful and easy to implement in high-frequency settings as it has clearly defined conditions and trading rules.

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## III. Future of High-Frequency Trading

### Challenges faced by HFT Industry

**Barrier to Entry**

- Large implementation cost in extremely fast and sophisticated trading algorithm, and significant investment co-location and high-speed network are some barriers that firms seeking to enter the industry need to consider.

**Operational Issue**

- Since HFT employs high-speed automated algorithm, firm must ensure that the algorithm is tested thoroughly before it goes live; otherwise, the faulty program may cause severe and undesired incidents.

**Risk Management**

- Firms face a number of market risks since HFT strategies are based on several assumptions; therefore, changes in market condition can have unexpected impact on the result.
- Firms also face technological and operational risks since HFT depends heavily on technology and IT infrastructure.

**Regulation Impact**

- Market participants and regulators have questioned potential negative impacts of HFT on the market and have put forward greater level of regulation that may create unfavorable environment for HFT.

## HFT in Thailand

Thai market provides good opportunity for HFT due to several factors such as co-location facility, modern trading platform, advanced technology and high market liquidity.

- **Infrastructure:** SET has improved its IT infrastructure according to the IT Master Plan in order to facilitate securities trading and serve customers with more complex strategies. The trading platform and network have been speed up and made more stable.

- **Market Liquidity:** HFT requires the ability to quickly move in and out of positions; therefore the market liquidity is a key. SET is among the exchanges that are well-established and liquid.

- **Regulation:** SET has to reform the trading rules in order to create favorable environment for the growth of HFT. In addition, the regulation must also aim to protect other investors by promoting high level of transparency and minimizing potential for market disruption and operational problem that may arise from HFT.

  Firms must send the strategy's detail to get approval from SET before using program trading.