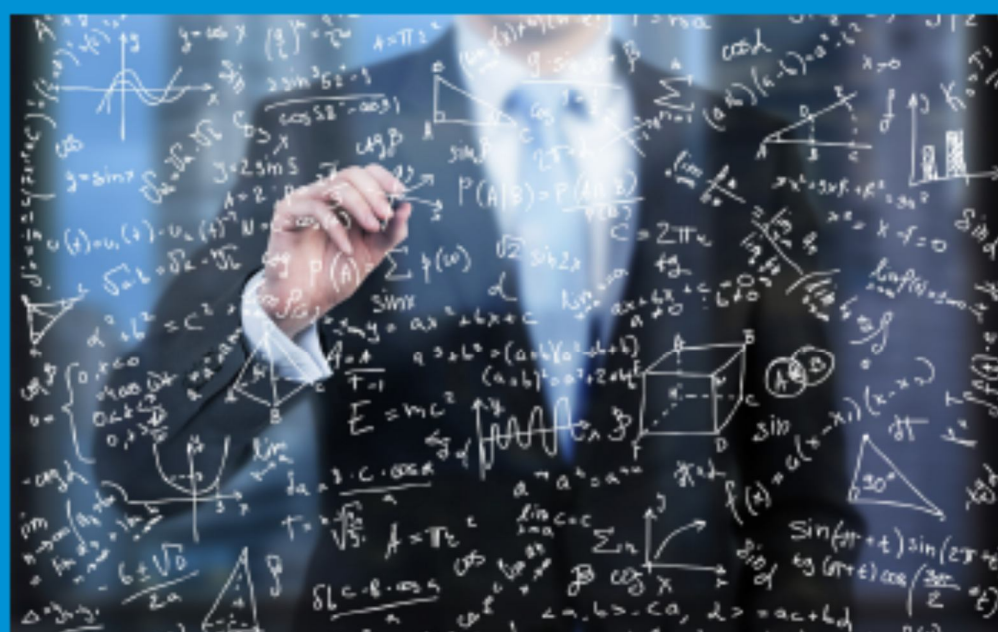


A STUDY ON ALGORITHM TRADING / HIGH FREQUENCY TRADING IN THE INDIAN CAPITAL MARKET



Report submitted under the aegis of
DEA-NIFM Research Programme



NATIONAL INSTITUTE OF FINANCIAL MANAGEMENT
(An Institute of Ministry of Finance, Government of India)

DISCLAIMER

This study report on Algorithm / High Frequency Trading is submitted to Department of Economic Affairs under the aegis of DEA-NIFM Research Program. The views expressed in the Report are the views of National Institute of Financial Management.

Algorithmic Trading (Algo or High Frequency Trading) is a technology platform providing an advantage of both the worlds – Artificial Intelligence and Human Intelligence. Algorithms are Mathematics and Rules; and Rules and Logic, Human Programming is responsible for the trade transactions. Here, the complex mathematical models and formulas enables the trader to make high-speed decisions and transactions in the financial markets, Given the advantages of such technological interventions to facilitate securities transactions in the market, Algo or High Frequency Trading has of late become the buzz word in the trading ecosystem. In developed countries, the volume of such technology-driven transactions is significantly increasing over the years. Indian market is also gradually embracing the Algo or High Frequency Trading, here also more and more transactions are being routed through this platform. Indeed, there are considerable advantages of these trading practices, yet at the same time, there are areas of serious concerns as well, and they may lead to market wide systemic risks besides others.

Every information has an underlying cost, Algo or High Frequency Trading software technology being still in the evolving stage, the obsolesce rate is not only very high besides generally being event-based software, the acquisition cost of the technology is also on the higher side. As a result, the institutional investors are the beneficiaries of this technology. Retail investors continued to be deprived of technological advancements in the trading models. But then, one must concede that this trading technology is going to stay.

Recent market developments in India have heightened the concerns of the Policy Makers and Market Regulators is a trading practice which is vulnerable enough to need regulatory protection.

This Report comprehensive deliberates on this contemporary market trading practices, benefits and areas of concern. While drawing conclusions, the Report makes an endeavour to propose improvements in Policy Framework for Algo or High Frequency Trading for the benefit of the Policy Makers.

DEA-NIFM Research Team

ACKNOWLEDGMENT

National Institute of Financial Management is pleased to be provided with an opportunity by the Department of Economic Affairs to make a purposeful academic contribution to one of the most contemporary issues of the Securities Markets – Algorithm Trading/High Frequency Trading.

Technology has made Artificial Intelligence as all-pervasive market wide. Developed markets and emerging markets have embraced this technology in the securities market. Market innovations and complexities have ensured that Algo Trading is fact-of-the -day and going to stay. As the cliché goes, every Coin has two sides. Be that so, the best insulation is that such trading must be Fair, Transparent, Accountable and above all ensure Investors' Protection. In the domestic market context, certain market developments have made Algo Trading and its fall out as an area of immense academic research and generated scope of future-learning.

Being an area where a restricted research has been conducted and debated, the Research Team had to mine information/data from various global resources, which are generally protected. Understanding and appreciating global developments and juxtaposing them with the Indian securities market ecosystem involved not only super-specialised domain expertise but also out-of-box thinking with a forward-looking approach. Given that the technology obsolescence rate is very high, the team had to anticipate the prospective regulatory framework for the Indian market. Hurdles were many on the way, perseverance paved the way to the successful culmination of the assignment.

We place on record our deep and sincere appreciation to the entire team of National Stock Exchange and Bombay Stock Exchange for providing us access to the inside of the regulatory platform and also to share all the requisite information/details that were necessary in writing this report.

Our report would not have been made possible but for the unprecedented contributions of Mr. Harjeet Singh, Mr. Kunal Nandwani, Consultants, DEA-NIFM Research Programme and also experts from the Fintech sector of the Capital Markets in preparing this Report and providing significant inputs in drafting the proposed Regulatory Framework for the Policy Makers and the Market Regulators alike for making the domestic markets more attractive and investor friendly.



Prof. (Dr.) A M Sherry
Chair, DEA-NIFM Research Programme

WHAT IS ALGORITHMIC TRADING?

Algorithmic trading is the use of programs and computers to generate and execute (large) orders in markets with electronic access. Orders come from institutional investors, funds and trading desks of big banks and brokers. These statistical, mathematical or technical models analyze every quote and trade in the stock market, identify liquidity opportunities, and turn the information into intelligent trading decisions.

Algorithmic trading, or computer-directed trading, cuts down transaction costs, and allows investment managers to take control of their own trading processes. The main objective of algo trading is not necessarily to maximize profits but rather to control execution costs and market risk.

ALGORITHMIC TRADING AND ITS COMPOSITION IN INDIAN MARKETS

Around 50% plus of total orders at both NSE and BSE are algo trades on the client side. Prop side algo trades are 40% plus of total orders placed at both the exchanges. More than 80% of the algorithmic orders are generated from colocation at both the exchanges. In developed markets it stands at about 80%.

KINDS OF ALGORITHMS

Algorithms are used extensively in various stages of the trading cycle. We can classify them into pre-trade analytics, execution stage, and post-trade analytics.

Depending on their usage, Algorithms can also be broadly classified into Agency trading algorithms, Proprietary Trading algorithms and High Frequency Trading (HFT) algorithms.

Execution Algorithms - Execution algorithms mean to systematically split a larger order into many smaller orders based on the available liquidity. These amounts are often larger than what the market can absorb without impacting the price. For instance, Time Weighted Average Price (TWAP) algorithmic strategy will break an order up into many smaller equal parts and execute them during the trading day, normally at 5 minute intervals. Another example is of the Volume Weighted Average Price (VWAP) strategy that will estimate the average volume traded for each 5-minute interval the order is traded using historical trading information, with the ultimate goal to split the order into smaller pieces based on an average weighted volume.

Proprietary Trading Algorithms - Proprietary trading (also "prop trading") occurs when a trader trades stocks, bonds, currencies, commodities, their derivatives, or other financial instruments with the firm's own money, as opposed to depositors' money, so as to make a profit for itself. Proprietary Trading algorithms are typically used with the strategies that involve directional bets on the markets – Net Long or Short depending on the market direction. Within this subset, we have Momentum, Mean Reversion and Trend Following strategies. Besides, another popular set of strategies called as Spread strategies or Market Neutral (both Long/Short) is also part of this suit of algorithms.

HFT Algorithms - High-frequency trading (HFT) is a subset of automated trading. Here, opportunities are sought and taken advantage of on very small timescales from nanoseconds up to

milliseconds. Some high-frequency strategies adopt a market maker type role, attempting to keep a relatively neutral position and providing liquidity (most of the time) while taking advantage of any price discrepancies. Other strategies invoke methods from time series analysis, machine learning and artificial intelligence to predict movements and isolate trends among the masses of data.

HOW IS AN ALGORITHM BUILT?

Decide upon the genre/strategy paradigm - The first step is to decide the strategy paradigm. It can be Market Making, Arbitrage based, Alpha generating, Hedging or Execution based strategy.

Establish Statistical significance - You can decide on the actual securities you want to trade based on market view. Establish if the strategy is statistically significant for the selected securities

Build Trading model – Next step would be to code the logic based on which you want to generate buy/sell signals in your strategy.

Quoting or Hitting strategy - It is very important to decide if the strategy will be “quoting” or “hitting”. Execution strategy to a great extent decides how aggressive or passive your strategy is going to be.

Backtesting & Optimization – This step is extremely important to understand if the strategy you chose works well in the markets or not. A strategy can be considered to be good if the backtest results and performance statistics back the hypothesis.

COLOCATION AND IMPLICATIONS

Colocation is locating computers owned by HFT firms and proprietary traders in the same premises where an exchange’s computer servers are housed. This enables HFT firms to access stock prices a split second before the rest of the investing public.

Co-location has become a lucrative business for exchanges, which charge HFT firms by rack space for the privilege of “low latency access.”

Colocation reduces latency, increases liquidity and levels the playing field among competing HFT market makers.

In the Indian context, the disadvantages of colocation include expensive and market inequality.

ADVANTAGES AND DISADVANTAGES OF ALGORITHMIC TRADING

Algo trading, colocation and HFT offer various advantages and disadvantages. It is observed that with algo trading and HFT there have been improvements in transactions costs, volatility, and buy-sell imbalance. Market prices have become more efficient and they have facilitated price discovery. Algorithms using Colocation reduce latency and enhance liquidity.

Lack of control has led to systemic risks. Fat finger or faulty algorithms can cause huge deviations from healthy prices. Examples include Flash crash that occurred on BSE Muhurat Session in 2011, Flash crash on Nifty April futures on April 21st, 2012 and Reliance Industries stock flash crash on June 2010, due to execution of a large ‘sell’ order using algorithms.

It has been proved in the past that Algo trading and HFT can be used to manipulate markets using techniques like quote stuffing, layering (spoofing) and momentum ignition. Evidence suggests that market manipulation algorithms lead to decreased liquidity, higher trading costs, increased short term volatility, impact performance and fill rates, and massive price moves backed by false volume.

ORDER TO TRADE RATIO AND SIGNIFICANCE

Order-to-trade (or order-to-execution) ratios involve financially penalising individual financial firms if the orders to buy or sell they enter do not lead to a 'sufficient' number of trades.

High order-to-trade ratios imply that market participants are placing and cancelling orders but not executing most of the orders. This could be due to the nature of market making algorithms or market manipulation algorithms, where orders are placed to drive volumes to that point and then cancelled – with the result that most of the orders are not converted into trades.

In the year 2016-17, order to trade ratio for NSE across all segments was 11.2. It has increased from 7.07 in 2014-15. In case of high order to trade ratio, NSE makes calls and alert trading members. BSE has issued circulars to keep a check on high order to trade ratios. Penalty is imposed by both the exchanges for high to trade ratios for the member brokers.

MEASURES ADOPTED BY SECURITIES MARKET REGULATORS IN DIFFERENT COUNTRIES

Minimum resting time, frequent batch auctions, random speed bumps or delays, randomization of orders during a period (1-2 seconds), max order message to trade ratio requirement, market maker pricing are some of the measures adopted globally by various market regulators.

Some of the other important measures carried out include the HFT transaction tax implemented by the regulators in France and Italy; Market Access Rule, Regulation SCI and registration of entities implemented by SEC; and the enactment of the Act on the Prevention of Risks and Abuse in High-Frequency Trading (HFT Act) by the German regulators in 2013.

SURVEILLANCE METHODS AT NSE & BSE

Currently both NSE and BSE have their own methods and levels of sophistication to manage surveillance. However, in our view, harmonization of surveillance mechanism would bring about uniformity in exchange action towards harmful HFT. There is a definite need to invest in advanced technology to automatically detect harmful HFT and market manipulative trends/algorithms. Exchanges hardly have advanced real-time surveillance mechanisms to detect harmful HFT.

SEBI'S DISCUSSION PAPER ON CURBING HARMFUL HFT

Minimum Resting Time: Resting time is defined as the time between an order is received by the exchange and the said order is allowed to be amended or cancelled thereafter. Securities market regulators have considered the idea of eliminating "fleeting orders" or orders that appear and then disappear within a short period of time. As per the Minimum Resting Time mechanism, the orders received by the stock exchange would not be allowed to be amended or cancelled before a specified amount of time viz. 500 milliseconds is elapsed. Currently, there are no instances of the 'resting time' mechanism being mandated by any regulator. It has been observed that Australian Securities and Investment Commission (ASIC) had sought feedback on the matter few years ago, but decided not to go ahead with the proposal. Perceived advantages include more stability in limit order book, reduce

fleeting orders, and reduce the excessive level of message traffic. Perceived disadvantages include longer queues & waiting time, rising transaction costs and increased volatility.

Frequent Batch Auctions: The mechanism of Frequent Batch Auctions would accumulate buy and sell orders on the order book for a particular length of time (say 100 milliseconds). At the end of every such period, the exchange would match orders received during the time interval. This proposal tries to address the problem of ‘latency advantage’ by undertaking batch auctions at a particular interval. The idea is to set a time interval for matching of orders which is short enough to allow for opportunities for intraday price discovery, but long enough to minimize the latency advantage of HFT to a large extent. There is no evidence of implementation of Frequent Batch auctions. Perceived advantages include reduction of the speed of trading and elimination of sniping. Perceived disadvantages include impediment of price discovery, increased execution risk and reduced liquidity.

Random Speed Bumps: The Speed Bump mechanism involves introduction of randomized order processing delay of few milliseconds to orders. Instances where this mechanism has been implemented include TSXA – Toronto Stock Exchange (1-3 ms) and ParFX – interdealer OTC broker (20-80ms) impose randomized order processing. Perceived advantages include nullify latency advantage, market equity and stop arms race for speed. Perceived disadvantages include reduction or withdrawal of liquidity.

Randomization of orders received during a period (1-2seconds): The time-priority of the new / modified orders that would be received during predefined time period (say 1-2 seconds period) is randomized and the revised queue with a new time priority is then forwarded to the order matching engine. Instances where this mechanism has been implemented include ICAP EB (wholesale FX electronic trading platform) Market Matching platform that has introduced the Latency floor. Perceived advantages include reduce latency advantage, market equity and stop arms race for speed. Perceived disadvantages include reduction or withdrawal of liquidity.

Maximum order to trade ratio requirement: A maximum order-to-trade ratio requires a market participant to execute at least one trade for a set number of order messages sent to a trading venue. The mechanism is expected to increase the likelihood of a viewed quote being available to trade and reduce hyper-active order book participation. NSE and BSE are already implementing this mechanism – disincentives include penalty charges and trading ban for 15 minutes on the subsequent trading session. Perceived advantages include increased market depth, curtailed market manipulation and reduced large number of electronic messages. Perceived disadvantages include reduction in liquidity, withdrawal during volatile times and increased bid-ask spread.

Separate queues for co-located and non-co-location orders: With the view to ensure that stock brokers who are not co-located have fair and equitable access to the stock exchange’s trading systems, stock exchanges facilitating co-location shall implement an order handling architecture comprising of two separate queues for co-located and non-co-located orders such that orders are picked up from each queue alternatively. It is expected that such architecture will provide orders generated from a non-co-located space a fair chance of execution and address concerns related to being crowded-out by orders placed from colocation. Perceived advantages include provide fair chance for non-Co-location orders. Perceived disadvantages include creation of 2 parallel markets and possible withdrawal of liquidity.

Review of tick by tick data feed: Tick-by-Tick (TBT) data feed provide details relating to orders (addition + modification + cancellation) and trades on a real-time basis. TBT data feed facilitates a detailed view of the order-book (such as depth at each price point, etc.). TBT facility is being provided

by BSE and NSE to collocated participants. Perceived advantages include more transparency, access to full order book and real time access to TBT data. Perceived disadvantages include reduce the level of transparency if the data feed is anything other than real time feed and the increased analytical capacity required at the brokers end to sift through TBT data.

ABBREVIATIONS

AI	Artificial Intelligence
ARC	Annual Recovery Charges
BSE	Bombay Stock Exchange
BEFS	BSE Electronic Filing System
CM	Capital Market
CAT	Consolidated Audit Trail
CAGR	Compound Annual Growth Rate
CDs	Currency Derivatives
DMA	Direct memory access
EBS	Electronic Broking Services
ETPs	Exchange Traded Products
ECN	Electronic Communication Network
ETFs	Exchange Traded Funds
F&O	Futures and Options
HFT	High-frequency trading
IOSCO	International Organization Of Securities Commissions
IPO	Initial Public Offering
IOC	Immediate or Cancel
IFSD	Interest Free Security Deposit
MOC	Market-On-Close
MFR	Monthly Fill Ratio
MQL	Minimum Quote Lifespan
MPLS	Multiprotocol label switching
NYSE	New York Stock Exchange
NASDAQ	National Association of Securities Dealers Automated Quotations
NSE	National Stock Exchange

NSEIL	National Stock Exchange of India Ltd.
OTC	Over the Counter
OER	Orders-to-Executions
PoV	Percent of Value
RTPC	Reverse Trade Prevention Check
SEC	Securities Exchange Commission
SSF	Single Stock Futures
STPC	Self-Trade Prevention Check
SMA	Sponsored Market Access
TOR	Terms of Reference
TWAP	Time Weighted Average Price
TBT	Tick-by-Tick
TWSE	Taiwan Stock Exchange
TSXA	TSX Alpha Exchange
VSAT	Very Small Aperture Terminal
VaR	Value-at-Risk
VWAP	Volume Weighted Average Price

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Chapter-1

ALGORITHMS

1.1 INTRODUCTION TO ALGORITHMS

Algorithmic trading is a special type of trading which contains computerized logic from making trading decision to transaction approval. Algorithmic trading became a popular tool after technological progress transformed the way assets are traded.

Algorithmic trading is the use of programs and computers to generate and execute (large) orders in markets with electronic access. Orders come from institutional investors, funds and trading desks of big banks and brokers.

Algorithmic trading, or computer-directed trading, cuts down transaction costs, and allows investment managers to take control of their own trading processes. The main objective of algo trading is not necessarily to maximize profits but rather to control execution costs and market risk.

Algorithms have become such a common feature in the trading landscape that it is unthinkable for a broker not to offer them because that is what clients demand. These mathematical models analyze every quote and trade in the stock market, identify liquidity opportunities, and turn the information into intelligent trading decisions.

Why Algorithms

- Institutional clients need to trade large amounts of stocks. These amounts are often larger than what the market can absorb without impacting the price.
- The demand for a large amount of liquidity will typically affect the cost of the trade in a negative fashion ('`slippage'')
- Large orders need to be split into smaller orders which will be executed electronically over the course of minutes, hours, day.
- The procedure for executing this order will affect the average cost per share, according to which algorithm is used.
- In order to evaluate an algorithm, we should compare the average price obtained by trading with a market benchmark ('`global average'') of the daily price, closing price, opening price, etc)

1.2 TYPES OF ALGORITHMS

I. Agency Trading algorithms (execution algorithms)

Execution algorithm means to systematically split a larger order into many smaller orders based on the available liquidity. The most commonly used algorithms are Time Weighted Average Price (TWAP), Volume Weighted Average Price (VWAP) and Percent of Value (PoV).

The Time Weighted Average Price algorithmic strategy will break an order up into many smaller equal parts and execute them during the trading day, normally at 5 minute intervals. The Volume Weighted Average Price strategy will estimate the average volume traded for each 5-minute interval the order is traded using historical trading information. The goal is to split the order into smaller pieces based on an average weighted volume.

- Large Institutional clients want superior execution with minimal market impact for large orders.

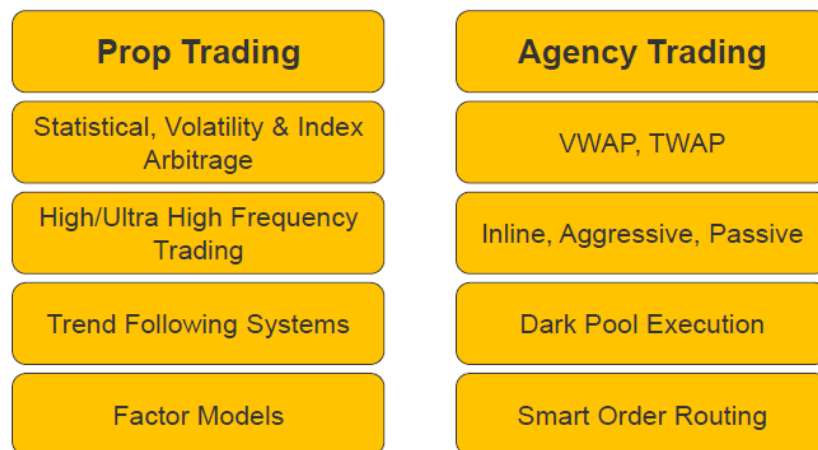
- Provide intelligence on executing large basket orders
- Some types of Agency Algorithms: Volume Weighted Average Price (VWAP), Time Weighted Average Price (TWAP), aggressive, passive algorithms
- For example, Buy side firms execute large orders using various kinds of execution algorithms

II. Proprietary Trading Algorithms

Proprietary trading (also "prop trading") occurs when a trader trades stocks, bonds, currencies, commodities, their derivatives, or other financial instruments with the firm's own money, as opposed to depositors' money, so as to make a profit for itself.

Proprietary Trading algorithms are typically used with the strategies that involve directional bets on the markets – Net Long or Short depending on the market direction. Within this subset, we have Momentum, Mean Reversion and Trend Following strategies. Besides, another popular set of strategies called as Spread strategies or Market Neutral (both Long/Short) is also part of this suit of algorithms.

Another subset of strategies involving proprietary trading uses a variety of Arbitrage strategies such as index arbitrage, statistical arbitrage, merger arbitrage or volatility arbitrage.



a) Momentum based Strategies

- Assuming that there is a particular trend in the market. An algo trader follows those trends. Further to the assumptions, the markets fall within the week. Using stats to determine if this trend is going to continue or if it will change in the coming weeks. Accordingly, algo trader will make the next move.
- Algo traders base their algorithmic trading strategy on the market trends which is determined by using statistics.
- This method of following trends is called **Momentum Based Strategy**.

b) Arbitrage

- Assume that a pharma-corp is to be bought by another company, then the stock price of corp could go up. This is triggered by the acquisition which is a corporate event. If a trader is planning to invest based on the pricing inefficiencies that may happen during a corporate event (before or after), then the trader is using an event-driven strategy. Bankruptcy, acquisition, merger, spin-offs etc could be the event that drives such kind of an investment strategy.
- These strategies can be market neutral and used by hedge fund and proprietary traders widely.

c) **Statistical Arbitrage**

- When an arbitrage opportunity arises because of misquoting in prices, it can be very advantageous to algo trading strategy.
- Although such opportunities exist for a very short duration as the prices in the market get adjusted quickly. And that's why this is the best use of algorithmic trading strategies, as an automated machine can track such changes instantly.
- Statistical Arbitrage algorithms take advantage of relative mispricing between 2 stocks.

d) **Market Making**

- A **market maker** or liquidity provider is a company, or an individual, that quotes both a buy and a sell price in a financial instrument or commodity held in inventory, hoping to make a profit on the bid-offer spread, or turn.
- Market making provides liquidity to securities which are not frequently traded on the stock exchange. The market maker can enhance the demand-supply equation of securities.
- Let's assume there is a market maker, who buys for Rs. 500 from the market and sell it at 505. He will give a bid-ask quote of Rs. 505-500. The profit of Rs. 5 cannot be sold or exchanged for cash without substantial loss in value.
- When the market maker takes a higher risk then the profit is also higher.

e) **Machine Learning based**

- In Machine Learning based trading, algorithms are used to predict the range for very short term price movements at a certain confidence interval. The advantage of using Artificial Intelligence (AI) is that humans develop the initial software and the AI itself develops the model and improves it over time.
- A large number of funds rely on computer models built by data scientists and quants but they're usually static, i.e. they don't change with the market. ML based models on the other hand can analyze large amounts of data at high speed and improve themselves through such analysis.

1.3 ADVANTAGES OF ALGORITHMS

a) **Lower Costs**

Algorithms are more cost effective for low-maintenance trades and that has meant head-count shifts and reductions on sales desks. The ability to submit orders electronically to exchanges directly rather than through brokers has been an important innovation in lowering the cost of trading. Back-office functions and post-trade services such as clearing and settlement have also benefited from automation.

b) **Enables improved liquidity and pricing on shares**

Algorithms are used extensively by broker-dealers to match buy and sell orders without publishing quotes. By controlling information leakage and taking both the bid and offer sides of a trade, broker Algorithms are in a way enabling improved liquidity, pricing on shares for client, and higher commissions to brokers.

c) **Algorithm can analyse and react to the news faster before a human trader**

An algorithm could, for example alert a trader if news is released on a company X and if the company stock rises or falls by say one percent in the value of that stock within five minutes. For example, Reuters News Scope Real-time product lets clients use live news content to drive automated trading and respond to market-moving events as they occur. Each news item is 'meta tagged' electronically to identify sectors, individual companies, stories or specific items of data to assist automated trading.

d) **To monitor and respond to risk conditions on real-time basis**

Using real-time analytics, algorithms can continuously re-calculate metrics like Value-at-Risk (VaR) and automatically hedge a position if VaR is exceeded.

e) **Address Regulatory Compliance Issues**

Compliance with law is of utmost importance and it is becoming burdensome with ever increasing stringent regulations. Firms going forward will increasingly harness the latest in algorithmic trading technology to address regulatory compliance issues.

f) **Automate Surveillance**

Regulators could automate surveillance to monitor algo-trading operations for patterns of abuse.

However, limited availability of automated surveillance tools for algo trades and lack of skilled staff and sufficient IT resources makes supervision technically challenging.

g) **Offers Better Price with Minimal Market Impact**

Most algorithms (categorized as execution algorithms) need to provide the best possible execution price for clients hitting large orders in the market. Execution algorithms parcel a large order into smaller orders into the market to minimize the market impact of a large order.

E.g. one of the most commonly used execution algorithms is implementation shortfall. Implementation Shortfall is designed to measure and understand trading costs at the fund level, by capturing the price slippage from the time the decision was made to implement an investment idea to the time the trade was actually executed. Most algorithms already allow customers to change the timing of executions, the rate of order-filling attempts at the beginning or end of the trading day, and the tolerance for the slippage of a stock from certain benchmarks.

Other commonly used strategies are **arrival price, time weighted average price (TWAP), volume weighted average price (VWAP) and market-on-close (MOC).**

1.4 DISADVANTAGES OF ALGORITHMS

a. **Technical sufficiency and resources required**

One of the biggest disadvantages of algo trading is the technical sufficiency and resources required for algo trading. Algo trading requires knowing how to program in specific program languages, which can take quite a while to learn. This facility may not be accessible to retail investors and small traders.

b. **Lack of Control**

Since trades are automated, if the program runs in a way that one doesn't want it to, one will be unable to control losses. Programs need to be tested thoroughly in order to avoid these mistakes that might be made.

c. Lead to systemic risk

Interconnections between markets, which may be amplified by algorithms programmed to operate on a cross-market basis, may allow for a shock to pass rapidly from one market to another, potentially increasing the speed at which a systemic crisis could develop. This was illustrated by the Flash Crash event of May 2010.

Facts of Flash Crash on 6 May 2010: That afternoon, major equity indices in both the futures and securities markets, each already down over 4% from their prior-day close, suddenly plummeted a further 5-6% in a matter of minutes before rebounding almost as quickly. Many of the almost 8,000 individual equity securities and exchange traded funds (ETFs) traded that day suffered similar price declines and reversals within a short period of time, falling 5%, 10% or even 15% before recovering most, if not all, of their losses. Over 20,000 trades across more than 300 securities were executed at prices more than 60% away from their values just moments before. Moreover, many of these trades were executed at prices of a penny or less, or as high as \$100,000, before prices of those securities returned to their pre-crash levels. By the end of the day, major futures and equities indices recovered to close at losses of about 3% from the prior day.

d. Lack of Visibility

We know what a specific algorithm is supposed to do, measure its pre-trade analytics and see how the post trade results match up to that expectation. But if the trader didn't select the most optimal algorithm for that trade little can be done. This problem is caused by a lack of visibility and transparency into the algorithm while it is executing orders.

e. Algorithms Acting on Other Algorithms

If fund managers' trading pattern is spotted and tracked with the use of algorithms, then these algorithms are liable to be 'reverse engineered'. This implies that their buy and sell orders are pre-empted and used to the maximum effect by their competitors. Here, algorithms are acting on other algorithms.

f. Lack of standard benchmark

With brokers offering many algorithmic strategies, one concern is that buy-side institutions lack the tools to understand which algorithm to use for a particular stock. The lack of a standard benchmark has made it almost impossible to assess the quality of algorithms.

g. Algorithmic trading requires careful real-time performance monitoring as well as pre and post-trade analysis

This is required to ensure algo trade is properly applied. Traders must calibrate the algorithms to suit portfolio strategy. More important is aligning execution choices with the level of order difficulty involved in terms of: order size, liquidity, and trade urgency. Low touch venues such as algorithmic trading lend themselves best to easier types of orders such as low-urgency and small orders for large cap stocks. But urgent orders for a large volume of small cap stocks would require a higher-touch approach to ensure best execution and cost efficiency.

High Touch Orders: Are orders that are sent electronically to the sell-side with the expectation that a broker/trader will use discretion to add value to the execution process.

Low Touch: Are electronic orders that are subjected to some form of a sell-side algorithm (e.g. smart order routing) or the possibility of some form of human involvement that might introduce latency into the execution process

h. Missing Ingredient—The Trader’s Gut Feel

Algorithms are simply advanced trading tools and they cannot replace the human elements or make interaction redundant. Algorithms fail to capture a trader’s “gut feel”. It is the intraday trading characteristics of a stock that assist a trader in determining the right strategy, whether to back off or be more aggressive.

i. Fat finger/faulty algorithms - Any flaw in algorithms can cause huge deviations from the healthy supply-demand arbitered prices

Algorithms react so quickly that by the time a human understands what is going wrong and pulls the plug, hundreds of millions of rupees can be lost. Below is a list of some Flash Crash Cases in India:

- Flash crash had occurred On BSE Muhurat Session in 2011. An algorithm that went into a loop kept entering repeat trades in the Sensex futures contract, resulting in trades worth ₹25,000 crore from one member in that session. All the trades in Sensex futures of that session had to be annulled.
- On April 21st, 2012, the Nifty April futures plunged to 5,000 from 5,300 levels with about 35,000 lots of Nifty futures getting traded in the space of a few minutes. The sharp drop in futures also dragged the underlying index, with the 50-share nifty declining from 5,313 to 5,245 within a few seconds. Nifty April futures finally closed at 5,304.8, down 0.96 per cent; while the benchmark Nifty closed at 5,290.85, down 0.78 per cent. According to market buzz, the sell order as placed due to an algorithmic trading error by a leading foreign institutional investor.
- In June 2010, the Reliance Industries stock had crashed nearly 20 per cent on execution of a large ‘sell’ order using algo. The order, which appeared to be a punching error, saw the Sensex plunge more than 600 points the moment it was executed.

1.5 CLASSIFICATION OF ALGORITHMS BASED ON LIFE-CYCLE STAGE

Algorithms are used extensively in various stages of the trading cycle. We can classify them into pre-trade analytics, execution stage, and post-trade analytics.

Pre-Trade Analytics

The Pre-trade analytics involve thorough analysis of historical data and current price and volume data to help clients determine where to send orders and when; whether to use algorithms or trade an order manually we can call this as back testing the algorithm etc.,. The pre-trade analysis is designed to help buy-side traders understand and minimize market impact by choosing the level of aggressiveness and a time horizon for trading various stocks. Traders can select varying levels of aggressiveness and visualize them against the time horizon for completing the trade. Most compare the spread between bid and ask prices, reference that against the volatility of a given stock, and attempt to create a range of potential outcomes. A lot of the broker-sponsored algorithmic trading systems attempt to measure or project the trade costs.

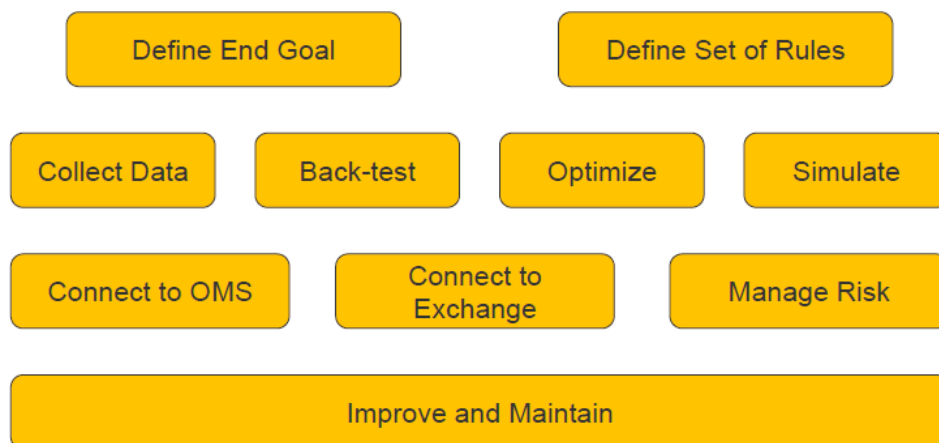
Execution

In the Execution stage, traders can create the lists of stocks, choose a particular strategy such as implementation shortfall and enter the start time and the end time. Traders can also monitor the performance and progress of the algorithms in real time and change the parameters if the stock is moving away. Additionally, users can filter portfolios by sector, market cap, exchange, basket, and percent of volume, profit and loss per share. Several brokers are designing algorithms that sweep crossing networks and so-called dark books liquidity pools that match buy and sell orders without publishing a quote.

Post-trade Analytics

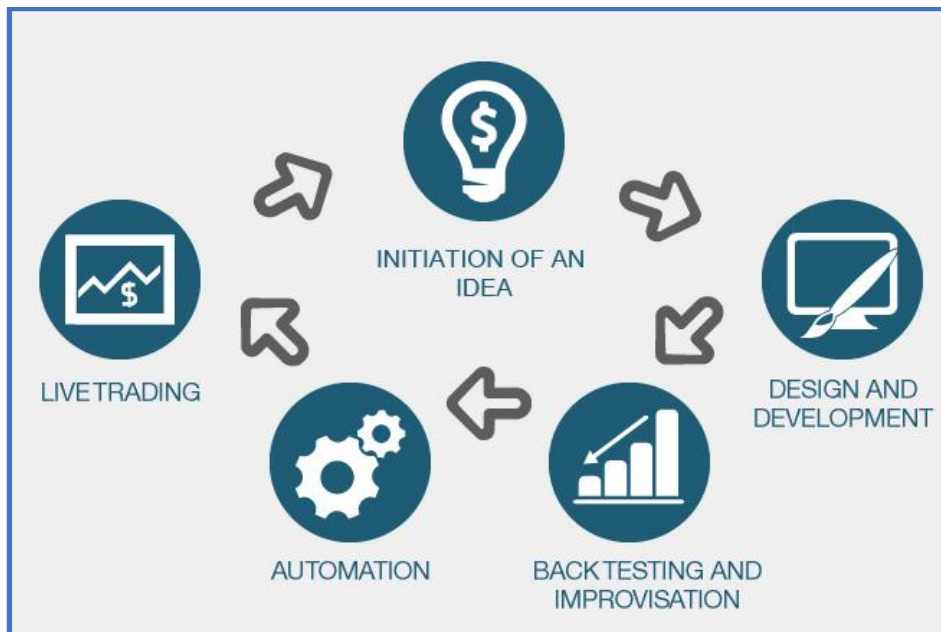
Post-trade analytics track commissions and assist in uncovering the costs involved from the time a trade is initiated all the way through to execution. Post-trade analytics are meant to improve execution quality and facilitate the making of investment decisions. The most prevalent trading benchmark in use today is VWAP, which is popular because it is easy to measure. Although it provides comparative results, it is not as useful for evaluating strategies that are trying to do something other than follow the market midpoint.

Following are the building blocks to creating algorithms:



1.6 LIFECYCLE OF AN ALGORITHM

Following is a typical life cycle of an algorithm:



How do you start with the implementation of algorithmic trading strategies?

1. Decide upon the genre/strategy paradigm

The first step is to decide the strategy paradigm. It can be Market Making, Arbitrage based, Alpha generating, Hedging or Execution based strategy. For this particular instance, let us choose pair trading which is a statistical arbitrage strategy that is market neutral (Beta neutral) and generates alpha, i.e. makes money irrespective of market movement.

2. Establish Statistical significance

You can decide on the actual securities you want to trade based on market view or through visual correlation (in the case of pair trading strategy). Establish if the strategy is statistically significant for the selected securities. For instance, in the case of pair trading, check for co-integration of the selected pairs.

3. Build Trading model

Now, code the logic based on which you want to generate buy/sell signals in your strategy. For pair trading check for “mean reversion”; calculate the z-score for the spread of the pair and generate buy/sell signals when you expect it to revert to mean. Decide on the “Stop Loss” and “Profit Taking” conditions.

- **Stop Loss**– A stop-loss order limits an investor’s loss on a position in a security. It fires an order to square off the existing long or short position to avoid further losses and helps to take emotion out of trading decisions.

- **Take Profit**– take-profit orders are used to automatically close out existing positions in order to lock in profits when there is a move in a favorable direction.

4. Quoting or Hitting strategy

It is very important to decide if the strategy will be “quoting” or “hitting”. Execution strategy to a great extent decides how aggressive or passive your strategy is going to be.

- **Quoting**– In pair trading you quote for one security and depending on if that position gets filled or not you send out the order for the other. In this case, the probability of getting a fill is lesser but you save bid-ask on one side.
- **Hitting**- In this case, you send out simultaneous market orders for both securities. The probability of getting a fill is higher but at the same time slippage is more and you pay bid-ask on both sides.

5. Backtesting & Optimization

How do you decide if the strategy you chose was good or bad? How do you judge your hypothesis?

This is where back-testing the strategy comes as an essential tool for estimation of the performance of the designed hypothesis based on historical data. A strategy can be considered to be good if the backtest results and performance statistics back the hypothesis.

Hence, it is important to choose historical data with a sufficient number of data points. This is to create a sufficient number of sample trades (at least 100+ trades) covering various market scenarios (bullish, bearish etc.). Ensure that you make provision for brokerage and slippage costs as well. This will get you more realistic results but you might still have to make some approximations while backtesting. For instance, while backtesting quoting strategies it is difficult to figure out when you get a fill. So, the common practice is to assume that the positions get filled with the last traded price.

What kind of tools should you go for, while backtesting?

Since backtesting for algorithmic trading strategies involves a huge amount of data, especially if you are going to use tick by tick data. So, you should go for tools which can handle such mammoth load of data.

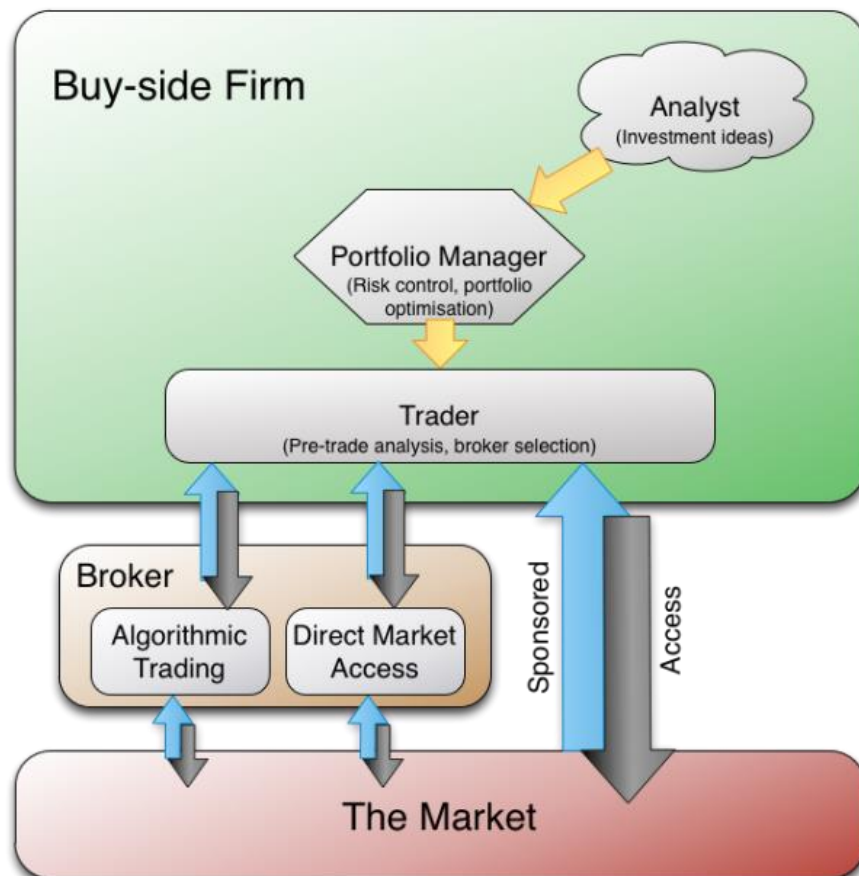
6. Risk and Performance Evaluation

No matter how confident you seem with your strategy or how successful it might turn out previously, you must go down and evaluate each and everything in detail. There are several parameters that you would need to monitor when analyzing a strategy’s performance and risk. Some important metrics/ratios are mentioned below:

- **Total Returns (CAGR)** - Compound Annual Growth Rate (CAGR). It is the mean annual growth rate of an investment over a specified period of time longer than one year.
- **Hit Ratio**- Order to trade ratio.
- **Average Profit per Trade**- Total profit divided by the total number of trades
- **Average Loss per trade**- Total loss divided by the total number of trades
- **Maximum Drawdown**– Maximum loss in any trade
- **Volatility of Returns**- Standard deviation of the “returns”
- **Sharpe Ratio**- Risk adjusted returns, i.e. excess returns (over risk free rate) per unit volatility or total risk.

1.7 WHAT ARE EXECUTION ALGORITHMS AND HOW ARE THEY DEVELOPED

- a) Algorithmic trading refers to trade execution strategies that are typically used by fund managers to buy or sell large amounts of assets.
- b) They aim to minimise the cost of these transactions under certain risk and timing constraints. Such systems follow preset rules in determining how to execute each order. These rules are pre-defined and coded in the form of algorithms and fed into a computer system.
- c) Algorithmic trading systems are offered by many brokers and simply execute the orders that they are given. Their job is to get a good price (as compared to various benchmarks) and minimise the impact of trading. This is done by slicing orders and dynamically reacting to market events.



Agency algorithms at I-Banks:

- All global I-bank have a desk in algorithmic trading
- Risk savvy banks -higher Prop focus E.g.: GS (US Banks)
- Risk averse banks -higher Agency focus E.g.: CS (EU Banks)

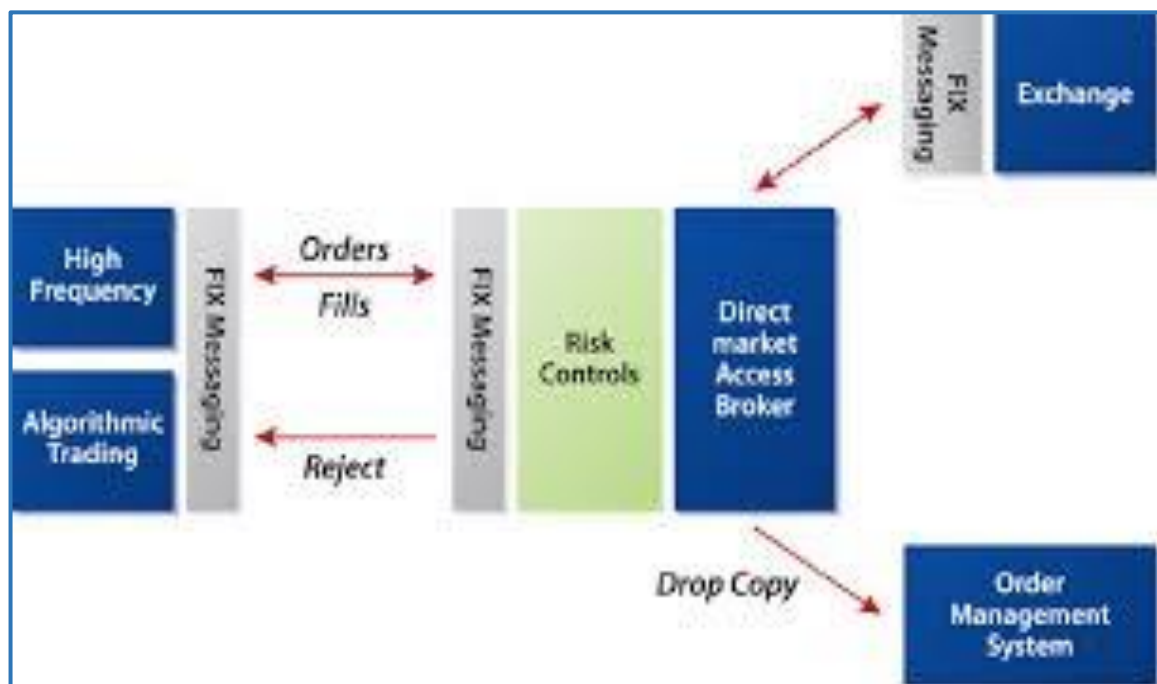
Table 1.1: Algo Products and Strategies

I-Banks	Products	Selected Strategies
BoA	Electronic Trading Services (ETS)	VWAP, TWAP, TVOL, Razor, Market on Close, Arrival Price, Market Call
Citigroup	Alternative Execution	VWAP, TWAP, MOC and Participation
CS	AES	Slippage from Arrival Price, Reducing market impact, VWAP and In Line with Volume
GS	GSAT	VWAP, Implementation Shortfall, Piccolo (Small Order Spread Capture algorithm) and TWAP.

I-Banks	Products	Selected Strategies
ITG	SmartServer	VWAP, TWAP, Implementation Shortfall (Decision Price) and Market Close
JPM	Electronic Execution Services	VWAP and Implementation Shortfall (Arrival Price, Close Price) and a 'trader pre-defined benchmark
ML	ML X-ACT	OPL (Optimal), QMOC, VWAP, CLOCK (a TWAP engine), POV (Percentage of Volume) and TWIN (trades two stocks based on a price per ratio or spread).

1.8 WHAT ARE HFT ALGORITHMS AND HOW ARE THEY DEVELOPED

- d) High-frequency trading (HFT) is a subset of automated trading. Here, opportunities are sought and taken advantage of on very small timescales from nanoseconds up to milliseconds.
- e) Some high-frequency strategies adopt a market maker type role, attempting to keep a relatively neutral position and providing liquidity (most of the time) while taking advantage of any price discrepancies.
- f) Other strategies invoke methods from time series analysis, machine learning and artificial intelligence to predict movements and isolate trends among the masses of data.
- g) Specifics of the strategy aside, for HFT, monitoring the overall inventory risk and incorporating this information into pricing/trading decisions is always vital.



Chapter-2

COMPOSITION OF ALGORITHMIC TRADING

2.1 COMPOSITION OF ALGO TRADING TAKING PLACE IN THE COUNTRY-
CLIENT OR PROPRIETARY

Client and proprietary contribution to turnover for all algorithmic orders across segments (CM, F&O and CDS) for the period FY 16-17 (Apr'16 to Feb'17) is provided below:

Table 2.1: Client and Proprietary Contribution to Algo Turnover

Category	% to Exchange Algo Turnover
Client	58%
Proprietary	42%

Notes:

1. In case of options, premium turnover is considered in F&O and CD segment.
2. Algorithmic order is identified based on identification code as provided by the trading member.
3. Proprietary account is identified where the member code is equal to client code.



Both Client and Prop orders are received from Algo/HFT. The composition of the same for FY 2016 till now is a given in the below table.

Table 2.2: Composition of Client Proprietary Orders from Algo/HFT

SEGMENT	PROPERIOTRY %	CLIENT %
EQUITY	34.00	66.00
EQUITY DERIVATIVES	76.05	23.95
CURRENCY DERIVATIVES	63.38	36.62
INTEREST RATE DERIVATIVES	32.97	67.03

2.2 CURRENTLY REGISTERED ALGORITHM TRADING PLAYERS



- A) Currently, there are 251 trading members as on February 2017 registered for Algo trading with the Exchange.
- B) 233 trading members are active.

Note: Trading members with at least one trade during the period from Dec 2016 to Feb 2017 in Capital Market (CM) or Futures and Options (F&O) or Currency Derivatives (CD) segment have been considered as active.

As on Feb 28, 2017, 141 trading members have taken approvals for Algo Trading facility out of which 35% i.e. 52 trading members are active.

2.3 TOP 20 ALGO PARTICIPANTS AND THEIR DAILY TURNOVER



Top 20 participants (trading members) ranked based on algorithmic trading turnover irrespective of colocation or non-colocation across segments (CM, F&O and CDS) for the period FY 16-17 (Apr'16 to Feb'17) and their contribution to total Exchange turnover is provided below:

Table 2.3: Top 20 participants ranked based on Algorithmic Trading Turnover

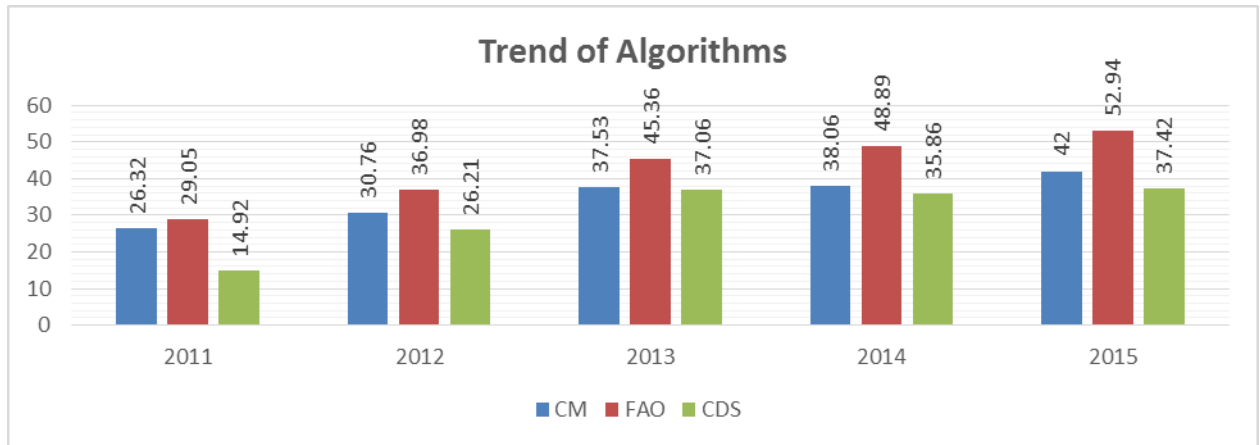
Participants Rank (Basis Algo Turnover)	% Contribution to Exchange Turnover
1	6.02%
2	4.37%
3	2.14%
4	1.80%
5	1.66%
6	1.43%
7	1.37%
8	1.19%
9	1.17%
10	1.11%
11	1.07%
12	1.06%
13	0.97%
14	0.95%
15	0.92%
16	0.85%
17	0.78%
18	0.69%
19	0.67%
20	0.64%
TOTAL	30.86%

Notes:

1. In case of options, premium turnover is considered in F&O and CD segment.
2. Algorithmic order is identified based on identification code as provided by the trading member.

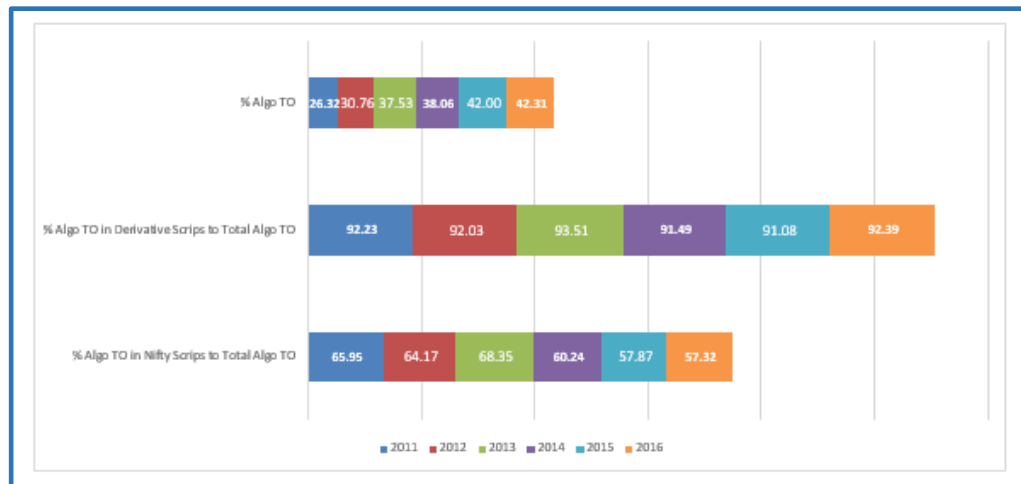
2.4 ALGORITHMIC TRADING TRENDS AND THE EXTENT TAKING PLACE IN INDIAN MARKETS VIS-À-VIS GLOBAL MARKETS

- After the initial spurt the share of Algorithmic trading to Exchange turnover has stabilised around 47% in India across cash and derivatives segment on NSE.

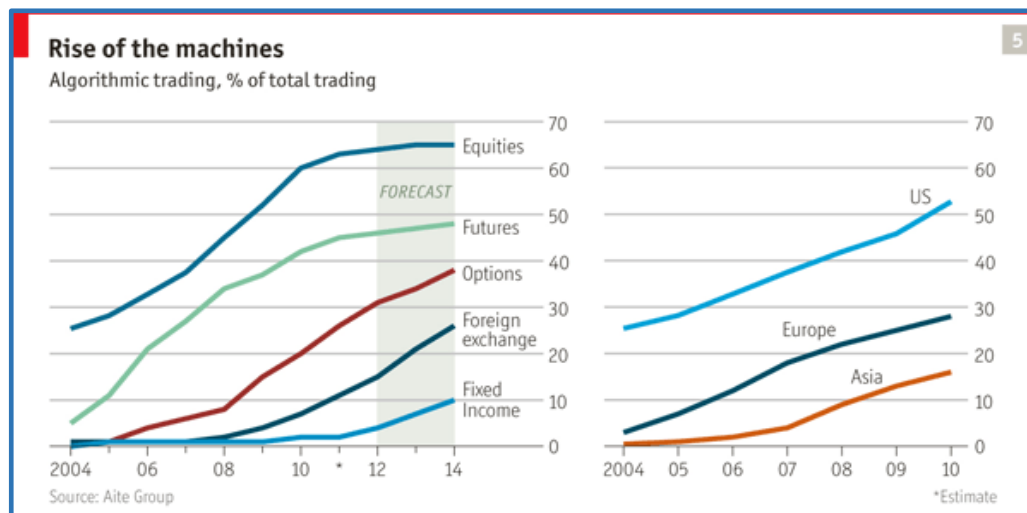


Source: NSE

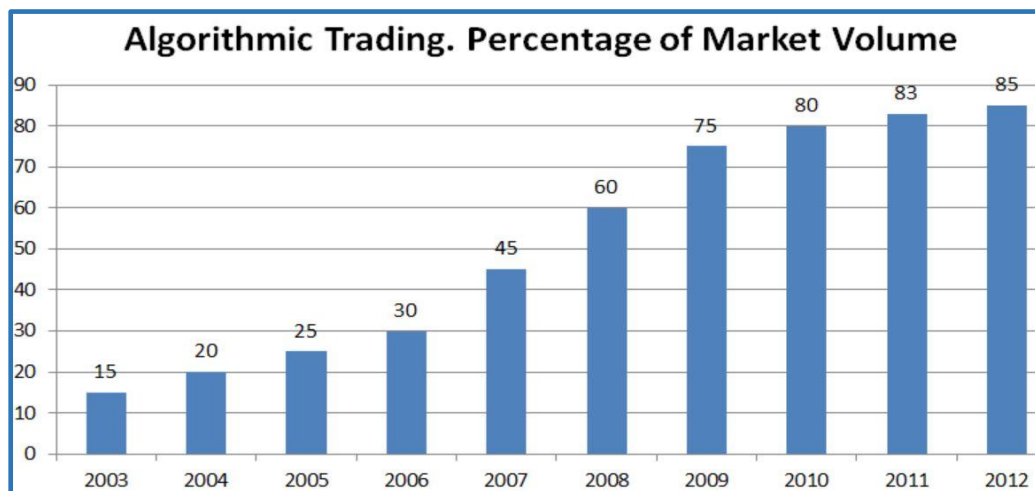
- As can be observed from below, majority of the trading activity of algo players is only in liquid scrips/contracts



- In developed markets such as US, it stands at approximately 70 - 80%.

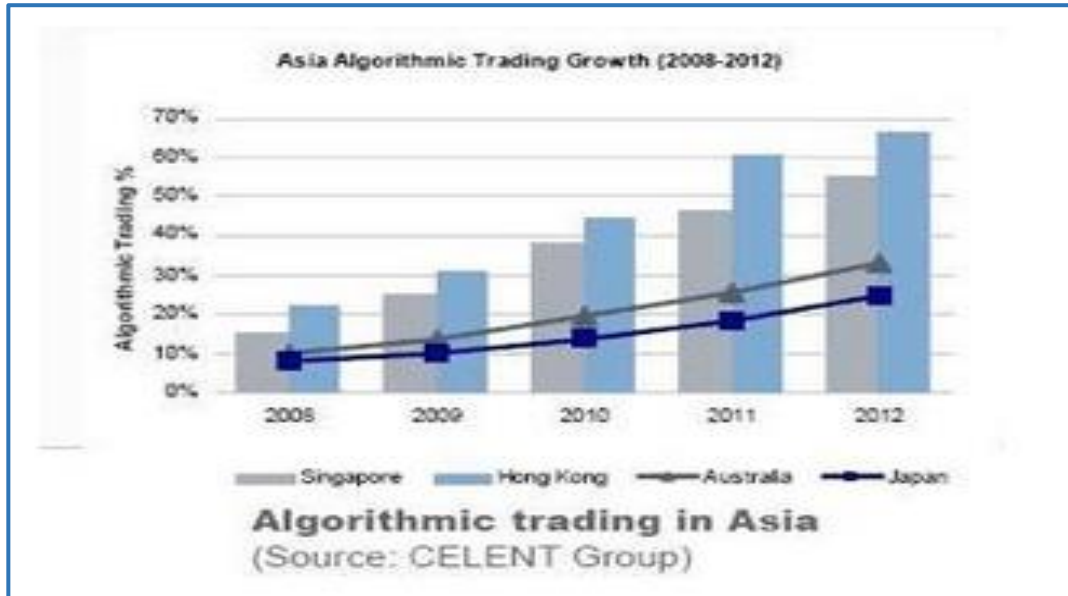


US Equity Markets



Source: Morton Glantz, Robert Kissell. Multi-Asset Risk Modeling: Techniques for a Global Economy in an Electronic and Algorithmic Trading Era.

Asian Markets



2.5 COMPARISON OF INDIAN MARKETS VIS-À-VIS GLOBAL MARKETS

Global Markets	Indian Markets
Exchanges, Alternate Trading Systems, Dark Pools	Registered Exchanges
Internalizing, Preferencing, Routing	Price Time Priority Retail Clients about 93% orders limited orders
Orders to pass through member risk management system	All orders pass through the member order level risk management systems
Complex web of interconnectivity amongst multiple venues (40 plus)	Only two Stock Exchanges
Market Data only through vendors	Market Data free for all members and its investors
Payment for order flow	All orders pass through member order level risk management systems
Maker Taker Pricing	No such facility
Broker Conflicts	Servers hosted in India. Audit trail for all orders generated by Algo

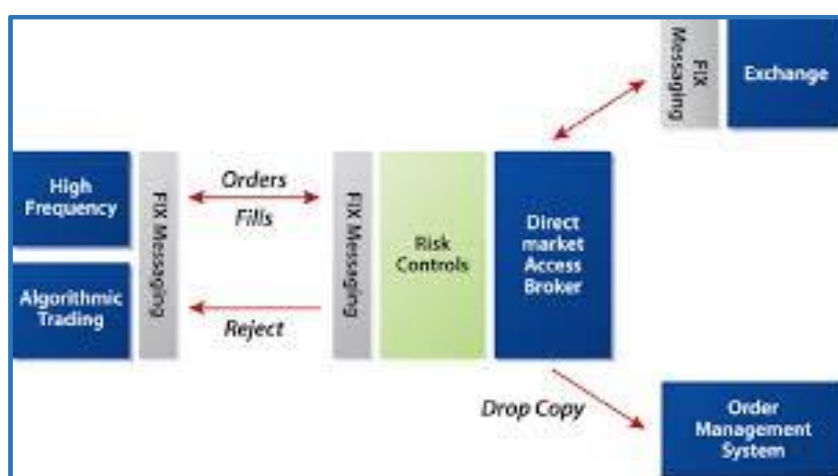


Chapter-3

HIGH FREQUENCY TRADING (HFT)

3.1 INTRODUCTION TO HFT ALGORITHMS

- High-frequency trading (HFT) is a subset of automated trading. Here, opportunities are sought and taken advantage of on very small timescales from nanoseconds up to milliseconds.
- Some high-frequency strategies adopt a market maker type role, attempting to keep a relatively neutral position and proving liquidity (most of the time) while taking advantage of any price discrepancies.
- Other strategies invoke methods from time series analysis, machine learning and artificial intelligence to predict movements and isolate trends among the masses of data.
- Specifics of the strategy aside, for HFT, monitoring the overall inventory risk and incorporating this information into pricing/trading decisions is always vital.



3.2 BENEFITS OF HFT

a) Lower Costs (lower bid-ask spreads)

Technological innovation, together with financial deregulation, has led to a long-term decline in trading costs in many financial markets and these benefits have been shared by both financial intermediaries and consumers of financial services.

The benefits of automation are not confined to trade execution. Back-office functions and post-trade services such as clearing and settlement have also benefited from automation.

The ability to submit orders electronically to exchanges directly rather than through brokers has been an important innovation in lowering the cost of trading.

Market Evidence

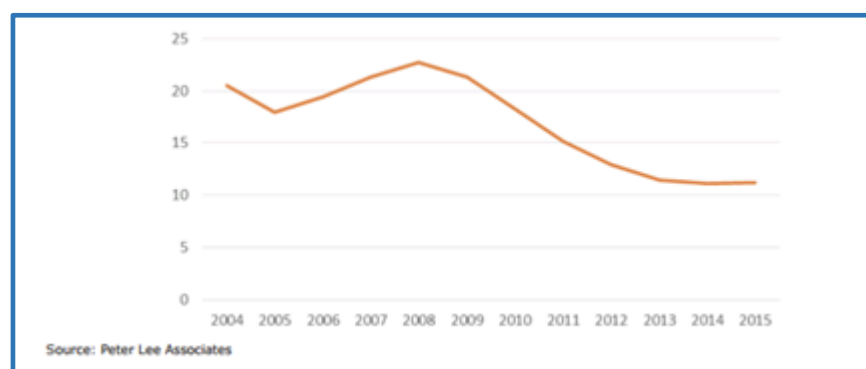
- In the US, equity market quality and liquidity have improved alongside the rise of electronic trading on a wide-range of measures. With HFT accounting for as much as 70% of US equity market turnover, the US also enjoys the world's lowest institutional trading costs for large cap stocks.
- In Australian equity markets, institutional brokerage and transaction costs have been on a declining trend in recent years, consistent with overseas trends. Below diagram

shows average commission and implementation shortfall (the difference between arrival and execution prices) in Australian equity markets measured in basis points as compiled by ITG, an independent broker-dealer.

- iii. A similar level and trend for implied institutional commission rates is evident in a survey of Australian fund managers by Peter Lee Associates (see below diagram). While the commissions and other transaction costs paid by Australian fund managers are influenced by a range of factors apart from the growth in HFT, the declining trend in these costs is consistent with the view that HFT lowers costs for investors.



Institutional Transaction Costs-Australia Basis Points



Average Commission/Average Portfolio Size Basis Points

b) Increased Liquidity

HFT provides liquidity in markets, which is essential to their functioning. Liquidity can be defined as the ease with which market participants can buy or sell financial instruments or securities. It is usually measured by reference to the spread between buying and selling prices, although measures of market depth (the volume of a security on bid or offer), the time taken to complete a trade (immediacy), total turnover and turnover ratios are also relevant measures of market liquidity. By adding to market liquidity, HFT narrows buy-sell spreads and lowers the cost of trading. HFT has also been important in driving reductions in tick sizes, which facilitates the narrowing in spreads.

HFT imposes a positive externality on market participants, because HFT firms do not fully capture all of the benefits of HFT in lowering trading costs for other market participants, nor do they fully capture the social value of the information generated through price discovery in financial markets.

c) Increased Efficiency

By lowering transaction costs, HFT improves the efficiency of markets. The main function of financial markets is price discovery, which in turn coordinates the economy-wide capital allocation process. The efficiency of financial markets can be defined as the speed with which markets incorporate new information in asset prices. The increased velocity of trading through HFT ensures that market prices reflect new information more quickly. Much of the innovation in financial markets historically has been driven by the desire to profit from bringing information to market more quickly.

d) Higher Returns for Investors

Transaction costs subtract from returns to investors. Lowering transaction costs raises returns to investors and thus asset prices. It follows that any permanent reduction in transaction costs through innovations such as HFT will lead to a permanent increase in asset prices and a positive wealth effect from the increased value of investors' portfolios.

e) Lower Cost of Capital

Higher asset prices also lower the cost of capital for firms, increasing investment, the capital stock, productivity, real wages and living standards. It is said, 'this is the main channel by which HFT can have societal value.'

f) Profitability and Market Efficiency

As financial markets become more efficient, the profitable trading opportunities available to HFT firms are reduced. As in any other industry, the competitive entry of HFT firms exploiting new technologies can be expected to reduce profits available to HFT and algorithmic trading over time. At some point, the marginal cost of deploying new HFT technologies will exceed the marginal benefit available from HFT-based trading strategies. Trends in the profitability of HFT firms may be indicative of the efficiency of financial markets.

g) Lower Volatility

Empirical evidence overwhelmingly supports the conclusion that HFT enhances market quality and reduces market volatility. HFT smooths market prices by trading against transitory price changes and in the direction of permanent price changes. There is also evidence that HFT reduces the probability of end-of-day price or market manipulation. These are all natural consequences of the role of HFT in improving market liquidity and efficiency.

3.3 DEMERITS OF HFT

HFT Impact on Retail Investors and Small Traders

a) HFT is playing against investors who are willing to invest fundamentally

Many HFT algorithms are based on finding a broker which is starting to purchase shares, then utilizing the fact that HFT Company has quicker links to other brokers - promptly buy available shares from that broker, and re-sell them to the one willing to buy at higher price. This is making the market less attractive to fundamental investors. It is a kind of a hidden tax for fundamental players. However this 'con' is smaller than it used to be because the majority of HFT transactions are done against other HFT's.

b) HFT firms leverage special services such as co-location facilities and raw data feeds

These facilities are typically not accessible to smaller firms and retail investors as they are not able to make the required investments. This places these smaller firms and investors at a disadvantage as they cannot afford these facilities.

c) Some HFT firms often enter trades just for the liquidity rebate

In rebate trading, instead of trader paying the commission for buying and selling, he is being paid by the service provider. ECN (Electronic Communication Network) rebate is the primary source of profit. This adds no value to the retail or long-term investor

d) Short term investors' end up paying higher price

Both traders and short-term investors who invariably whirl in and out of financial securities are victimized in that they end up paying a higher price over a short window or limited time for what they buy. However for long term investors, the impact is much less and not as dramatic on their total returns since they don't depend on quick returns.

e) HFT firms gather certain market information faster

Some analysts believe the fact that HFT firms are often able to gather certain market information and execute trades faster than other participants puts the overall fairness and integrity of the markets at risk.

3.4 HFT IMPACT ON INSTITUTIONAL INVESTORS

a. High-frequency traders detect and front-run large orders by institutional investors

This is a practice that pushes the stock price up (down) if institutional investors have large buy (sell) orders (i.e. upon detecting an incoming order flow, after which the HFT system buys the same security and then turns around and sells it to the institution at a slightly higher price) thereby also increasing stock price volatility.

b. HFT leverage services such as Colocation

HFT firms co-locate their computers physically close to the exchanges' computers to gain millisecond speed advantages, so they can beat slower orders from buy-side institutional investors to the quote. In some cases, HFT firms even co-locate their computers in the same room as an exchange's computers

c. Impact on Shortfall

Shortfall is the difference between the prevailing price or value when a buy or sell decision is made with regard to a security and the final execution price or value after taking into consideration all commissions, fees and taxes. As such, implementation shortfall is the sum of execution costs and the opportunity cost incurred in case of adverse market movement between the time of the trading decision and order execution.

Market Evidence

A paper published by Professor Lin Tong "A blessing or a curse? The impact of High Frequency Trading on Institutional Investors" (2015) (attached below) suggests that high frequency trading often has a negative effect on institutional trading. His findings are as follows:

- HFT activity is positively correlated with execution shortfall
- When HFT activity is more intense, institutional investors' execution shortfall is higher.
- The increasing effect of HFT activity on execution shortfall is stronger on smaller stocks.
- When HF traders on the net are buying (selling), it is more costly for institutional investors to sell (buy).
- Even though HFT activity increases institutional investors' execution shortfall, it does not provide the benefit of reduced timing delay cost.

Research Paper



lin_tong HFT on
institutional investors

d. Mutual funds are worst hit

Mutual funds (mostly active funds) that do a lot of large block trading and tend to trade urgently or predictably are worst hit. Since mutual funds trade in large quantities, there are possibilities where other HFT algorithms sniff these large orders and capitalize on this information, thus front-running large orders and manipulating markets in the process.

e. HFT strategies use the order flow entering the market to extract profits, whereas institutional investors use fundamental information to extract profits

HFTs profit from the order flow information arriving from the institutional investors. Essentially, HFTs are skimming cream off the top of an institutional investor's fundamental analysis, but they win regardless of whether the institutional investor's analysis was correct or not.

f. HFT hinders the market's ability to incorporate news about a firm's fundamentals into asset prices

Market Evidence

Froot, Scharfstein, and Stein (1992) Research Paper: "Herd on the Street: Informational Inefficiencies in a Market with Short-Term Speculation" (attached below)

Using analyst forecast revisions and earnings surprises as proxies for news about firm fundamentals; it is found that stock prices react more strongly to news about fundamentals when HFT is at a high volume. However, the incremental price reactions due to HFT are almost entirely reversed in the subsequent period. Taken together, the evidence suggests that HFT exaggerates otherwise-sound price reaction. The price swings introduced by HFT also represent direct evidence that HFT increases stock price volatility.

Research Paper:



herd_on_the_street
_froot scharfstein.pdf

- g. HFT firms are often able to gather certain market information and execute trades faster**

This puts other participants at a disadvantage and the overall fairness and integrity of the markets at risk.

- h. Increasing cost of Transaction**

The temporary price impact of large trades causes noise in prices due to price pressure arising from liquidity demand by long-term investors. If HFTs trade against this transitory pricing error, they can be viewed as reducing long-term investors' trading costs.

However, if HFTs trade in the direction of the pricing error, they can be viewed as increasing the costs to those investors. HFTs trading in the direction of pricing errors could arise from risk management, predatory trading, or attempts to manipulate prices while HFTs following various arbitrage strategies could lead to HFTs trading in the opposite direction of pricing error

3.5 HFT IMPACT ON VOLATILITY

- a. HFT is positively correlated with stock price volatility after controlling for the volatility of a stock's fundamentals and other volatility drivers.**

There seems to be a positive correlation between HFT and volatility that grows stronger during periods of high market uncertainty. Hence, a certain section of the market believes that HFT increases volatility.

Evidence: Research Paper by Zhang (2010) on The Effect of High-Frequency Trading on Stock Volatility and Price Discovery (research paper attached below)

Study shows that this positive correlation is especially strong for the top 3,000 stocks in market capitalization and for stocks with high institutional holdings. The positive correlation between HFT and volatility is also stronger during periods of high market uncertainty. Taken together, the results are consistent with the view that HFT increases volatility

Research Paper:



Zhang effect of hft
on volatility.pdf

b. HFT hinders price discovery

HFT causes stock prices to overreact to news about company fundamentals. The incremental price changes due to HFT are almost entirely reversed in the subsequent periods. Thus, HFT algorithms could cause erratic movements in markets, thus hindering price discovery.

c. HFT can give rise to price fluctuations and short term volatility

HFT involves rapid intraday trading with positions generally held only for minutes—or even just seconds. Given that HFT volumes are normally a relatively high percentage of overall trading; the price fluctuations caused by this strategy can lead to overall volatility in the market.

Also, the practice of making trades and instantly cancelling them only to trigger automated buying from other firms is an ethical issue that has been questioned by many analysts.

- **HFT algorithms have made certain market related jobs redundant**

High frequency trading has displaced many of the traditional market makers whose job it was to keep an orderly market, and who were required to step in and provide a backstop during volatile periods.

- **The odds of a sudden liquidity drain go up**

HFT firms are under no obligation and can enter or leave the market unbelievably fast, the odds of a sudden liquidity drain go way up.

Market Evidence:

This is what we witnessed during the **flash crash in US markets on May 6, 2010**. One mutual fund firm entered an ETF order incorrectly, and in a matter of minutes that information had flashed across the market and without human intervention, liquidity was instantly pulled. Some stocks were left with no bids at all and traded at \$0.01. The market recovered later in the day, but the damage was done.

Partly in response to these calamities, regulators have introduced **circuit breakers** into the market that automatically halt trading if a stock moves more than a certain amount. The hope is that these algorithmic halts will give human traders time to intervene and prevent widespread disruption.

- **Fat finger/faulty algorithms - Any flaw in algorithms can cause huge deviations from the healthy supply-demand arbitered prices**

In a real market instance of machines running amok, on **August 1st, 2012 Knight Capital** mistakenly put a trading algorithm meant for development into the US markets and in a matter of an hour or two the system had racked up so many losing trades that the company almost went bankrupt. These programs react so quickly that by the time a human understands what is going wrong and pulls the plug, hundreds of millions of dollars can be lost.

Flash Crash Cases in India

Flash crash had occurred On BSE Muhurat Session in 2011. An algorithm that went into a loop kept entering repeat trades in the Sensex futures contract, resulting in trades worth ₹25,000

crore from one member in that session. All the trades in Sensex futures of that session had to be annulled.

On April 21st, 2012, the Nifty April futures plunged to 5,000 from 5,300 levels with about 35,000 lots of Nifty futures getting traded in the space of a few minutes. The sharp drop in futures also dragged the underlying index, with the 50-share nifty declining from 5,313 to 5,245 within a few seconds. Nifty April futures finally closed at 5,304.8, down 0.96 per cent; while the benchmark Nifty closed at 5,290.85, down 0.78 per cent. According to market buzz, the sell order as placed due to an algorithmic trading error by a leading foreign institutional investor.

In June 2010, the Reliance Industries stock had crashed nearly 20 per cent on execution of a large 'sell' order using algo. The order, which appeared to be a punching error, saw the Sensex plunge more than 600 points the moment it was executed.

3.6 MISUSING HFT FOR MARKET MANIPULATION

Harmful HFT Algorithms that might cause market disruption such as high Intra-Day volatility and high Order-to-Trade Ratio.

A lot of academic research has happened on algorithmic trading. Some of the inferences from the research paper are given below:-

- a) Susan Thomas and Nidhi Agarwal from IGIDR have attempted to study the impact of algorithmic trading on market quality and has published their research paper titled "The causal impact of algorithmic trading on market". Their findings suggest that algorithmic trading improves market quality. There are improvements in transactions costs, volatility, and buy-sell imbalance. There are improvements in some, but not all of the depth measures and these are sensitive to the match design. Two areas where the results provide new insights are the intraday volatility of liquidity and the probability of extreme price movements and reversal over a very small period during the day, often referred to as a flash crash. Policy makers have been very concerned that liquidity provided by algorithmic trading can rapidly deteriorate when news breaks. Their results show that the liquidity risk is lower with more algorithmic trading. A similar concern has often been voiced about the probability of a flash crash. However, they found that higher algorithmic trading intensity either leads to fewer of such episodes or has no effect. They have concluded by inferring that there are more benefits than costs to securities that attract higher algorithmic trading activity. With proper safeguards in place, more meaningful policy measures could be built to increase the level of algorithmic trading to a broader base of securities, rather than inhibit it.
- b) In another research paper titled "How do High-Frequency Traders Trade?" By Nupur Pavan Bang and Ramabhadran S. Thirumalai (ISB) have tried to examine the order handling and trading behavior of high-frequency traders (HFTs) around firm specific earnings surprises as well as unexpected interest rate changes. In this paper they have observed that high frequency traders do not significantly change their order handling and trading behavior around earnings surprises but do reduce their participation in the market after a macroeconomic shocks. High frequency traders also do not change the mix of order types that they use around earnings surprises, although they appear to increase the number of liquidity-demanding orders. They use fewer aggressively priced limit orders around macroeconomic shocks. The profitability of their orders does not change around earnings announcements. However, despite reducing their market participation after a macroeconomic shock, they still make losses to informed traders.

The research work also tried to examine the trading behavior of buy-side algo. They observed an increase in their market participation around earnings surprises and do not change it around macroeconomic surprises.

- c) Austin Gerig From Division of Economic and Risk Analysis U.S. Securities and Exchange

Commission has published a paper titled “High-Frequency Trading Synchronizes Prices in Financial Markets”. The paper has inferred that high frequency trading facilitates information transfer between investors, which increases the accuracy of prices and redistributes profits from informed individuals to average investors by reducing transaction costs.

- d) European Central Bank has published a working paper titled “High Frequency Trading and Price Discovery”. The paper in its concluding remarks have stated that high frequency trading increase the efficiency of prices by trading in the direction of permanent price changes and in the opposite direction of transitory pricing errors. Their results also show no direct evidence that high frequency traders contribute directly to market instability in prices.

3.7 MARKET MANIPULATION TECHNIQUES USING HFT

I. QUOTE STUFFING

Quote stuffing is a practice where a large number of orders to buy or sell securities are placed and then cancelled almost immediately. It is estimated that the majority of Quote stuffing episodes last up to 2 seconds (as per research by Tse, Lin, and Vincent (2012))

Quote stuffing is easily observed via several characteristic patterns of quote volatility which may occur on the Ask, the Bid or both simultaneously. Empirically, Quote Stuffing is observed as having some influence on the direction of price moves immediately following an episode with prices seen as more likely to move in the direction of the stuffing.

Evidence 1

Research Paper by Egginton and Van Ness (2011) “Quote Stuffing” examines the impact of intense episodic spikes in quoting activity (frequently referred to as quote stuffing) on market conditions. It is found that that quote stuffing is pervasive and that over 74% of US exchange listed securities experience at least one episode during 2010.

It is also found that **stocks experience decreased liquidity, higher trading costs, and increased short term volatility** during periods of intense quoting activity. Also the most quote stuffing events occur on the NYSE, ARCA, NASDAQ and BATS.

Research Paper:



quote-stuffing.pdf

Evidence 2

(Using Research Paper-High Frequency Trading – Measurement, Detection and Response by Tse , Lin and Vincent(2012))

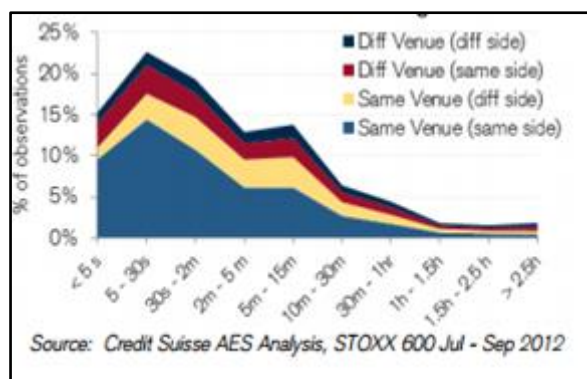
Tse, Lin, and Vincent (2012) note that during quote stuffing events, **the trade prices tend to move in the direction of the stuffing activity** i.e. increase when stuffing occurs on the ask side or decline when it is happening on the bid side.

On average, the price tends to move toward quote stuffing after the event (i.e. the mid-price moves up if quote stuffing occurred on the offer). This holds whether the affected quote finished “ticked in” – narrower than the initial spread – or “ticked out”, but is more pronounced when finishing “ticked in” (see below diagram). However, these moves tend to be very small (< 0.23bps).



Average Mid-price move toward quote stuffing (5 seconds post event)

A stock which has already experienced quote stuffing has a higher probability of further activity on that same day, with an 82.3% chance of a “repeat” event. The second event occurs on the same venue 73% of the time, and over 70% of “repeats” occur within 5 minutes (see below diagram)



Time between Quote Stuffing Events

II. LAYERING

i. Layering in Stock Trading:

This is a scheme used by securities traders to manipulate the price of a stock ahead of transactions that they wish to execute, creating more advantageous executions for them. It is a variety of a stratagem that has come to be called spoofing, itself an element of high frequency trading.

Through layering, a trader tries to fool other traders and investors into thinking that significant buying or selling pressure is mounting on a given security, with the intent of causing its price to rise or fall.

The trader does this by entering multiple orders that he has no intention of executing, but instead plans to cancel.

Buying Example: A trader is looking to buy 1,000 shares of XYZ stock, which is trading at \$20.00 per share. In hopes of pushing its price down, he enters 4 large orders to sell:

10,000 shares	\$20.05 per share
10,000 shares	\$20.10 per share
10,000 shares	\$20.15 per share
10,000 shares	\$20.20 per share

The trader has layered these sell orders at incrementally higher prices above the current market price. Thus, they will not execute unless the current market price moves upward. The trader intends to make other market participants believe that selling pressure is mounting among holders of XYZ stock, and that the price thus is bound to fall below \$20.00 per share.

Intention: If the scheme works, other traders eager to sell will enter orders below \$20.00, anticipating that those orders to sell 40,000 shares soon will be re-entered at even lower prices.

The trader then will be able to purchase 1,000 shares of XYZ at less than \$20.00 per share, and cancel those layered sell orders.

Risks Involved: The trader runs a risk that orders to buy XYZ will intervene, instead pushing the price above \$20.00 per share. In this case, the trader will have to deliver up to 40,000 shares to buyers, shares that he might have to obtain at yet higher prices, incurring a large loss in the process.

ii. Regulatory Response

The Dodd-Frank Financial Reform Bill of 2010 made all forms of spoofing illegal in the United States. Under its provisions, for example, the U.S. Justice Department charged a U.K.-based day trader with illegal actions that allegedly caused the May 6, 2010 “Flash Crash” in which stock market prices plummeted suddenly.

Meanwhile, the SEC has taken enforcement actions against traders and firms who engaged in spoofing and layering even prior to the passage of Dodd-Frank.

iii. Market Evidence

(Using Research Paper-High Frequency Trading – Measurement, Detection and Response by Tse, Lin and Vincent (2012))

Below exhibit shows a real example where a trade of 100@29.13 in Legrand SA on Euronext Paris lead to the 1200 shares at 29.135 being cancelled within milliseconds. This behaviour can impact performance and fill rates, particularly for aggressive trading that targets multiple levels of displayed liquidity.



Price Fade Example, Legrand SA (Paris) September 21st, 2012

III. MOMENTUM IGNITION

Introduction

Momentum Ignition is an HFT strategy that is characterized by a specific pattern observed in both trade prices and trade volumes. This usually comprises three main stages:

- An initial spike in trade volume, which is not accompanied by any significant changes in price.
- A subsequent sharp price move (positive or negative), accompanied by a new, even larger increase in volume
- A gradual price reversal to levels observed before the event, accompanied by low volume.

This pattern is observed over significantly longer time frames than Quote Stuffing, and may last for up to several minutes.

Evidence

Evidence 1 (using Research Paper-High Frequency Trading – Measurement, Detection and Response by Tse , Lin and Vincent(2012))

Momentum ignition does not occur in the blink of an eye, but its perpetrators benefit from an ultra-fast reaction time. Generally, the instigator takes a pre-position; instigates other market participants to trade aggressively in response, causing a price move; then trades out. Momentum ignition is identified with a combination of factors, targeting volume spikes and outsized price moves - see below exhibit for an example of this pattern in Daimler on 13th July, 2012:

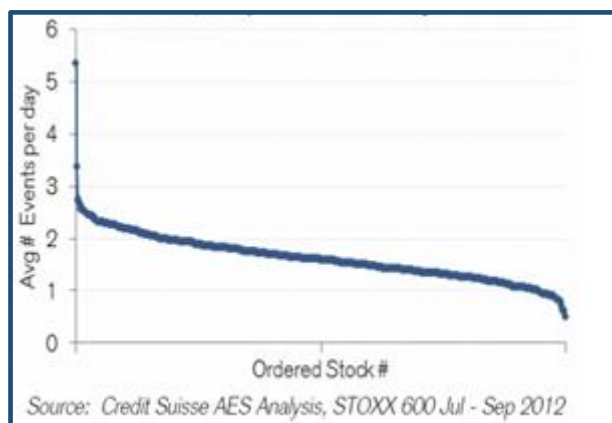


Daimler AG, 13th July, 2012

Though one cannot conclusively determine the intention behind every trade, this is the kind of pattern one would expect to emerge from momentum ignition. This can be used as a proxy to estimate the likelihood and frequency of these events.

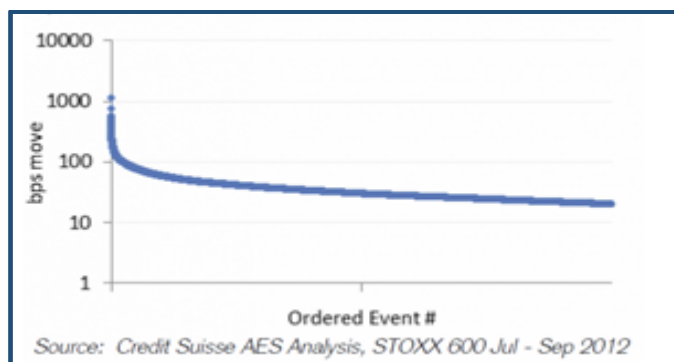
Likelihood and Rapid Price Moves

As shown in below figure, it is estimated that momentum ignition occurred on average 1.6 times per stock per day for STOXX 600 names in Q3 2012, with almost every stock in the STOXX600 exhibiting this pattern on average once a day or more.

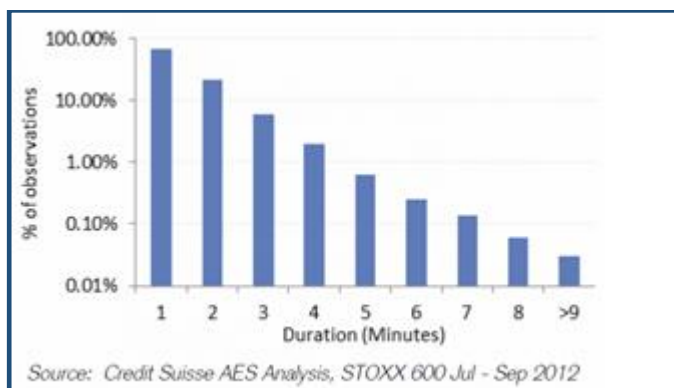


Frequency of Momentum Ignition Patterns

In addition, it is noted that the average price move is 38bps (but over 5% are more than 75bps, with some significantly higher – see below Exhibit), and the time it takes for that move to occur is approximately 1.5 minutes (see below exhibit).



Price Move Distribution (Post Momentum Ignition Pattern)



Duration Distribution (Momentum Ignition Patterns)

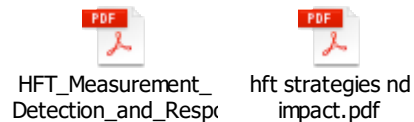
While 38bps may not sound like a big move, it is a bit more significant when compared to the average duration of these events (1.5 minutes) and the average spread on the STOXX600 (approximately 8bps).

Though not all momentum ignition events result in massive price moves, those that do can cause significant impact. Percentage of volume orders that would normally execute over hours may complete in minutes on the back of “false” volume (one of the causes of the 2010 flash crash was a straightforward percentage of volume order).

Sources:

1. An Empirical detection of High Frequency Trading strategies by Dimitar Bogoev1 and Arz'e Karam of Durham University
2. High Frequency Trading – Measurement, Detection and Response by Tse , Lin and Vincent(2012)

Research Papers:



IV. LIQUIDITY REBATE TRADING

Introduction

Certain exchanges and ECNs offer traders a rebate for providing the markets with shares, or liquidity, when there is a need for it. They generally pay traders to buy at the bid price and sell at the ask price, thereby providing liquidity, and charge traders for placing market orders.

Liquidity rebate traders look for large orders, fill a part of that order, and then offer these shares back to the market by placing a limit order, which makes them eligible to collect the rebate fee for providing liquidity, with or without them making a capital gain.

Research Papers:





Chapter-4

CO-LOCATION

4.1 WHAT IS CO-LOCATION

In a sign of the rush for speed in trading, exchanges are building huge data centres where traders, members and non-members alike, can place computers containing their trading algorithms next to an exchange's matching engine, which matches "buy" and "sell" orders. This "co-location" shaves crucial milliseconds from the time it takes to complete a trade.

Basically, colocation is locating computers owned by HFT firms and proprietary traders in the same premises where an exchange's computer servers are housed. This enables HFT firms to access stock prices a split second before the rest of the investing public.

If traders are located 100 miles away from an exchange, they face a delay of one millisecond whenever they seek to trade a price via their computer screen. Few serious investors can afford to be that late to prices that flash so quickly. Many HFT traders now operate in the smaller realm of microseconds.

Co-location has become a lucrative business for exchanges, which charge HFT firms by rack space for the privilege of "low latency access."

4.2 ADVANTAGES OF CO-LOCATION

a. **Co-location reduces latency**

Latency is the time it takes to make and execute trading decisions and therefore enables co-located market-maker high-frequency traders to more rapidly adjust their quotes as market conditions change.

b. **Levels the playing field among competing HFT market makers**

It also levels the playing field among competing HFT market makers who are also co-located by ensuring that none has a latency advantage over the other from an exchange perspective.

c. **Increases Liquidity**

The introduction of co-location facilities is expected to increase liquidity by encouraging HFT and increasing competition among HFT market makers.

Market Evidence

The ASX introduced co-location for ASX futures markets on February 20, 2012. As per the research paper by Frino Mollica Webb (2013) "The Impact of Co-Location of Securities Exchanges' and Traders' Computer Servers on Market Liquidity", (attached below) there is evidence of an **increase in HFT activity** following the introduction of colocation.

There is also strong evidence of a **decrease in bid-ask spreads and an increase in market depth** following the introduction of colocation, across all futures contracts examined. It is also proved that the introduction of colocation resulted in an **improvement in liquidity** of futures contracts.

Research Paper:



Co-Location_impact_
_Securities_Exchange

4.3 DISADVANTAGES OF CO-LOCATION

a. **Expensive**

Colocation services can prove to be extremely expensive, especially if the HFT algorithms work across multiple exchanges or locations

b. **Market Inequity**

HFT firms leverage special services such as **co-location** facilities, which are typically not accessible for smaller firms and retail investors as they are not able to make the required investments. This causes inequity and a huge disadvantage to smaller traders/retail investors.

4.4 CO-LOCATION FACILITIES IN INDIA

India boasts of the fastest colocation in the world. BSE is the fastest Exchange in the world with a speed of 6 microseconds. Market access across Equity, Equity Derivatives and Currency Derivatives segments.

BSE provides the fastest Co-location service in India with round trip network latency of less than 10 microseconds. At BSE Colocation response for an order has round trip latency of about 16 microseconds (including 10 microseconds of Co-location network latency).

AT BSE, there is equitable distribution of market data to all members by usage of same length cables for all members. Also, Full order book (EOBI) multicast is provided to Co-location members at no cost.

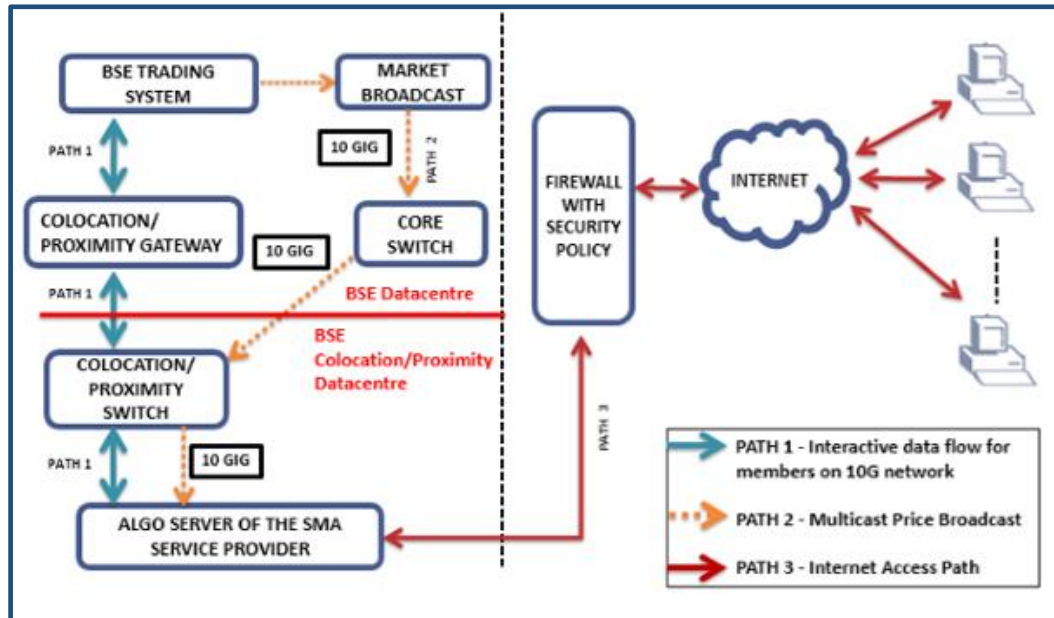
Service Type	Details
Co-location Network Bandwidth	10 Gbps fiber optic network
10G Fibre Connectivity	Available
Roundtrip Latency (in μ sec): Exchange Response Time	6
Roundtrip Latency (in μ sec): Colo Network*	10
Roundtrip Latency (in μ sec): Exchange Response Time + Colo Network Latency	16*

In keeping up with the global trends and in continuation of service excellence, NSE is facilitating its members to co-locate their DMA and ALGO IT infrastructure at NSEIL premises. The co-location facility would have the following features:

- Co-location facility shall be used only for DMA and Algo trading on NSE.
- Co-location facilitates with dual UPS power source and 100% DG capacity which ensures uninterrupted power.

- Multiple Precision air conditioning units, with N+1 redundancy ensuring optimal temperature at all times.
- Co-location facility at the Exchange comes in 2 variants: Standard 42U Full Rack with 6KVA power and Half rack of 21U with 3.5KVA.

4.5 CO-LOCATION ARCHITECTURE



Diagrammatic representation of Sponsored Market Access under the Technology Programme of BSE

Racks:

There are 3 types of racks provided by Netmagic. Members can apply for the rack type as per their requirement.

1. Quarter Rack with 10 Gbps Fibre Link
2. Half Rack with 10 Gbps Fibre Link
3. Full Rack with 10 Gbps Fibre Link

Connectivity:

The members, who utilize the facilities of the colocation, will also be provided with the following services to connect to their servers:-

1. Remote Secure Access (1 Mbps Internet connection with Firewall)
2. Additional 1 Mbps Capped Internet Bandwidth
3. Cross Connect for copper including Patch Cord

The Members can avail 'Sponsored Market Access' (SMA) at BSE Co-location and features thereof are:

- SMA is a software distribution model in which applications are hosted by a service provider and made available to customers over a network.
- Free of cost rack space is allocated by BSE to the SMA Service providers to install their algo trading application server at Co-location. The members can connect to this SMA algo server at Co-location via Internet.
- The algo strategy parameters can be triggered from the member front-end application and sent to the SMA algo server at Co-location.
- The corresponding algos will generate orders to be sent to BSE trading system through Co-location network.
- The algo orders will be sent to the BSE Trading system via the high speed Co-location gateway for minimum latency.
- Members can execute orders over high speed Co-location network without installation of any infrastructure at Co-location by the members.

10Gbps network at BSE Co-location:

- Low latency 10Gbps switches deployed at Co-location.
- Dedicated Co-location gateways with minimum hops to route the algo orders to BSE Trading system for low round trip latency.
- Connectivity between members' Colo Racks and Co-location switches upgraded from 1 Gbps Copper to 10 Gbps Fibre network.
- Members' trading servers directly connected to Co-location low latency switches via 10 Gbps Fibre network for low latency trading.
- Low latency 10 Gbps Solarflare NIC cards (Model No. : SFN7322F) is provided to members by BSE.

Advantages of SMA at BSE Co-location –

Advantages for Members -

- Zero capital expenditure on infrastructure at Co-location.
- The algo orders will be generated at Co-location and sent to the BSE Trading system via the high speed 10G Co-location network for minimum latency.

Advantages for Vendors -

- Free of cost rack space is allocated by BSE to SMA Service providers to install their algo trading application server in BSE Co-location.
- Vendor can service multiple clients with a centralized algo server installed at Co-location. Hence, vendor's cost of maintenance is low.

4.6 QUANTUM OF ORDERS EMANATING FROM CO-LOCATION



Count of 25,155 million algorithmic orders generated in co-location servers across segments (CM, F&O and CDS) for the period FY 16-17 (Apr'16 to Feb'17).



Table 4.1: The segment wise percentage of Algo orders coming from co-location

SEGMENT	% ALGO ORDERS OUT OF TOTAL ORDERS IN BSE	% COLO ORDERS OUT OF TOTAL ALGO ORDERS IN BSE
EQUITY	98.56	80.00
EQUITY DERIVATIVES	99.89	80.10
CURRENCY DERIVATIVES	94.93	91.88
INTEREST RATE DERIVATIVES	93.22	96.16

4.7 COLOCATION COSTS AT NSE

*(Charges in Rs. Lacs)

Rack Size	Charges per rack p.a.(incl basic IT charges) *
Full Rack	12.00
Half Rack	6.00

Any taxes, duties, levies etc. would be extra, as applicable.

Key Points

- Backup restore facility will be charged at Rs. 66000/- per rack. (Taxes, as applicable, would be extra)
- For a new applicant, a one-time initial set up charge of Rs. 1,00,000/- for a Full rack and Rs. 50,000/- for a Half rack would be levied. (Taxes, as applicable, would be extra)

Additional Costs apart from Rack Charges

Apart from rack charges, member may incur the following costs which varies from member to member depending upon their choice:-

- Cost for each interactive connection varies from Rs. 50,000 to Rs. 10,00,000 p.a. plus taxes depending upon the message capacity of the connection
- Cost of availing Tick By Tick data is Rs. 1,00,000 per connection p.a. plus taxes
- Optional Tape Back Up charges of Rs. 66,000 p.a. plus taxes

Apart from the above Exchange's costs, the trading members need to deploy requisite hardware, software and connectivity of their choice at their cost.

Connectivity Costs

Members can choose from various connectivity options available for market data and order message connectivity.

NSE uses TCP/IP protocol based Wide Area Network facilitating standard/higher bandwidth, expansion and scalability.

In order to provide equal access to all the Trading Members spread over a wide geographical area, the Exchange offers the following forms of telecommunication connectivity:

- VSAT (Very Small Aperture Terminal) - Satellite-based Connectivity
- Leased Line-Terrestrial-based Connectivity
- MPLS (Multiprotocol label switching)

Trading Members are required to choose a scenario from the available categories to apply for connectivity.

Members may take one or more leased line to the co-location facility from different telecom service providers for the purpose of setting up or modifying parameters, trading related activities and hardware, software, network related access, software download / upload and monitoring and data downloads.

Table 4.2: VSAT, Leased Line and MPLS connectivity cost (in Rs.)					
	One Time Deposit/Charges		Annual Charges		
Type of Connectivity	Interest Free Security Deposit (IFSD)	Installation Charges (approx)	Annual Recovery Charges(ARC)	Last Mile Charges	Hardware Rent (approx)
A) VSAT					
1) Option I: Premium	-	17750	36000	-	-
2) Option II: Standard	-	17750	23500	-	-
B) Leased Line (All bandwidths)					
1) Category A (40 m.p.s)	100000	As per service providers rate card	50000	As per service providers rate card	As per service providers rate card
2) Category B (100 m.p.s)	250000		250000		
3) Category C (200 m.p.s)	500000		500000		
4) Category D (400 m.p.s)	1000000		1000000		
5) Category T (#)	100000		100000		

6) Category S	100000		50000		
C) MPLS					
	Category	Category	Category	Category	Category
Particulars	A	A	B	C	D
Bandwidth	2Mbps	4 / 6 / 8 / 10 /20 Mbps			
Interactive messages per second	40	40	100	200	400
Message Annual Recovery Charges (excluding service tax)	NA	NA	2,50,000	5,00,000	10,00,000
Other Charges (Last mile /Port Charges, etc.)	Rate Charts of Service Provider as per NSE Circular Download Ref No. NSE/MEM/31583 Dated January 18 , 2016				

- The above charges are to be paid to the service provider except as follows:
 - i. In case of any leased lines emanating from POPs located at Rajkot, Jaipur and Cochin, the IFSD and ARC shall be payable to NSE
 - ii. In case of category B, C & D Leased Lines, the IFSD shall be payable to NSE

Other than ARC, other annual charges may vary depending on the service provider

VSAT, MPLS and category S are not available at co-location

First category a connection on a Rack in co-location shall be provided free. Applicable ARC shall be collected by NSE for connections at co-location

All above costs are exclusive of taxes. Applicable taxes will be charged extra.

(#) In case of availing Multicast TBT data on Higher Bandwidth Leased Lines, IFSD will not be applicable. Applicable ARC shall be payable to NSE.

4.8 COLOCATION COSTS AT BSE

Exchange provides open access to all members to setup in the Exchange colocation. Trading members do not have to incur any cost for setting up servers in BSE co-location. The Exchange provides both rack space and servers to the members.

Technology Programme (Software and Hardware)

In order to facilitate usage of newer technology/development amongst the market participants, BSE has launched a Technology Programme. The details are given below:

Under the Technology Programme, BSE bears the cost on behalf of the member for:

- The software license cost for Algo trading and market access. Algo software is provided to members for trading from their Co-location and Non Co-location sites registered with Exchange.
- The infrastructure cost for Co-location rack space
- The Algo trading servers at Co-location
- The internet connectivity between BSE Co-location and member's office

Table 4.3: Co-location Infrastructure Cost	
Full Rack	Free
Half Rack	Free
Quarter Rack	Free
Servers	Free
Algo software	Free
10G Switch at Member Rack	Not Mandatory
Additional cost to member for 10G migration	NIL
10G NIC Card from Exchange per member	2 Solarflare Cards (SFN7322F) - Free
Interactive and Market data connectivity cost	No cost for order throughput and market data feed

Additional Costs apart from Rack Space: While there is no cost charged by BSE to members for setting up colocation infrastructure, a member may have to incur their internal costs for development and maintenance of their software application for ALGO trading, human resources, lease lines and any other service that is not provided by BSE.

4.9 REQUIREMENTS TO BE MET FOR SETTING UP COLOCATION SERVER



Currently, to use colocation for trading purpose, Exchange approval for algo and/or DMA product is a prerequisite.



A member needs to apply through BEFS (online member service portal of BSE) for the colocation services required. This application is processed post approval from Business and Operations teams of BSE.

4.10 LENGTH AND QUALITY OF WIRE USED



The colocation service is uniform for all members. We assume that the wire being discussed refers to the connection of colocation racks with Exchange systems. All racks are equidistance with a maximum tolerance of 0.43% and the tech specs of the connection is 50 Micron Lazerspeed OM3 MM Fiber.



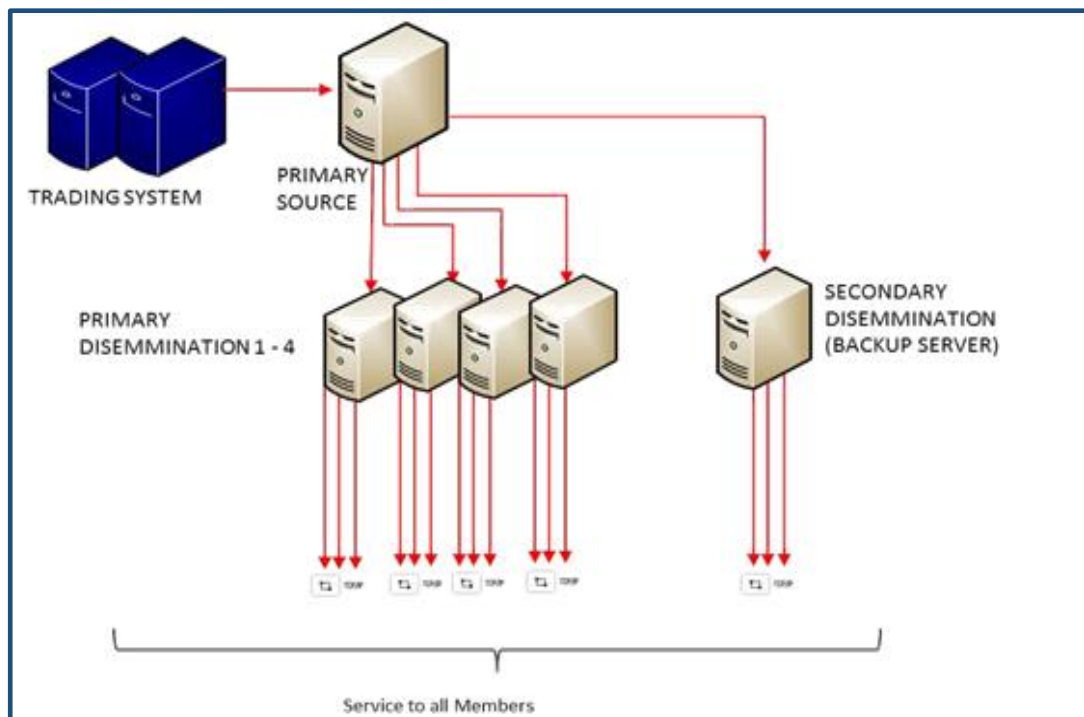
Yes, the wire quality and length is same for all the members located at co-location. The wire length is 20 meters (from Colocation switch to Members' servers in colocation racks) and the wire type is Cat6 Multimode Fiber optic.

4.11 SYSTEM (UNICAST/MULTICAST) IN EXISTENCE FOR THE LAST 5 YEARS

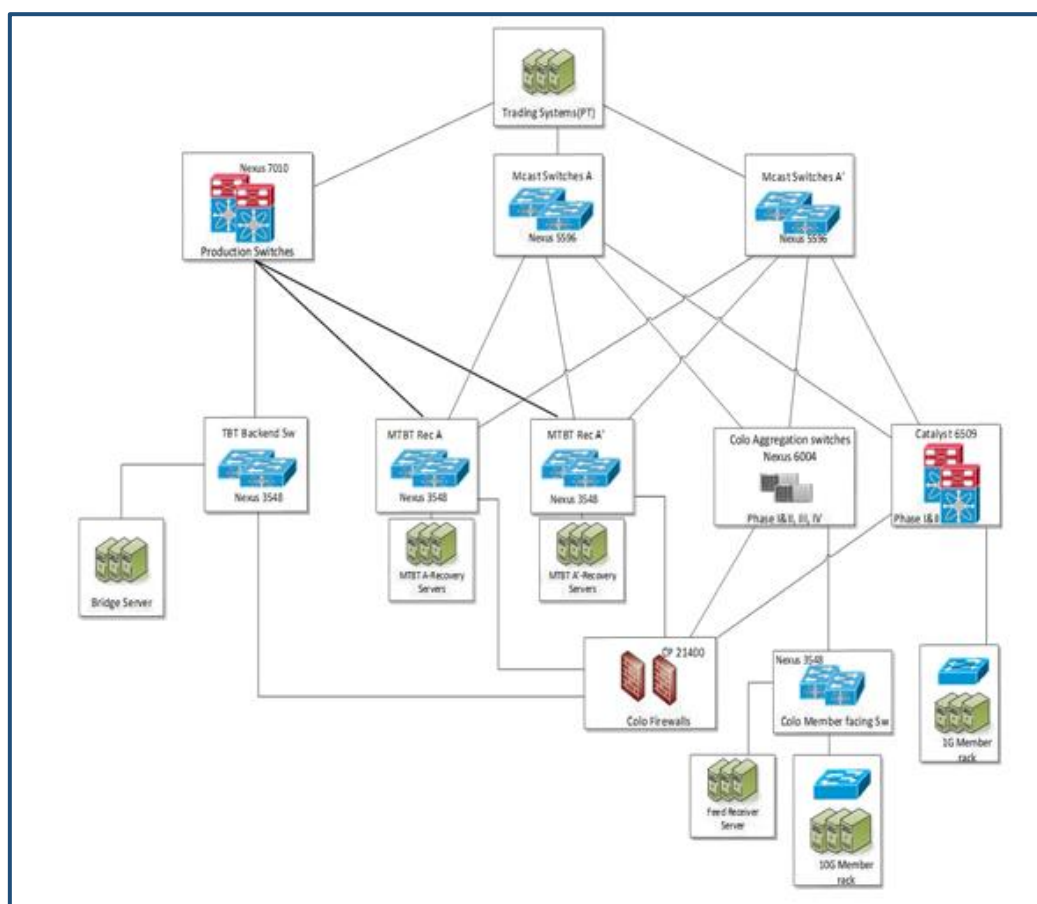


The market data (TBT) system was available in unicast (TCP/IP) till December 2016. At present only multicast TBT is available which was introduced in May 2014.

- A. TCP TBT** (discontinued in December 2016) – The system was divided into two modules –
- Primary source which receives data from trading system and converts it into TBT data format
 - Primary/secondary disseminator which accepts and maintains user sessions and sends data to each connected user in round robin fashion.



- B. Multicast TBT** – The data feed is disseminated directly from trading system over multicast channel. In this system all users can listen to a predefined multicast IP address and port and receive the data over multicast.



The market data is provided on multicast only. The exchange supports full order book dissemination in its Enhanced Order book interface, EOBI. Another variant of this is the EMDI, Enhanced Market data interface, which provides real time updates for top 5 price points, and netted data for other depths. For trading terminals a low bandwidth netted data stream called MDI, market data interface, is also supported. All these above mentioned streams are disseminated on 2 incremental channels for redundancy supported by 2 redundant snapshot channels. All such channels are multicast based. The exchange also supports its older market data protocol called NFOCAST, which is a periodic snapshot based market depth feed.

4.12 POSSIBILITY OF UNDUE ADVANTAGE TO SOME PARTICIPANTS DUE TO SEQUENTIAL ACCESS DUE TO EARLY LOG-IN



Currently only multicast TBT data feed is available. The multicast protocol does not require any user to login to a system. The data is sent over a multicast channel and network switches take care of sending data to all the users who are connected and are receiving the data. The network switches disseminate the data in parallel to all the users connected to it. Hence there is no undue advantage in multicast TBT data feed.



No participant can gain undue advantage as the market data is multicast to all users and there is no requirement for any login for getting market data.

For order and trades, the Gateways are assigned randomly based on load balancing logic built into the session management process.

4.13 REQUIREMENT OF MAIN SERVER and BACK UP SERVER?



In multicast TBT, there is no concept of main and backup server. Currently, there are two multicast feeds available - A and A'. Both the feeds are in active-active mode. The user can listen on either or both the feeds simultaneously. Both the feeds receive data from same source and in same manner. There are no additional charges for the data feeds.



Since all market data is multicast, there is no requirement of having a main or backup server. Due to the multicast protocol, there is no scope of preferential treatment.

Chapter-5

ORDER TO TRADE RATIOS

5.1 INTRODUCTION

Order-to-trade (or order-to-execution) ratios involve financially penalising individual financial firms if the orders to buy or sell they enter do not lead to a ‘sufficient’ number of trades.

High order-to-trade ratios imply that market participants are placing and cancelling orders but not executing most of the orders. This could be due to the nature of market making algorithms or market manipulation algorithms, where orders are placed to drive volumes to that point and then cancelled – with the result that most of the orders are not converted into trades.

5.2 AVERAGE ORDER TO TRADE RATIO FOR ALL ACTIVE ALGO PARTICIPANTS IN THE LAST 3 YEARS (YEAR-WISE BIFURCATION)

Order to trade ratio computed for all algo participants (trading members) on NSE irrespective of colocation or non-colocation across segments (CM, F&O and CDS) for the last 3 financial years. Average of all the participants (trading members) is provided below:

Table 5.1: Average Order to Trade Ratio for all active Algo Participants

FY	Average of Order to Trade Ratio
2014-2015	8.91
2015-2016	26.44
2016-2017 (Apr'16 to Feb'17)	12.26

Notes: Algorithmic order is identified based on identification code as provided by the trading member.

5.3 ORDER-TO-TRADE RATIO FOR THE TOP 10 PARTICIPANTS (BY TURNOVER) ACROSS THE LAST 3 YEARS (YEAR-WISE BIFURCATION)



Order to trade ratio computed for all Algo participants (trading members) irrespective of colocation or non-colocation across segments (CM, F&O and CDS) for the last 3 financial years. The top 10 participants (trading members) based on algorithmic trading turnover identified for the respective year and their order to ratio for the respective year is provided below:

Table 5.2: Order to Trade Ratio for top 10 Algo Participants (by turnover)

Participant Rank - Based on Algo Turnover	2014-2015	2015-2016	2016-2017 (Apr'16 to Feb'17)
1	6.43	6.19	7.99
2	7.50	14.94	8.68
3	0.74	2.24	31.62
4	4.30	9.28	2.53
5	2.62	0.77	2.77
6	3.91	1.76	7.81
7	2.04	10.96	29.41
8	1.75	32.78	2.89
9	59.50	28.16	1.77
10	8.69	3.97	16.98

Notes:

1. In case of options, premium turnover is considered in F&O and CD segment.
2. Algorithmic order is identified based on identification code as provided by the trading member.



5.4 ORDER-TO-TRADE RATIOS FOR EFFICIENT VS INEFFICIENT MEMBERS ACROSS THE LAST 3 YEARS (YEAR-WISE BIFURCATION)



Order to trade ratio computed for all algo participants (trading members) irrespective of colocation or non-colocation across segments (CM, F&O and CDS) for the last 3 financial years. The top 25 participants (Efficient members) and bottom 25 participants (Non Efficient Members) based on algorithmic order to trade ratio identified for the respective year. The category wise average order to trade ratio for these 25 members in the respective financial year is provided below:

Table 5.3: Average Order to Trade Ratio for Efficient and Non-Efficient Members (NSE)

FY	Efficient Members	Non Efficient Members
2014-2015	0.21	91.02
2015-2016	0.17	433.13
2016-2017 (Apr'16 to Feb'17)	0.14	181.47

Notes: Algorithmic order is identified based on identification code as provided by the trading member.

The below table provides the bifurcation for efficient vs non-efficient members (based on top and bottom decile categorization) on the Equity segment at BSE:

Table 5.4: Average Order to Trade Ratio for Efficient and Non-Efficient Members (BSE)

FY	Efficient Members	Non Efficient Members
2014-2015	0.53	2230
2015-2016	0.85	4591
2016-2017 (Apr'16 to Feb'17)	0.85	1647

5.5 TREND OF ORDER-TO-TRADE RATIO OVER THE LAST 3 YEARS



Number of orders entered and executed into trades across all segments (CM, F&O and CDS) by all algo participants (trading members) considered to arrive at the order to trade ratio for the respective financial year.

FY	Order to Trade Ratio
2014-2015	7.07
2015-2016	12.31
2016-2017 (Apr'16 to Feb'17)	11.22

The trend of order-to-trade ratio over the last 3 years (year wise – segment wise) is as given in the table below:

Table 5.5: Year wise trend of order to trade ratio of ALGO trading members			
SEGMENT	YEAR		
	2016-17 (Till February 28,2017)	2015-16	2014-15
	Avg. Order to Trade Ratio	Avg. Order to Trade Ratio	Avg. Order to Trade Ratio
Equity	218.13	571.21	321.57
Equity Derivatives	3597.70	3083.59	8612.31
Currency Derivatives	195.22	290.42	111.09
Interest Rate Derivatives	132.87	968.82	884.55

5.6 EXCHANGE PRO-ACTIVENESS IN CONTROLLING THE ORDER-TO-TRADE RATIO



Exchange on an Intra-day basis makes calls and alert trading members in case of High Order to Trade ratio, these calls act as a preventive measure. From April 2016 till date Exchange has made about 110 calls which resulted into lesser disablements. Exchange also held member meet to make them aware of the trends in the market which help them benchmark their order to trade ratio etc.

In Equity Segment the Order to trade ratio stood at 6.95 in November 2016 as against 9.41 in April 2016. Similarly in Equity derivatives segment the Order to trade ratio stood at 151 in November 2016 as against 215 in April 2016.





Further, Exchange also levies fair usage charges for multi leg order in derivatives segment such as 2 Leg and 3 Leg (2L/3L) orders which are Immediate or Cancel (IOC) in nature. Since this facility enables trading members to enter orders in multiple contracts through single order entry, order to trade ratio tends to be higher. In order to facilitate and encourage fair usage of such order entry facility, trading members are charged for 2 Leg and 3 Leg orders in equity and currency derivatives segment.



Exchange has imposed throttles on the order flow to keep a check on trading members' Algos as per Exchange circular ref. [20161019-35](#) (Equity Segment), [20160930-3](#) (Currency derivative), [20160503-22](#) (Equity Derivative.)

Exchange levies fair usage charges to trading members who do not satisfy the fair practices criteria prescribed by the exchange as per Exchange circular no [20161027-14](#).

Circulars

			
20160930-3 - Currency Derivatives	20161019-35 - Order flow rate for Equity.p	20161027-14 - Fair Usage Charges.pdf	20160503-22 -Order Flow Rate for Equity

5.7 PENALTIES OR STRUCTURES IN PLACE TO CURB HIGH ORDER-TO-TRADE RATIOS



Structure 1 (Penalty charges for higher order-to-trade ratios)

Table 5.6: Penalty charges levied at member level for high algo order to trade ratio (NSE)

Daily algo Order to Trade Ratio	Charges (per algo order)
Less than 50	NIL
50 to less than 250 (on incremental basis)	2 paise
250 to less than 500 (on incremental basis)	10 paise
500 or more than 500 (on incremental basis)*	10 paise

*In case the ratio is 500 or more than 500 during a trading day, the concerned member is not permitted to place any orders for the first 15 minutes on the next trading day (in the continuous trading session) as a cooling off action.

Structure 2 (Fair usage charges categorized according to execution efficiency)

Further, charges are levied at member level for 2 Leg and 3 Leg orders. The charges are based on order execution efficiency i.e. the ratio of number of trades resulting from 2L/3L orders and total number of 2L/3L orders as explained below:

Table 5.7: Fair usage charges categorized according to execution efficiency

Execution Efficiency %	Levy on each 2L/3L order*
More than 90%	NIL
Between 70% to 90%	Rs. 0.01 (one paisa)
Between 50% to 70%	Rs. 0.02 (two paisa)
Less than 50%	Rs. 0.03 (three paisa)

*Applicable taxes extra

Execution Efficiency % = (Total number of trades executed by trading member / Total number of Chargeable Algo orders) * 100



Structure 1 (Penalty charges for higher order-to-trade ratios)

Table 5.8: Penalty charges levied at member level for high algo order to trade ratio (BSE)

Daily Algo Order to Trade Ratio	Charges (per algo order)
Less than 50	Nil
50 to less than 250 (on incremental basis)	2 paise
250 to less than 500 (on incremental basis)	10 paise
500 or more than 500 (on incremental basis) *	10 paise



20130529-6 - Equity 20141010-26 - Order
Der Order to Trade ratio to Trade ratio for Cur



Structure 2 (Fair usage charges categorized according to execution efficiency)

Table 5.9: Fair usage charges categorized according to execution efficiency

Slab	Execution Efficiency %	Fair Usage Charges per Chargeable Algo Order * (in Rs)
1	Greater than or equal to 90%	NIL
2	Greater than or equal to 70% but less than 90%	0.0025
3	Greater than or equal to 50% but less than 70%	0.0050
4	Less than 50%	0.0075

Following is the procedure to calculate Fair Usage charges:

1. Execution Efficiency % = (Total number of trades executed by trading member / Total number of Chargeable Algo orders) * 100
2. For the computation of 'Execution Efficiency %',

Total number of trades executed by trading member:

- a. All trades executed by a trading member resulting from the member's algo and non-algo orders across all instruments in a BSE trading segment shall be considered.

Total number of Chargeable Algo Order:

- a. Chargeable Algo Order: This is defined as all active algo orders which are entered with a price beyond the first 10 price levels or further than 1% of the best bid/ask order (whichever is higher) prevailing at the time of entry in the order book of a given instrument shall be considered. For this purpose, best bid shall be considered for the active buy algo order and best ask for the active sell algo order.
- b. Non-algo orders shall not be considered.
- c. Algo order 'add' and 'modify' requests shall be considered. Order cancellation requests shall not be considered.
- d. Every modification of an algo order resulting in the order to be categorized as 'Chargeable Algo Order' shall be considered as an additional algo order count
- e. If an order is already a 'Chargeable Algo Order' then each modification of any parameter in such order that continues to position it as a 'Chargeable Algo Order' shall be considered as an additional algo order count.
- f. If an algo order at the time of entry in the market is not a 'Chargeable Algo Order' but later loses its price priority and is positioned beyond the first 10 price levels or further than 1% of the best bid/ask order (whichever is higher) then it shall not be considered.
- g. 2 lakhs 'Chargeable Algo Orders' per day per member in each trading segment will be exempted.

3. Charges shall be computed on a daily basis for all trading members. Sum of daily charges shall be debited to the respective members at the end of a calendar month only if the amount is equal to or greater than INR10,000 per trading segment for a particular month.

5.8 PENALIZING REPEAT OFFENDERS OF HIGH ORDER-TO-TRADE RATIO



In order to discourage repetitive instances of high daily order-to-trade ratio, there is an additional penalty in form of suspension of proprietary trading right of the trading member for the first trading hour on the next trading day in case trading member is penalized for maintaining high daily order-to-trade ratio, provided penalty was imposed on the trading member on more than ten occasions in the previous thirty trading days.



In case of Trading members whose OTR is more than 500 in the derivatives market, such trading members shall be placed in risk reduction mode for the first 15 minutes on the next trading day (i.e. they can place orders only to reduce their existing position and not to increase their position) .

5.9 CAUSES OF A VERY HIGH ORDER-TO-TRADE RATIO



Based on our discussions with market participants, we are given to understand that order to trade ratios are affected by various factors like type of strategy deployed, maturity/effectiveness of the algo as it evolves, market conditions, volatility, liquidity etc. Further, market makers are known to use algos extensively as they make markets in multitude of assets, scrips and contracts simultaneously which is humanly not possible. It is further understood that the important function of market making involves providing sitting quotes across large number of tradable books which may not necessarily result in trades.



Algos with repeated order modifications are the primary cause of high OTRs.

5.10 WHAT CATEGORY OF HFT ALGORITHMS COULD LEAD TO HIGH ORDER-TO-TRADE RATIOS



Trading members are not required to share the business logic of algo as it is a proprietary information. Further market making activity may lead to high order to trade ratio.



HFT algorithms with high order modifications and low order execution resulting in trades generally cause high Order to Trade ratio.



Chapter-6

REGULATORY FRAMEWORK

6.1 OVERVIEW OF REGULATORY CONCERNS

Following are some of the regulatory concerns raised in the discussion paper by SEBI:

- I. Algorithmic / high frequency trading has continued to attract the attention of investors and regulators across the world during last few years. Some of such issues that have been drawn regulatory attention are contribution to price volatility, market noise (excessive order entry and cancellation), cost that high-frequency trading imposes on other market users, technological arms race, limited opportunities for regulators to intervene during high volatility, strengthening of surveillance mechanism, etc.
- II. Fair, Transparent and Non-discriminatory access is one of the key pillars of a safe and vibrant capital market. As some market participants across the globe have highlighted the concern of unfair access and inequity to the non-HFT participants vis-à-vis the participants that use trading algorithms and co-location to trade, securities market regulators are examining various proposals to address such concern.

6.2 MEASURES ADOPTED BY SECURITIES MARKETS REGULATORS IN DIFFERENT COUNTRIES:

I. Minimum Resting Time

- a. In June 2009, ICAP introduced a minimum quote lifespan (MQL) on its electronic broking services (EBS) platform. These quote requirements set a minimum life of 250 milliseconds (ms) for their five 'majors' (generally currency contracts) and 1,500ms in selected precious metals contracts. In public statements, ICAP credits the absence of a major Flash Crash to MQLs

II. Frequent Batch Auctions

- a. Taiwan Stock Exchange (TWSE) used to have continuous auction mechanism as the order matching method wherein orders were batched over various time intervals. TWSE has now moved to continuous limit order book mechanism for regular trading. Auction methodology is used only for opening and closing price sessions.
- b. Further, effective from April 2013, trading in illiquid stocks in the equity markets of NSE, BSE, MSEI are conducted only through a periodic call auction mechanism.

III. Random Speed Bumps or Delays

- a. ParFX, a wholesale electronic trading platform designed by Tradition (an interdealer broker in over-the-counter financial and commodity-related products), applies randomized pause to all order submissions, amendments and cancellations by between 20-80 milliseconds. This limits the advantage of 'first in, first out' trading and nullifies advantages gained by low-latency trading strategies. It is understood that the objective is to provide a level

playing field for participants wherever they are located and whatever their technological or financial strength.

- b. TSX Alpha Exchange (TSXA) imposes a randomized order processing delay of between 1 and 3 milliseconds on all orders that have the potential to take liquidity. This is intended to discourage opportunistic liquidity taking strategies. The intention is to encourage orders to contribute to greater volume at the best bid/offer, translating to larger trade sizes and better fill rates for active orders.
- c. SEC (USA) has approved a proposal of IEX that non-routable Immediate-or-Cancel (“IOC”) orders shall be subjected to a certain sub-millisecond delay before arriving at the IEX system.

IV. Randomization of orders received during a period (1-2 seconds)

- a. ICAP’s EBS Market Matching Platform has introduced ‘Latency Floor’ that consists of a random batching window of 1, 2 or 3 milliseconds, whereby all messages submitted within this period are collected and then randomly released to the matching engine. The process is aimed at ensuring that speed as a stand-alone strategy is not a pre-requisite for success on EBS Market.

V. Maximum order message to trade ratio requirement

- a. The ICAP has a monthly fill ratio (MFR) requiring that at least 10% of all quotes submitted into the market must result in an execution.
- b. LSE’s Millennium trading system has message throttling constraints and penalties for excessive ordering strategies. Anecdotal evidence suggests that the LSE message policy was not fully effective in that it gave rise to new patterns of trade in low-priced stocks. The LSE has experimented with changes in pricing effective May 4, 2010 whereby, among other measures, the threshold for the high usage surcharge for FTSE 350 securities increased from an OTR of 100/1 to a ratio of 500/1 (which is still the figure in use at the time of writing). The frequency of order book updates nearly doubled for a few months as a result before coming down again.

VI. Market Maker Pricing

- a. Toronto Stock Exchange applied Market Maker Pricing :Examining the effects of a controlled experiment on maker-taker pricing on the Toronto Stock Exchange, Malinova and Park (2011) find that the bid-ask spread adjusted to reflect the breakdown of maker-taker fees. They also found that the quoted depth of stocks eligible for maker-taker pricing increased significantly, suggesting provision of greater liquidity. Adjusting for the fees, the average bid-ask spread was the same before and after the introduction of maker-taker pricing, and volume was greater for those stocks. Overall, maker-taker fees improve markets by increasing depth and volume while holding spreads (including fees) the same.
- b. There was an introduction of maker-taker exchange fees for Australian securities cross-listed on the New Zealand Stock Exchange in 2008. Berkman et al. (2011) found that depth at the best quotes as well as trading activity increases with the introduction of maker-taker fees, though there is little evidence of a change in bid-ask spread.

- c. It was introduced in European Markets. The only study focusing specifically on maker-taker pricing in European markets identified by the Project is Lutat (2010). He finds that the introduction of maker-taker pricing by the SWX Europe Exchange did not affect spreads but led to an increase in the number of orders at the top of the book.
- d. Dutch Index introduced Maker Taker Model. Menkveld (2012) finds that spreads fell dramatically when Chi-X began trading Dutch index stocks, suggesting that its maker-taker model may have improved market competitiveness

VII. HFT Transaction Tax

a. HFT transaction tax in France

In 2012, France introduced a national levy on certain financial transactions with French shares and certain derivatives as well as cancelled orders in the context of 'high frequency-trading'. In particular, the tax on cancelled (or modified) HFT orders (0.01% of the value of the orders) applies in case the ratio of cancelled orders to all orders during one trading day exceeds 80%. The tax is payable by each financial intermediary (except if undertaken in the context of market making) established in France and using automated algorithm trading characterized by the successive sending of purchase or selling orders and the modification or cancellation of the initial trading orders, respectively, within a time period of no more than half a second.

A subsequent report by the European Commission to assess the impact of the tax on trading volumes, price levels and volatility concluded that while no significant impact was seen on the volatility and price level of the stocks, a decline of 10% in liquidity was observed.

b. HFT transaction tax in Italy

In 2013, Italy levied a 0.02% tax on order changes and cancellations occurring within a time frame shorter than 0.5 seconds. The tax is calculated on a daily basis and is payable where - in a single trading day, the ratio between the sums of cancelled and modified orders, and the sum of entered and modified orders exceeds 60% with reference to a single financial instrument. The tax is applicable from March 2013 for equities and from July 2013 for derivatives.

VIII. Global regulatory response to algorithmic trading

a. The U.S. Securities and Exchange Commission (SEC)

The SEC has undertaken a series of steps overtime to prevent instability in the market that may arise from automated trading. The most significant of these are: Market Access Rule, Regulation SCI and registration of entities. These are:

1. Market access rule

In November 2010, the SEC approved a new rule to require brokers and dealers to have risk controls in place before providing their customers with direct access to the market. The rule prohibits broker-dealers from providing customers access with “unfiltered” and “naked” access to an exchange or alternative trading system. Specifically, the rule requires broker-dealers to:

- Create risk controls to prevent the entry of orders that exceed appropriate pre-set credit or capital thresholds, or that appear to be erroneous.
- Create risk controls designed to ensure compliance with all regulatory requirements applicable in connection with market access.
- Have certain risk management controls applied automatically on a pre-trade basis before orders route to an exchange or ATS
- Maintain risk management controls and supervisory procedures under the direct and exclusive control of the broker-dealer with market access except in limited instances.
- Establish, document and maintain a system for regularly reviewing the effectiveness of its risk management controls and for promptly addressing any issues.
- SEC directed self-regulatory organizations to maintain a consolidated audit trail (CAT). This audit trail is intended to increase the data available to regulators investigating illegal activities such as insider trading and market manipulation.

2. Registration of persons responsible for algorithmic trading strategies

In April 2016, the SEC approved a rule which require registration of Securities Traders of associated persons primarily responsible for the design, development or significant modification of algorithmic trading strategies, or who are responsible for the day-to-day supervision or direction of such activities.

3. Initiatives planned as per SEC Director’s testimony

Further initiatives planned as per SEC Director Stephen Luparello (Testimony given on 3 March 2016):

- a. Additional timestamps for consolidated data feeds and data feed usage by Self-Regulatory Organizations or SROs.
- b. Membership requirements for dealers trading in off-exchange venues.
- c. Rules to strengthen record-keeping requirements for algorithmic trading.
- d. Work on recommendations to clarify the status of active proprietary traders not registered as broker-dealers.

- e. Work on recommendations to address the use of aggressive, destabilizing trading strategies in conditions when they could most seriously exacerbate price volatility.
- f. In addition, the Equity Market Structure Advisory Committee has formed a market quality subcommittee to consider the impact of technology on the efficiency of the markets and systemic risk.

b. The German HFT Act

In May 2013, Germany enacted the Act on the Prevention of Risks and Abuse in High-Frequency Trading (HFT Act).

- i. Licensing: The HFT Act requires that firms engaged in HFT must be licensed. HFT is defined to include each of the following elements:
 - Trading for one's own account, or by proprietary trading firms;
 - Trading algorithmically without human intervention;
 - Trading using low-latency infrastructures; and
 - Trading that generates a high intra-day message rate.
- ii. Risk Controls: Firms that engage in HFT-type business must fulfil requirements to ensure that markets are not distorted or interrupted.
- iii. Market Manipulation: The Act broadens the definition of market abuse.
- iv. Order to Trade Ratio: The Act requires exchanges to impose, on a product-by-product basis, an excessive system usage fee and an order-to-trade ratio limit intended to prevent unnecessary messaging. Electronic Identification of Algorithmic Trading: The Act mandates that exchanges have to implement rules requiring all exchange members to flag all algorithmically generated orders with a unique key when sent to a German exchange so as to allow the market surveillance system to allocate all orders to the generating algo.

c. Australia

In 2013, the Australian Securities and Investments Commission (ASIC) released its consultation paper with regard to market integrity rules in the presence of HFT to address: excessive messaging and market noise (in particular, small and fleeting orders and order-to-trade ratios). The proposals that were open for public consultation included:

- i. Prevent small orders* being cancelled or amended within 500 milliseconds of being submitted to the trading platform of a lit exchange market; and
- ii. Establish systems, policies and procedures to prevent the cancellation or amendment of small orders within 500 milliseconds of being submitted to the trading platform of a lit exchange market.

*(For the purposes of the above proposal, ASIC proposed to define 'small order' as being less than or equal to:

- \$500 value for equities traded on the ASX and Chi-X markets;
- \$500 value for contracts for difference traded on the ASX 24 market
- 10 futures contracts for the ASX 24 market (for all contracts with the exception of the ASX SPI 200 Index Future (ASX SPI 200 Future);
- Three futures contracts for the ASX SPI 200 Future)

However, ASIC said that it decided to not go ahead with proposals to rest small orders on the market for a set time or for dark orders to meet a minimum size.

At present, ASIC does not have any specific regulation on AT/HFT. Instead, it periodically publishes a review of HFT and dark-liquidity in the Australian markets.

IX. Other Measures Employed:

- a. In a bid to curb high-frequency trading, Australia has unveiled plans for the introduction of **'kill switches'** as part of a wider package of new market integrity rules. By the middle of 2014, traders were required to have direct control over algorithms, including 'kill switches' to immediately stop one if required and avoid a repeat of the infamous May 2010 US flash crash.

NSE has also employed kill switches as part of market integrity rules. However, the kill switch is manual and the control given to the member for the execution of the same. Until now, not even once has a kill switch been employed on NSE trades.

- b. On April 15, 2014, the **European Parliament** approved new legislation to curb high frequency trading by **restricting the smallest price increments for securities and requiring testing of trading algorithms to identify any behaviour mimicking front running**. However in EU, proposals to ensure orders stay on a trader's book for a minimum time, making it difficult for high-frequency traders to operate, were dropped last year.
- c. Another measure introduced by **EBS** was to **widen the spread of pricing** on some of its currency pairs, so the fifth decimal point in a quote was a “5” or “0” rather than increments of a 10th. It also raised the ratio of quotes traders were allowed to send before they were required to buy. The changes resulted in fewer “flash” orders – automatic trades made at lightning speeds – at the top of the order book while trades further down the order book were being filled

6.3 WHAT DOES IOSCO PRESCRIBE

Regulatory Issues Raised by the Impact of Technological Changes on Market Integrity and Efficiency – Final Report by TECHNICAL COMMITTEE OF THE INTERNATIONAL ORGANIZATION OF SECURITIES COMMISSIONS, October 2011.

IOSCO Recommendations on Market Integrity and Efficiency

- i. **Recommendations regarding trading venue operators and trading participants**
 - a. **Recommendations regarding trading venue operators**

Recommendation 1: Regulators should require that trading venue operators provide fair, transparent and non-discriminatory access to their markets and to associated products and services.

Recommendation 2: Regulators should seek to ensure that trading venues have in place suitable trading control mechanisms (such as trading halts, volatility interruptions,

limit-up-limit-down controls, etc.) to deal with volatile market conditions. Trading systems and algorithms should be robust and flexible such that they are capable of dealing with, and adjusting to, evolving market conditions. In the case of trading systems, this should include the ability to adjust to changes (including sudden increases) in message traffic

b. Recommendations regarding trading participants

Recommendation 3: All order flow of trading participants, irrespective of whether they are direct venue members or otherwise, must be subject to appropriate controls, including automated pre-trade controls. These controls should be subject to the regulatory requirements of a suitable market authority or authorities. In addition, regulators should identify any risks arising from currently unregulated direct members/participants of trading venues and, where any are identified, take concrete steps to address them.

ii. Recommendations for regulators

a. Regulator's knowledge of the markets and trading, and associated risk mitigation

Recommendation 4: Regulators should continue to assess the impact on market integrity and efficiency of technological developments and market structure changes, including algorithmic and high frequency trading. Based on this, regulators should seek to ensure that suitable measures are taken to mitigate any related risks to market integrity and efficiency, including any risks to price formation or to the resiliency and stability of markets, to which such developments give rise.

b. Market surveillance and market abuse

Recommendation 5: Market authorities should monitor for novel forms or variations of market abuse that may arise as a result of technological developments and take action as necessary. They should also review their arrangements (including cross-border information sharing arrangements) and capabilities for the continuous monitoring of trading (including transactions, orders entered or orders cancelled) to help ensure that they remain effective.

IOSCO's panel sessions gave rise to numerous suggestions on how regulators' tools could be enhanced to address the risks associated with the technological and market developments that have been seen over the past number of years.

Below are the possible tools to address Risk:

i. Level: Trading Firms:

- a. Given that relatively few jurisdictions currently have regulations that are designed specifically to address algorithmic trading or HFT, market authorities should consider whether tailored regulatory requirements should be introduced, especially in those markets where algorithmic trading or HFT is a dominant component of the market structure. Some presenters suggested that this might include anything from specific stress testing and sign-

off processes for new algorithms to specific charges or a tax on high order entry or cancellation rates;

- b. Consider whether those firms that are non-intermediary members of trading venues should be subject to registration/authorisation by a regulator in those jurisdictions where this is not already the case;
- c. Reassess whether requirements for managing conflicts of interest are sufficient in the circumstances where either:
 - an investment firm simultaneously conducts client-serving activities and proprietary trading; or
 - trading participants that trade on venues in which they hold an ownership stake;
- d. Review existing regulatory requirements regarding pre-trade risk controls applicable to intermediaries in order to evaluate whether they are suitable for today's high-speed markets. As part of this, consider banning the provision of DEA to customers if the customer's trading is not subject to appropriate pre-trade controls (i.e. so-called naked access)
- e. Assess whether HFT or algorithm traders should provide for specific forms of stress testing and internal sign-off processes for new algorithms

ii. Level: Markets/Market Operators

- a. Consider whether trading control mechanisms such as order entry controls to mitigate against anomalous order entry and circuit breakers or limit-up/limit-down systems should be mandated within the markets and, if so, whether venue operators should be permitted to design their own controls or whether they should be harmonised/coordinated across venues (including between interrelated instruments such as a derivative and its underlying).
- b. Consider whether there should be common trade cancellation arrangements in place across markets to ensure consistent treatment in the event of a sudden extreme price movement. These arrangements should be coherent in their operation with any order entry controls and volatility controls.
- c. Consider requiring that market infrastructure operators undertake appropriate stress testing to ensure that their systems are robust in the face of unusual spikes in trading activity
- d. Consider whether to require market operators to have appropriate testing environments in place to enable participants to stress test their algorithms;
- e. Assess whether a trading venues registered market makers should be subject to mandatory minimum criteria so as to ensure that they provide meaningful liquidity support to the market. As part of this, consider:
 - clarifying how market making should be defined; and

- banning so-called stub quotes (i.e. automatically-entered quotes that involve an extremely low bid price e.g. 1c, and an extremely high offer price (e.g. \$100k));
- f. Assess whether specific charges, fees or taxes on high order entry and cancellation rates or messaging rates should be introduced; and
- g. Consider the introduction of minimum tick sizes and minimum order book resting time.

iii. **Level: Market Structure**

- a. Reconsider the appropriate balance between encouraging competition between trading spaces (including between trading venues and OTC space), which helps to reduce trading fees and improves innovation, and promoting the use of transparent, on-venue trading;
- b. Consider banning flash orders, through which trading interest may be exposed on a market for less than a second during which only technically-adept participants are able to react to it, before it is routed elsewhere;
- c. Evaluate what could be done to improve market surveillance, taking into account the needs of different market structures. A high-level of surveillance of potential unfair activity by market participants is crucial. Up-to-date order screening/monitoring tools should be implemented (either by trading venue operators or by competent authorities) to help identify trading patterns and prevent inappropriate trading behaviour. Other possible measures could include the introduction of consolidated “audit trails” that are able to track orders, quotes and trades in the market. Other possibilities include introducing large trader reporting requirements (where these do not already exist), and introducing the use of entity identifiers to identify trading on a participant-by-participant basis or to flag algorithmic/HFT orders; and
- d. Review how existing market manipulation rules and laws apply to computer generated orders and whether activity traditionally deemed manipulative is still appropriate in today’s market environment (e.g. layering the book given the common HFT strategy of submitting orders at multiple price points).

Source:



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Chapter-7

**SEBI DISCUSSTION PAPER:
Strengthening of the Regulatory Framework
for Algorithmic Trading & Co-location**

Below points have been raised in SEBI's discussion paper and have been discussed in detail below with pros and cons, global review of similar measures and NSE and BSE response to the discussion points

7.1 MINIMUM RESTING TIME FOR ORDERS

i. Introduction

- (a) Resting time is defined as the time between an order is received by the exchange and the said order is allowed to be amended or cancelled thereafter.
- (b) The proponents of algorithmic trading have always argued that it has improved liquidity and depth of orders. The opponents of algorithmic trading have contended that the liquidity and depth provided by trading algorithms is 'Apparent' and 'Fleeting' as it vanishes as the traders intend to execute trade.
- (c) This issue of 'fleeting' or 'vanishing' liquidity arises from the ability of the trading algorithms to react to new developments (such as receipt of new order or market news) by usually modifying / cancelling their orders or placing new orders. It is also gathered that such ability to modify their orders has raised concerns with a section of market participants who consider that this ability is prone to market abuse.
- (d) In view of the above, securities market regulators / stock exchanges are considering / have considered the idea to eliminate "fleeting orders" or orders that appear and then disappear within a short period of time. As per the Minimum Resting Time mechanism, the orders received by the stock exchange would not be allowed to be amended or cancelled before a specified amount of time viz. 500 milliseconds is elapsed.

ii. Benefits

a. Can increase the likelihood of a viewed quote being available to trade

This has two important benefits:

- First, it provides the market with a better estimate of the current market price, something which 'flickering quotes' caused by excessive order cancellations obfuscates.
- Secondly, its visible depth at the front of the book should be more aligned with the actual depth. This knowledge of the depth improves the ability of traders to gauge the price impact of potential trades. Quotes left further away from the current best bid or offer are less likely to be affected by the measure since the likelihood of them being executed within a short time is small. Nonetheless, minimum resting times might be expected to make the order book dynamics more transparent to the market.

- b. **Reduces the excessive level of message traffic currently found in electronic markets**
Minimum resting times may also reduce the excessive level of message traffic currently found in electronic markets. Cancellations and resubmissions are a large portion of these messages, and at peak times they can overwhelm the technological capabilities of markets (as seen for example in the recent Facebook initial public offering (IPO) problems on NASDAQ) (<http://www.nanex.net/aqck/3099.html>).
- c. **Allay concerns that markets are currently ‘unfair’ in that high frequency traders are able to dominate trading by operating at speeds unavailable to other traders.**
This notion of ‘slowing down’ markets is not generally supported by economic analyses, but it does speak to the challenge of inducing participation if some traders, particularly small retail investors, feel that speed makes markets unfair.

iii. Cost and Risks

- a. **Picking off stale orders**
Preventing passive orders from being cancelled means that such orders are in constant danger of becoming stale. This rule change will artificially increase **adverse selection** effects for passive orders and will therefore cause an increase in the bid-ask spread as passive orders will need to be compensated for this additional adverse selection risk.

What is Adverse Selection?

Suppose that in between the time when a passive sell order is placed and when it can be cancelled, there is a positive news event that makes most market participants believe the price should be higher. The passive order is unable to respond to this event, thus it becomes a target to be picked off by an aggressive market order that buys the shares in the passive order and then immediately sells them at a higher price. The aggressive market order thus profits at the expense of the passive order. Such an effect is called adverse selection.

- b. **Raising transaction costs**
Aggressive orders remove passive orders from the book, which means less liquidity. Similarly, fewer passive order placements mean less liquidity. The net result is to increase the bid-ask spread, which increases the cost to make a round-trip transaction. In general, aggressive orders have more market impact, i.e. they cause larger changes in price. Thus transaction costs will likely go up across the board, for both large and small orders, and for both passive and aggressive orders.
- c. **Will hurt retail investors because of increased bid ask spread**
It will cause an increase in bid-ask spreads and therefore increased costs to retail investors not involved in the high frequency trading zero-sum game. Wider bid-ask spreads will also mean that less trades happen as they impose a larger cost to trading that needs to be exceeded by the benefits of each voluntary trade. Therefore the gains-from-trade will be reduced.
- d. **Increased volatility**
Less liquidity in the book may result in increased volatility. The price changes are noisy. Under this view, decreased liquidity leads to larger price changes when an aggressive order of a given size hits the market, thus causing more volatility.

- e. **It is unfair to impose a regulation that will so clearly benefit one type of HFT technology (aggressive) at the expense of another (passive)**

Firms specialize and this will lead to a shuffling in the market ecology, with possibly unpredictable consequences. Worse still, many market participants feel that it is fast predatory market orders that cause unstable or volatile price moves, which may be an additional reason to expect increases in volatility.

- f. **Change the dynamics of the market by attracting more aggressive high frequency traders whose sole aim is to take advantage of the free options**

Depending on the length of compulsory resting, those limit orders close to the best bid or offer are likely to become stale (that is, no longer at the efficient price) before they can be cancelled. This can spawn 'front running' by automated traders who collect the low-hanging fruit from such options. In return, the providers of passive quotes will protect them against staleness through yet larger bid-ask spreads, or by simply not posting quotes at all. Using the estimates by Farmer and Skouras, the cost of hitting such stale quotes may be as high as €1.33 billion per year in Europe.

- g. **High frequency traders may reduce their market making activities and possibly be replaced by institutional market makers**

Reduced competition among market makers and their need to earn a return on their capital may also drive up transaction costs for end users. Moreover, to the extent that minimum resting times inhibit arbitrage between markets, which is essentially at the heart of many HFT strategies, the efficiency of price determination may be diminished

- h. **Reduced liquidity around volatile periods**

During periods of high market volatility, new information enters more frequently than during normal periods. Around such periods, quoted prices can become stale in very short time intervals, based on the new information. Without the ability to modify / cancel the quotes, market participants would be reluctant to place their orders when it is **most** needed. This will make market liquidity less resilient and more un-stable around high information periods due to the imposition of minimum resting time.

- i. **HFT firms in the future may just redirect their gaze to pinpoint 499 and 501 milliseconds**

This can be done to generate their profits by picking off traders whose orders have remained in clear sight for half a second or more.

iv. Ambiguity

It is unclear if IOC orders will also be subject to the minimum resting time. If such orders continue to remain available, then there will be a movement from placement of limit orders to IOC orders by participants. This will not be an optimal solution as this will reduce the depth in the markets. If the restriction of minimum resting time is also imposed on IOC orders, these orders will lose their importance.

v. Evidence from Global Markets

- a. Currently, there are no instances of the ‘resting time’ mechanism being mandated by any regulator. It has been observed that Australian Securities and Investment Commission (ASIC) had sought feedback on the matter few years ago, but decided not to go ahead with the proposal.
- b. The commissioned study EIA3, examined the effects of minimum resting times inside simulated market. They did not recommend its adoption.
- c. In June 2009, ICAP introduced a minimum quote lifespan (MQL) on its electronic broking services (EBS) platform. These quote requirements set a minimum life of 250 milliseconds (ms) for their five ‘majors’ (generally currency contracts) and 1,500ms in selected precious metals contracts. In public statements, ICAP credits the absence of a major Flash Crash to MQLs

vi. Evidence from Indian Markets

As per IGIDR Comments on “SEBI’s Discussion Paper Strengthening of the Regulatory framework for Algorithmic Trading & Co-location” :using data for NSE spot and single stock futures (SSF) segment, the proportion and placement of orders cancelled in less than one second was analyzed. The analysis is done for the 150 derivative securities traded on NSE for November – December 2013.

Key Observations are:

- Spot market experiences lower percentage of cancellations in one second than the SSF market (36.83% in Q1 stocks on spot versus 70.05% on SSF).
- Across all stock quartiles, less than 8% of the orders are cancelled within one second while they are at best prices.
- A majority of the cancellations that occur in less than one second of arrival take place when the order is away from top five prices in the order book.
The above observations suggest that that less than 8% of the orders could be called fleeting orders. The remaining cancellations in less than one second occur when the order is far away from the touch.

- vii. **NSE’s view** is that resting time mechanism may be counterproductive and may lead to more order being pumped into the system and longer queues and waiting time, besides complexity induced in trading software.

viii. BSE's view

Objective

- To prevent repeated actions on orders and eliminate fleeting orders.
- Matching engine will validate timestamp of book order with incoming modification\cancellation request and accept only if it is compliance with resting period, else the request will be rejected.
- The matching engine will perform this additional validation in addition to the matching process itself

Comments

- More stability in limit order book
- Reduce fleeting orders
- Increased possibility of orders getting matched as they will be retained in the order book

7.2 FREQUENT BATCH AUCTIONS (PERIODIC CALL AUCTIONS)

i. Introduction

- a) Under the 'continuous matching' system deployed by the stock exchanges, the buy and sell orders received by an exchange are continuously matched and resultant trades take place.
- b) The mechanism of Frequent Batch Auctions would accumulate buy and sell orders on the order book for a particular length of time (say 100 milliseconds). At the end of every such period, the exchange would match orders received during the time interval.
- c) This proposal tries to address the problem of 'latency advantage' by undertaking batch auctions at a particular interval. The idea is to set a time interval for matching of orders which is short enough to allow for opportunities for intraday price discovery, but long enough to minimize the latency advantage of HFT to a large extent.
- d) For example: if one-way observed latency for a co-located participant at an exchange and an investor located at New Delhi is 1ms and 15ms respectively, Batch Auctions at every 20ms - 30ms may offer a fair chance to non-colocated participants to capture a trading opportunity.
- e) Expected impact: The proposal may nullify the latency advantage of the co-located players to a large extent. However, due to batch auction sessions happening every few milliseconds, the market infrastructure may require corresponding changes.

ii. Ambiguity

It is not clear whether the proposal is meant for all segments of equity markets, or any one particular segment. It is also not clear what time interval will be used for the proposed batch auctions. What information will be supplied **during** the batch auction period is also not clear. Whether only the equilibrium price will be indicated or whether the top five prices will be indicated is not clear. Further, it's also not clear if the orders will be executed on pro-rata basis, or on time priority basis.

iii. Benefits

a. Reduction of the speed of trading and the elimination of the arms race for speed

The speed of trading could be controlled through the timing and frequency parameters which could be tuned to individual and market conditions. It might increase liquidity or at least concentrate it at particular time points.

b. Eliminate Sniping

The proposal draws from Budish et al Research Paper, which argues that frequent batch auctions could eliminate sniping. The paper also claims that the measure can reduce the potential for manipulative activities such as spoofing and layering.

iv. Costs and Risks

a. Increased execution risk

Investors will face this risk if they do not know when the auctions will take place and then whether their bid will be in the winning set. If the frequency of auctions does not reflect market conditions, there may be some shortfall in matching supply and demand.

b. May reduce Liquidity

Since this is a proposal and has not been tested anywhere in the world, it is unclear how frequent batch auctions will affect liquidity. In the presence of one exchange offering continuous trading (example: SGX for Nifty futures) and another offering batch auctions (NSE for Nifty futures), traders will prefer immediacy and migrate to the SGX. This will exacerbate the fragmentation of a single market for the security, and can drive away liquidity from domestic markets.

c. Reduce incentives to supply liquidity

Periodic call auctions would have a severe impact on the business model of market makers and may reduce incentives to supply liquidity

d. Lead to drastic change in Trading Landscape

The current market structure allows a variety of different trading mechanisms and allows for auction-based trading as well as the continuous limit order book (in both lit and dark modes in international markets). This proposal would limit choice and require quite a drastic change in the trading landscape. Furthermore, it would require coordination at the global level, which may be difficult to achieve.

e. **Cross-market arbitrage**

The implementation will require perfect time synchronicity across exchanges for cross-market arbitrage. If not, then it will raise the arbitrage risk and can adversely affect the pricing efficiency across two markets auctions.

f. **Increased adverse selection costs**

The implementation of batch auctions could increase adverse selection costs for traders by making the quotes stale as in the case of an intervention that forces a minimum resting time. This will especially be true of high volatility periods when information arrival in the market is high

Evidence: Haas and Zoican, (2016) “HFT Competition and Liquidity on Batch Auction Markets”

g. **Reduced transparency**

In a continuous market mechanism, a trader sending a market order can compute execution price for his trades. Such markets update prices in real terms and provide price discovery in its true sense. This will not be possible if markets move to frequent batch auctions model

h. **Implementation costs**

The implementation of frequent batch auctions requires incurring the cost of a structural change in the market infrastructure from continuous trading. This means that all current market institutions and processes (including the calculation of margins for clearing and risk management such as price bands and margin limits). This cost will be imposed on all market participants which makes this an expensive approach.

v. **Evidence in Global Markets**

Taiwan Stock Exchange (TWSE) used to have continuous auction mechanism as the order matching method wherein orders were batched over various time intervals. TWSE has now moved to continuous limit order book mechanism for regular trading. Auction methodology is used only for opening and closing price sessions.

Cheng and Kang (2007) analyzed the impact of the new mechanism on market quality of TAIEX using intra-day data. They find that, “the market is more liquid, and volatility is slightly lower, under continuous auction than under call auction. Also, there is robust evidence that continuous auction improves informative efficiency.”

vi. **Evidence from Indian Markets**

Trading in illiquid stocks in the equity markets of NSE, BSE, MSEI are conducted only through a periodic call auction mechanism from April 2013

i. **As per NSE**, Call auction mechanism introduced in Indian markets have had negative impact in terms of:-

- i. Liquidity in those securities

ii. Spreads have increased

iii. Overall investor's participation has been adversely impacted.

ii. **NSE's view** is that introduction of call auction market would be an extremely retrograde step for our markets and seriously impede price discovery. No large and progressive market in the world uses an auction for regular trading session.

iii. **BSE's Views**

Objective

- a. Replace continuous matching by multiple and frequent call auctions.
- b. This is a change in the market scheduler, no code change is required.
- c. Risk is of one auction overflowing into another.

Observations

- a. Fundamentally change the core matching model from continuous matching to a staggered matching.

7.3 RANDOM SPEED BUMPS OR DELAYS IN ORDER PROCESSING / MATCHING

i. Introduction

The Speed Bump mechanism involves introduction of randomized order processing delay of few milliseconds to orders.

ii. Benefits

a. **Nullify Latency Advantage**

The intent behind such mechanism is to nullify the latency advantage of the co-located players to a large extent. The delays would affect HFT but would not deter non-algo order flow for which delay in milliseconds is insignificant.

b. **Could stop the arms race for speed**

However it is not clear how much it will nullify the speed advantage of HFT. No positive impact on any other HFT related concern is expected.

iii. Costs and Risks

1. **Increase Uncertainty and adverse selection costs**

The randomness element will add to the uncertainty on when the order will go to the exchange, and will increase the adverse selection costs.

2. Reduced / withdrawal of liquidity

The reduced participation because of higher adverse selection costs will likely be exacerbated during high information periods and reduce liquidity to traders and investors when it is needed most. Finally, for products which are traded on international markets (such as the SGX, DGCX), such a measure is likely to drive away liquidity from domestic markets. This will lead to higher price discovery of Indian assets on foreign shores.

3. Increased price disparities across different market segments

Since this intervention increases uncertainty for traders, and reduced participation, it would increase persistence of violation of cross-market arbitrage and worsen price inefficiencies across market segments.

4. Implementation costs

The implementation of speed bumps will a direct cost for the exchange, and will raise costs of trading to end investors.

iv. Evidence from Global Markets

- a. ParFX, a wholesale electronic trading platform designed by Tradition (an interdealer broker in over-the-counter financial and commodity-related products), applies randomized pause to all order submissions, amendments and cancellations by between 20-80 milliseconds. This limits the advantage of ‘first in, first out’ trading and nullifies advantages gained by low-latency trading strategies. It is understood that the objective is to provide a level playing field for participants wherever they are located and whatever their technological or financial strength.
- b. TSX Alpha Exchange (TSXA) imposes a randomized order processing delay of between 1 and 3 milliseconds on all orders that have the potential to take liquidity. This is intended to discourage opportunistic liquidity taking strategies. The intention is to encourage orders to contribute to greater volume at the best bid/offer, translating to larger trade sizes and better fill rates for active orders.
- c. SEC (USA) has approved a proposal of IEX that non-routable Immediate-or-Cancel (“IOC”) orders shall be subjected to a certain sub-millisecond delay before arriving at the IEX system.
- d. As per Thomson Reuters, it will be introducing a mechanism for its FX Spot Matching services that introduces a short delay of several milliseconds before processing orders.

v. Evidence from Indian markets

As per IGIDR Comments on “SEBI’s Discussion Paper Strengthening of the Regulatory framework for Algorithmic Trading & Co-location” the average time to modifications of an order by algorithmic traders and non-algorithmic traders for Nifty 50 and Nifty Next set of stocks was calculated. The analysis is done for the NSE spot market for the period of 2013.

The median time between modifications of algorithmic traders is recorded as 0.21 second on Nifty stocks. The same for non-algorithmic traders is 97 seconds. This indicates a significant difference between the reaction time of algorithmic and non-algorithmic traders. However, this doesn't come as a surprise since algorithmic traders are expected to be much faster than the non-algorithmic traders. (Find Table below for reference)

Given the difference, the question that arises is: will the speed bump of some milliseconds bring the latency experienced by algorithmic traders closer to the latency of non-algorithmic traders, and will it make the market a level playing field? The answer to the question appears to be a no.

Average time between modifications on NSE spot segment:

The table below presents average time between modifications for Nifty 50 and Nifty Next stocks on the NSE spot market in 2013. Algo represents average time between modifications in an order by algorithmic traders, while non-algo represents average time between modifications by non-algorithmic traders.

Table 7.1: Average Time between Modification for Nifty 50 and Nifty Next Stocks on the NSE Spot Market (2013)

All values in milliseconds

	Nifty stocks		Nifty Next stocks	
	Algo	Non algo	Algo	Non algo
Q1	26	6,847	27	8,366
Median	211	97,220	371	89,943
Q3	1,400	1,638,676	2,252	1,548,837

vi. **In NSE view**, speed bumps will not deter algo traders as it can be programmed to cushion against the bumps.

vii. **BSE's view**

Objective

- a. Forcefully delay orders with random time delays before taking up for matching. Orders will continue to have price time priority, with a random delay introduced in the flow.

- b. Randomization logic is of utmost importance. Orders will be scheduled for processing after a random delay within a specified time range and taken up for matching after the delay.

Comments

- i. Time priority is retained, but with an introduced delay in the flow
- ii. All orders including non-colo orders will be impacted by the delay.
- iii. Possibility of cascading effect of random delay on subsequent orders.

7.4 RANDOMIZATION OF ORDERS RECEIVED DURING A PERIOD (SAY 1-2 SECONDS)

i. Introduction

- a. As per the mechanism, time-priority of the new / modified orders that would be received during predefined time period (say 1-2 seconds period) is randomized and the revised queue with a new time priority is then forwarded to the order matching engine.
- b. Similar to the mechanism's mentioned above, the said mechanism is expected to nullify the latency advantage of the co-located players to a large extent that they get on the basis of physical proximity to the trading platform and thereby, discourage latency sensitive active strategies.

ii. Benefits

- a. **Reduce Latency Advantage**
The proposal is to reduce the latency advantage by changing the time priority of the new / modified received in a certain time period. The revised queue with new time priority will be forwarded to the order matching engine.
- b. **Profits available to fast traders will reduce**
By making the timing of the market event uncertain, the profits available to fast traders will also go down as they will not be guaranteed a "last-mover advantage".

iii. Costs and Risks

- a. **Relevance of IOC orders**
The mechanism defeats the time priority of the present system, and will vitiate the purpose of IOC orders.
- b. **Increased uncertainty**
The introduction of randomized order delay will increase the uncertainty and the adverse selection costs of the trader, especially during volatile periods.
- c. **Lower liquidity**
The new constraint could deter traders from trading. This will cause liquidity to migrate to markets where such a feature does not exist, and will benefit the offshore exchanges at the cost of domestic exchanges.

d. **Reduced cross-market arbitrage**

The uncertainty regarding when an order will reach the exchange's order matching could deter the participants from executing cross-market arbitrage at short time frames. This can result in increased disparity in prices across market segments.

e. **Synchronizing randomization across all market venues and its global implementation**

The hardest part to implement is the synchronized randomization across all market venues and its global implementation. However, relaxing the synchronization requirement and the fully global implementation would still likely yield significant benefits

f. **Reduced market quality under the new mechanism**

This may occur for example because of an increase in execution uncertainty and execution price uncertainty for high frequency traders. However, low frequency participants are already subject to these uncertainties and may in fact find it easier to monitor slower markets.

g. **Reduce incentives to provide liquidity**

Another negative implication is that by reducing the profitability of fast liquidity provision it may reduce the positive externalities emerging from private incentives to provide liquidity.

iv. **Evidence from Global Markets**

- a. ICAP's EBS Market Matching Platform has introduced 'Latency Floor' that consists of a random batching window of 1, 2 or 3 milliseconds, whereby all messages submitted within this period are collected and then randomly released to the matching engine. The process is aimed at ensuring that speed as a stand-alone strategy is not a pre-requisite for success on EBS Market.
- b. Randomization is commonly used in opening and closing auctions especially in European exchanges but there is no such study specifically of the effect of randomization

- v. **NSE's view** is that in absence of any substantiated advantage of randomization of already randomly received orders and the uncertainty it brings in the order book the proposition does not serve any objective.

vi. **BSE's view**

Objective:

- a. Collect orders over time intervals and taking up randomly for processing
- b. Randomization logic is of utmost importance. Orders will be held into a common pool and taken up for matching based on the randomized seed. This will be done on regular intervals say 1 millisecond.

Comments

- a. Akin to holding back orders for a duration, and randomly taking up for matching
- b. Paradigm shift from an event based matching to timer based matching
- c. Inherently has the ability to offer a chance to non-Colo orders even if the ratio of Colo to non-Colo orders is huge.
- d. Time priority is affected in this case.

7.5 MAXIMUM ORDER MESSAGE-TO-TRADE RATIO REQUIREMENT

i. Introduction

A maximum order-to-trade ratio requires a market participant to execute at least one trade for a set number of order messages sent to a trading venue. The mechanism is expected to increase the likelihood of a viewed quote being available to trade and reduce hyper-active order book participation.

The mechanism is slightly different from ‘Order-to-Trade Penalty Rule’ implemented by the stock exchanges in Indian securities market as the trader in the proposed case would not be able to place such orders that further increase the ratio, after the limit is breached. As per the Order-to-Trade penalty mechanism implemented by the stock exchanges in Indian securities market penalty as per the prescribed slabs are imposed on the traders. There does not exist restrictions on the placement of orders.

ii. Ambiguity

The proposal lacks clarity on the design. It is unclear at what time interval the ratio will be calculated; whether it will be measured in real time at every point of time or whether it will be accumulated over a certain time interval; whether it will be computed at the member level

iii. Benefits

a. Reducing the number of economically excessive messages

Receiving, handling and storing messages is costly for exchanges, brokers and regulators. A ratio of orders-to-executions (OER) will reduce the number of economically excessive messages. This, in turn, will reduce the need for exchanges, brokers and other market participants to invest in costly capacity.

b. Increase Market depth

With fewer quote cancellations, the order book may be less active and traders may find it easier to ascertain current prices and depths. An OER also may increase the likelihood of a viewed quote being available to trade, partly because passive order submitters would focus more on those limit orders with a higher probability of execution.

c. Curtail market manipulation strategies

Strategies such as quote stuffing, spoofing and layering are illegal but they are often hard to detect. By limiting order cancellations, an order-to-execution ratio will reduce the ability to implement these strategies.

iv. Costs and Risks

a. Reduced liquidity

If the requirement to maintain the maximum message to trade ratio becomes binding, the imposition of this rule could constrain the traders from sending new orders or modify or cancel existing orders. The inability to send new orders could reduce liquidity provision. Such restrictions will inevitably result in stale quotes. This is likely to trigger a similar

trigger of higher adverse selection costs, higher inventory risk for a liquidity provider, to disincentive market participants to competitively place quotes at the best prices.

b. **Withdrawals during volatile periods**

The inability to send orders after breaching of the maximum limit will adversely affect the ability of traders to provide liquidity during volatile periods.

c. **Implementation costs:** The implementation would require the exchanges to monitor the message to trade ratio of each participant at a certain time interval. This will be an additional cost for the exchange

d. **Depth may be affected**

If the order-to-trade ratio will be a non-binding constraint, the depth and bid-ask competitiveness will not be affected. However, when a market participant does near the maximum quote-to-trade ratio they will likely be more cautious about placing quotes given they will be penalized if they withdraw too many quotes. This hesitance is most likely to occur in volatile times, meaning that depth may be removed

e. **Increase bid ask spread**

Market participants will be more hesitant to place shares on the order book, they will also be less likely to aggressively compete for posting quotes at the best bid and offer prices, which will result in increased bid-ask spread

f. **Less Transparent Limit Book**

To find liquidity, traders often 'ping' or send small orders inside the spread to see if there is hidden liquidity. Because such orders are typically cancelled, a binding OTR would result in less pinging and, therefore, less information extraction at the touch. As a result, more hidden orders will be posted, leading to a less transparent limit order book.

g. **Where exactly to set any ratio and to what type of orders or traders it will apply**

If the upper limit of the OER is small, then it will stifle legitimate activities and prevent socially useful trading. For instance, ETFs and derivatives valuations may become unaligned, leading to inefficient pricing. Because of this, the London Stock Exchange (LSE) has an OTR of 500/1 for equities, ETFs and exchange traded products (ETPs), with a high usage surcharge of five pence for equities and 1.25 pence for ETFs/ETPs.

If instead the upper limit is set high enough not to impinge on legitimate order strategies, it may not have much impact on the market either (a point made by Farmer and Skourous (EIA2:Minimum Resting Time and Transaction Order Ratio))

If the intent is to limit manipulative strategies, a specific charge for messages (and greater surveillance) may be a better solution.

v. **Evidence from Global Markets**

a. There have been no published academic studies of OERs, and this greatly limits the ability to gauge the costs and benefits of order activity restrictions in general and OERs in particular. The commissioned study, (EIA18: Order to trade ratios and their impact on

Italian stock market quality), investigates the effect of the introduction of an OER penalty regime on the Milan Borsa on 2 April 2012. The authors' preliminary findings are that liquidity (spreads and depth) worsened as a result of this policy measure. They also find that the effect is more pronounced in large stocks, although they acknowledge some issues with their methodology.

- b. There are a variety of actual market programs that provide some evidence of OER impact. The ICAP has a monthly fill ratio (MFR) requiring that at least 10% of all quotes submitted into the market must result in an execution.
- c. LSE's Millennium trading system has message throttling constraints and penalties for excessive ordering strategies. Anecdotal evidence suggests that the LSE message policy was not fully effective in that it gave rise to new patterns of trade in low-priced stocks. The LSE has experimented with changes in pricing effective May 4, 2010 whereby, among other measures, the threshold for the high usage surcharge for FTSE 350 securities increased from an OTR of 100/1 to a ratio of 500/1 (which is still the figure in use at the time of writing) along with high usage surcharge of five pence for equities and 1.25 pence for ETFs/ETPs. The frequency of order book updates nearly doubled for a few months as a result before coming down again.

vi. Evidence from Indian Markets

- a. A similar instrument has been implemented twice before on orders in the Indian equity derivatives markets:
 - The first was by the NSE in 2009 (reduced in 2010) in order to manage excessive placement of IOC orders causing bandwidth constraints at the exchange
 - The second was by SEBI in 2012 (doubled in 2013) on orders that fell outside one percentage band around the LTP.
- b. Aggarwal et al. (2016) in their research paper "The causal impact of algorithm trading on market quality" analyse the impact of these interventions and find that such interventions can be used effectively when:
 - the objective is clearly stated and
 - When it is effectively designed.

Research Paper:



Agarwal
Thomson_Causal Imp

- vii. NSE's view** is that this rule of order to trade ratio and penalties and severe action including not able to participate in trading are already in place in India and the same is effectively working.

viii. BSE's view

Objective:-

- a. Manage order to trade ratio in real time
- b. Trading system will maintain the order and trade count and compute OTR in real time.
Based on the OTR rules, orders may be rejected\accepted.

Comments

- a. Benefit in this case may be similar to that of minimum resting time
- b. Present mechanism - disciplinary action for cooling off for first 15 minutes of trading on the next trading day
- c. Ensures that orders translate to trades more effectively

7.6 SEPARATE QUEUES FOR CO-LOCATION ORDERS AND NON-COLO ORDERS (2 QUEUES)

i. Introduction

- a. With the view to ensure that stock brokers (and thereby the investors) who are not co-located have fair and equitable access to the stock exchange's trading systems, stock exchanges facilitating co-location / proximity hosting shall implement an order handling architecture comprising of two separate queues for co-located and non-colocated orders such that orders are picked up from each queue alternatively. It is expected that such architecture will provide orders generated from a non-colocated space a fair chance of execution and address concerns related to being crowded-out by orders placed from colocation. The proposed architecture is as described below:
- b. Stock exchange shall identify and categorize orders as (a) orders emanating from servers of the stock broker placed at the co-location / proximity hosting facility, and, (b) orders emanating from other terminals / servers of the stock brokers.
- c. Separate order-validation mechanism and a separate queue shall be maintained for each of the aforementioned categories of orders.
- d. A round-robin methodology shall be used to time-stamp and forward validated orders from the two order-queues to the order-book, i.e., if an order is taken from the queue of orders emanating from co-location / proximity hosting facility, then the next order shall be from the other queue. In the event any of the order-queues are empty, orders can be sequentially taken from the other queue till a valid order arrives in the empty queue.
- e. As per the mechanism, separate queues and order-validation mechanism would be maintained for co-lo orders and non-colo orders. Orders from queues will be taken up in the order-book in round-robin fashion.
- f. It may however be noted that the colocated participants would still be among the first to receive the market data feeds due to their proximity to the trading platforms of the exchange and this coupled with the capability to make trading decisions in fraction of seconds (by use of trading

algorithms) would still provide the co-located participants the ability to quickly react to such market data.

ii. **Benefits**

The benefits will be limited since the co-located participant would still be among the first to receive the market data feeds due to his proximity to the exchange, and react to an opportunity because of technological advantage. Thus, the benefits appear to be non-existent.

iii. **Costs**

a. **Implementation costs**

The implementation of the proposed mechanism would impose substantial costs on the market and the economy.

b. **Two markets for two sets of investors**

The presence of two queues will result in two sets of prices at any given time for a security: one coming from collocated participants and another for non-co-located participants. Since the collocated participants will have the advantage of responding first to prices, these prices will be the most efficient prices. This will lead to liquidity migrating to only the co-located market, and killing off the market for non-co-located trading.

c. **Withdrawal of liquidity**

Such a mechanism has the potential to drive liquidity from domestic exchanges to offshore exchanges where no such constraints would apply

iv. **NSE's view** is that two queue proposition is effectively splitting the market into algo market vs non algo market. Splitting the market may not be the regulatory objective. Exchanges may be required to provide co-location service to all members transparently.

v. **BSE's Views**

Objectives

- a. Collect orders from Colo and non-Colo in separate queues for matching
- b. Take up orders from each queue based on prescribed logic
- c. Need to ensure that orders from non-Colo get a fair chance vis-à-vis orders from Colo
- d. Apply exception conditions when order rates are skewed

Comments

- a. Can potentially provide fair chance for non-Colo orders
- b. Colo users will not have any visibility of the implementation
- c. Algorithms can be applied to change the fairness when order rates between Colo and non-Colo are skewed
- d. No impact on trading members software

7.7 REVIEW OF TICK-BY-TICK DATA FEED

i. Introduction

- a. Tick-by-Tick (TBT) data feed provide details relating to orders (addition + modification + cancellation) and trades on a real-time basis. TBT data feed facilitates a detailed view of the order-book (such as depth at each price point, etc.).
- b. At present, the exchanges provide TBT data feeds to any desirous market participant upon payment of requisite fee.
- c. Tick-by-Tick data feed is mainly subscribed by HFTs who coupled with their access to colocation use such feeds to recreate the order-book and analyze the impact of execution.
- d. TBT data feed is usually not availed by small players due to the feed being data-heavy (as it includes details of all the order submissions, cancellations and modifications) and because of the additional fee-component.
- e. This has been viewed by a section of market participants to create disparity and inequality in terms of access to data.
- f. The proposal under examination is to provide 'Structured Data' containing Top 20 / Top 30 / Top 50 bids / asks, market depth, etc. to all the market participants at a prescribed time interval (or as real-time feed).
- g. The objective of the proposal is to adhere to the principle of market fairness by providing a level playing field to the market participants irrespective of their technological or financial strength.

ii. Benefits

The information may be provided to all participants at the same time interval

However, a trader can benefit from real time feeds only if he has the infrastructure to assimilate the huge data and act upon it. Inability to process this information will not result in any benefit from elimination of TBT data and provision of real time feeds to all traders.

iii. Ambiguity

It is unclear as to how equality in access to data will help small traders, especially if these investors are unable to take advantage of the tick by tick due to infrastructure requirements needed to process large data sets.

iv. Costs

- a. Can reduce the level of transparency if the data feed is anything other than real time feed
In this case, traders will not be able to see the price situation at every given point which will adversely impact the price discovery process in the market.

v. **Evidence from Indian Market**

- a. BSE uses multicast to disseminate TBT data(also known as EOBI) thereby ensuring fairness for all consumers. Data is available free of cost to all colo members. Members need to have suitable infrastructure to handle and process the TBT data. All colo members are using this data. BSE can restrict dissemination of Full order book data immediately, if mandated.

- vi. **In view of NSE**, tick by tick data allows for more transparency to the market. Not giving or restricting tick by tick data is restrictive and goes against the principles of transparency and will affect market integrity and efficiency.

vii. **BSE's views**

Comments

- a) Allows members to access full order book.
- b) Real time access to TBT data

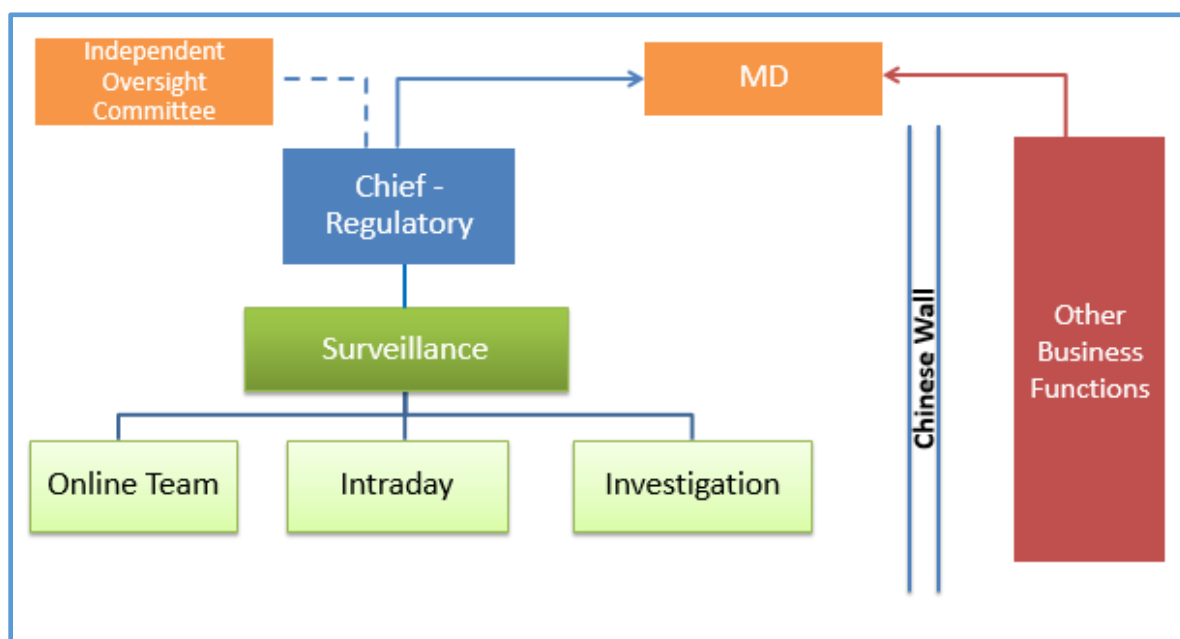


Chapter-8

SURVEILLANCE SYSTEM AT STOCK EXCHANGES

8.1 CURRENT SURVEILLANCE STRUCTURE AT NSE

Below given diagram illustrates the functional architecture



8.2 SURVEILLANCE FUNCTIONS COVERED AT NSE

These include online surveillance, surveillance actions and alert generation, as illustrated below:



8.3 CURRENT SURVEILLANCE MECHANISM ON NSE AT INTRA-DAY BASIS FOR ALGO TRADES BASED ON ORDER TO TRADE RATIO

Introduction

- Applicable only for Algo Orders and trades and in FAO and CDS Seg.
- Order to Trade ratio = Order Messages / No. of Algo Trades

Note: - Order Messages = Orders Entered + Orders Modified + Orders Cancelled

Actions

- If ratio exceeds 500, **member disabled** for first 15 minutes on the next trading day. If ratio exceeds 50, in more than 10 instances in previous 30 rolling days, **member's prop account** disabled for 1 hour on next trading day.
- Monetary penalty is being levied to members depending on their ratio and slabs.

Table 8.1: Monetary Penalty levied in last 3 Financial Years

Year	Total Penalty	Avg. Penalty	Disabilities
2014-15	6,96,097	58,008	9
2015-16	6,80,899	56,742	4
2016-17	1,76,963	58,988	Nil

Impact of current Surveillance mechanism on NSE at intra-day basis for algo trades

1. Impact on Order to Trade Ratio at Market level -

Table 8.2: Order to Trade Ratio at Market Level 2016

Month	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16
OTR	8.68	9.41	8.36	8.29	8.41	7.97	7.35	6.95

Note: Order to trade ratio has reduced from 9.41 to 6.95 levels

2. Impact on Member having highest Order to Trade Ratio

Month	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16
Ratio	214.72	213.28	280.53	266.13	222.78	222.58	182.59	151.79

Note: Order to trade ratio has reduced from 213 to 151 levels

3. Impact on Order to Trade Ratio in Northern Region–

OTR has improved from 32 to 25. Further letters were sent to 20 Members of which 14 Members have improved their OTR. Exchange is pursuing the members who have not shown any improvement.

After Meeting	Before Meeting
25.44	32.10

8.4 RISK MANAGEMENT MECHANISMS FOR ALGORITHMS EMPLOYED BY THE EXCHANGE



As prescribed by SEBI vide its circular CIR/MRD/DP/09/2012 dated March 30, 2012 trading members desirous of placing orders using algorithms are required to ensure that the orders are routed through risk management checks. For detailed risk controls, refer below attached Exchange circular no. 21793 dated September 28, 2012.



Circular 21793 dated
September 28 2012.p



Exchange has various technical and functional checks to prevent rogue algos. There are order flow controls or throttles for controlling the order flow from a member. Functionally, there are price bands and price reasonability checks (dynamic price bands) in place to prevent cases of high volatility. Other functional checks like Self Trade Prevention Check (STPC) and Reverse Trade Prevention Check (RTPC) to prevent the same user(s) from manipulating trades, are also applied. Exchange also levies 'Fair Usage Charges' on members for inefficient execution of the order flow.

Refer Below for more details:



Annexure 5 - Sec 6
Q40 BSE Market Surv

Below is the summary of order-level and client -level algorithmic trading risk management:

S.N.	Risk Control	Applicability
At Individual Order Level:		
1	Price Check	Algo orders shall not be released in breach of the price bands /dummy filters as defined by the Exchange in respective segments.
2	Quantity Check	Algo orders shall not be released in breach of order quantity limit per order as defined by the Exchange in respective segments
3	Order Value Check	Algo orders shall not be released in breach of the “value per order” (combination of price and quantity checks) as defined by the Exchange for the security in respective segments
4	Trade Price Protection Check	Algo orders shall not be released in breach of the bad trade price as defined by the Exchange for the security in respective segments
5	Market price protection	Market orders emanating from Algo system shall not be released beyond a pre-set percentage of LTP. The limit thus set shall be less than the applicable circuit limits as prescribed above
At Client Level :		
6	Cumulative Open Order Value Check	Algo orders shall not be released in breach of Individual client level cumulative open order value check at the client level. Open order value for a client is the total value of its unexecuted orders released from trading members system. System shall not permit the user to set “Unlimited values”
7	Automated Execution Check	Algo to account for all executed, unexecuted, and unconfirmed orders placed by the system before releasing further orders. Algo system to have pre - defined parameters for an automatic stoppage in event of Algo execution leading to a loop or a runaway situation.
8	Net Position Vs. available margin	Algo orders shall not be released in breach of Net positions as against the available margin defined by the trading member for the client.
9	RBI Violation checks for FII Restricted stocks	Algo orders shall not be released for security restricted by RBI from time to time
10	MWPL violation check	Algo orders shall not be released in breach of market wide position limit as defined by the Exchange for the security in respective segments
11	Position Limit Checks	Algo orders shall not be released in breach of position limit as defined by the trading member for the client

12	Trading Limit Checks	Algo orders shall not be released in breach of overall trading limits as defined by the trading member for the client
13	Exposure Limit check at individual client level and at overall level for all clients	Algo orders shall not be released in breach of exposure limit as defined by the trading member for the client

8.5 SEPARATE RISK MANAGEMENT MECHANISMS FOR HFT



Trading members are not required to share the business logic of algo as it is a proprietary information. Further, SEBI has not prescribed any specific requirements for HFT as it is a part of Algos. However members may build risk management systems over and above the ones prescribed by SEBI



Risk management controls are implemented for all order flows. Users of HFT have the HF ids, while the non algo users are provided the LF ids. The order flow rate for HF ids is controlled at millisecond level while the LF ids rate is controlled at seconds level

8.6 SURVEILLANCE MECHANISMS IN PLACE TO CATCH HARMFUL HFT ACTIVITIES



The Exchange amongst other alerts, generates and analyses following type of alerts specifically from algo trading behaviour:

- Order Spoofing,
- Quote Stuffing,
- Marking the close,
- Large Cancelled orders
- Large unexecuted orders



Surveillance processes are applied to all trades irrespective of the origin or mode in various jurisdictions including in India. At BSE, HFTs are generally routed through Co-Location which has a unique identifier. The Exchange Surveillance system based on the pre-determined criteria generates alerts and reports for monitoring the trading for Algo as well as Non-Algo orders. The Algo orders carry separate indicator as an identifier.

Exchange has various technical and functional checks to prevent rogue algos. There are order flow controls or throttles for controlling the order flow from a member. Functionally, there are price bands and price reasonability checks (dynamic price bands) in place to prevent cases of high volatility. Other functional checks like Self Trade Prevention Check (STPC) and Reverse Trade Prevention Check(RTPC) to prevent the same user(s) from manipulating trades, are also applied. Exchange also levies 'Fair Usage Charges' on members for inefficient execution of the order flow.

8.7 DO SURVEILLANCE MECHANISMS CHANGE IN PERIODS OF HIGH VOLATILITY



Prior to any major event Surveillance calls for a meeting of members wherein members share their views, trends prevailing in the market and their risk containment measure. The same process is carried out along with SEBI.

Further Exchange has put in place various systems/ measures such as price bands, trade execution range, dynamic price bands, risk reduction mode etc. which helps mitigate risk and helps in orderly functioning of the market.



High volatility in the market can be witnessed on account of specific micro & macro events and may lead to increase in inflow of orders/trades and price volatility in the contacts/securities being traded at the Exchange.

The Surveillance systems at BSE is regarded as mission critical system and the same has been tested at their peak capacity and are capable of handling instances of high volatility.

Further, to address in the event of high volatility, the Exchanges in India have put in place a mechanism of Market Wide Circuit Breaker as per the Regulatory mandate to be applied across the Exchanges in coordinated manner. These circuit breakers when triggered bring about a coordinated trading halt in all equity and equity derivative markets nationwide i.e. across the Exchanges.

8.8 KILL SWITCHES



Kill switch facility allows the member to cancel all orders sent to and pending at the Exchange with a single function. All orders entered by the specific user invoking the said facility and if pending at the Exchange, shall be cancelled.

NSE has deployed kill switch functionality in trading vide its circular no. 26337 dated March 31, 2014.(refer below)



Circular 26337 dated
March 31 2014.pdf



Members are required to terminate the dysfunctional algorithm at their end using kill switch. This can be either manual or automated as developed by the member.

Till date, the kill switch is not deployed by the Exchange. If Exchange detects rogue behavior of an algo, Exchange would inform the member to deploy the kill switch.

8.9 NEED BY EXCHANGES TO ENHANCE ITS SURVEILLANCE SOFTWARE/ PROGRAMS

It can be concluded that NSE and BSE has robust broader level Risk Management and Surveillance systems in place that are capable of identifying abnormal market activity and trade manipulation for necessary actions.

However, the exchanges need to control and curb HFT malpractices through the introduction of advanced Surveillance mechanisms and technology, some of which are discussed below:

- SEBI should have a unified framework for exchanges to manage surveillance on the algorithmic trading front.
- Currently each exchange has its own methods and levels of sophistication to manage surveillance. Harmonization of surveillance mechanism would bring about uniformity in exchange action towards harmful HFT.
- There is a definite need to invest in advanced technology to automatically detect harmful HFT and market manipulative trends/algorithms.
- Currently, exchanges hardly have advanced mechanisms to detect harmful HFT – there is a need for technological advancement wherein a team of advanced algo specialists be setup and appropriate infrastructure be invested in, which build detection algorithms to catch consistent market manipulative behaviors of harmful HFT algorithms and also consistently mine market manipulative trends emerging from order-to-trade ratios.
- Currently, there is no mechanism to check the algo submitted by any trading member. From surveillance, if consistently high order-to-trade ratios are detected for certain trading members, there should be norms to check the algorithm logic of the member. There needs to be regulatory framework allowing this as well as enough algo experts on the exchange front who understand algorithms.



Chapter-9

ALGO TRADING AND EXCHANGE APPROVALS

9.1 PROCEDURE FOR GAINING ALGORITHMIC TRADING APPROVAL



A) Following are the pre-requisite for trading members seeking algo trading approval:

- Submission of Undertaking
- Meeting Base Minimum Capital (BMC) requirement of Rs.50 lakhs
- Testing of Software in UAT, Test and Mock environment
- Auditor certificate

B) Below is the approval process:

- Submission of application: Trading members desirous of seeking approval for algo trading are required to make an application to the Exchange electronically.
- Demonstration of Software: Trading members shall be required to give demonstration of the Automated Risk Management features as mandated by SEBI /Exchange.
- Approval: On verification of the documents and fulfilment of the conditions as satisfactory and meeting SEBI / Exchange minimum requirements, the Exchange grants permission to the trading member.



As per SEBI circular CIR/MRD/DP/ 09 /2012 dated March 30, 2012 Exchange has designed a comprehensive application form and undertaking to be provided by members desirous of seeking approval of algos from Exchange. Trading Members desirous of using algo trading facility for Prop / Client trades are required to seek approval from the Exchange. Members desirous of getting their algos approved should make an application with details of the algo and version. They also need to either participate in the mock, or get the algos verified in the Exchange simulation environment. They also need to get their algos certified by a CISA/DISA certified auditor of having tested the same with respect to the Exchange risk management requirements. Subsequently, the certified algo is placed before the exchange Algo committee. Based on the approvals from the exchange Algo committee, the algo is allowed for use by the member.

9.2 PROCESS FOR FIRST TIME ALGO APPROVAL OR ADDITIONAL SOFTWARE FROM
DIFFERENT IT VENDOR:

1. Trading member submits the following documents as per checklist :
 - i. Algo application form
 - ii. Auditor Testing Report
 - iii. Auditor Covering letter and system audit report

- iv. Software & Algo Undertaking (one time submission. Not required if given earlier)*
2. On the receipt of complete documents Exchange verifies that whether the trading member has ensured that the such algo facility adheres to following automated risk management checks
- i. Fat Finger' check - Any single order does not carry abnormally large quantity beyond pre-defined limit
 - ii. Any single order does not carry abnormally large value beyond pre-defined limit
 - iii. The price of any single order should not be more than the applicable price bands including dummy price bands defined by the Exchange for security/contract.
 - iv. All orders generated by Algorithmic trading products are tagged with appropriate location code(s) as specified by the Exchange and such location code(s) are registered with the Exchange
 - v. The stock broker has maintain logs of all trading activities to facilitate audit trail. The stock broker has maintain record of control parameters, orders, trades and data points emanating from trades executed through algorithm trading.
 - vi. All orders generated by Algorithmic trading products are adhering to limit of maximum number of permissible orders per second as may be specified by the broker at his end.
 - vii. Before pumping in further orders, the algo checks if the orders already released by it (executed, unexecuted, unconfirmed) are sufficient with respect to strategy of the algo.
 - viii. The system has sufficient security features including password protection for the user ID, automatic expiry of passwords as the end of a reasonable duration and re-initialization of access on entering fresh passwords. This functionality is verified that the system has enough security features to ensure that the access to the software is only available to authorized persons at the members end.
 - ix. Dysfunctional algos are broadly defined as algo that does not work as per defined logic or does not conform to the risk management checks defined by the broker or affects orderly trading and market integrity on account of its potential misfiring.



1 - Annexure 1a
(Sec1 Q 3 Algo appro



Algo Trading
Application Form.doc

9.3 RULE FOR CHECKING ALGOS AT A LOGIC LEVEL BY THE EXCHANGE.

Is there any kind of versioning system to capture the algorithms used by participants in a secure location?



1. Trading members are not required to share the business logic of algo as it is a proprietary information.
2. Versions as reported by trading members during the approval process are captured by the Exchange



Exchange does not examine the business logic of Algorithms. However each algo version is certified. The onus is on the Trading Member to report any subsequent change/s in the version of ALGOs being used. Any major change/s in the business logic of the ALGO being used or a new ALGO being proposed for use shall require the Trading Member to seek fresh approval from the Exchange before use.

9.4 MECHANISM TO CAPTURE CHANGE IN ALGOS AT PARTICIPANTS END BY THE EXCHANGE



- A) As prescribed by SEBI vide their circulars CIR/MRD/DP/09/2012 dated March 30, 2012 and CIR/MRD/DP/24/2013 dated August 19, 2013, trading members are required to seek approval before effecting material changes to the algo trading software already approved by the Exchange. The process for approval of modifications to Algos remains same as for new Algo approval explained above in response to point 3.

Further, as prescribed by SEBI vide its circular CIR/MRD/06/2014 dated February 07, 2014 for approval of change/modification in the trading software arising out of the bug in software, change undertaken in software/system pursuant to change prescribed by exchange or software purchased from a software vendor that has already been tested in mock environment, Exchange adopts the following algo approval process:

- i. Submission of application: Trading members desirous of seeking approval for modification in algo are required to make an application to the Exchange electronically along with auditor certificate confirm testing of software in UAT, test and simulated environment of Exchange.
 - ii. Demonstration of Software: Trading members shall be required to give demonstration of the Automated Risk Management features as mandated by SEBI /Exchange.
 - iii. Approval: On verification of the documents and fulfilment of the conditions as satisfactory and meeting SEBI / Exchange minimum requirements, the Exchange grants permission to the trading member.
- B) As prescribed by SEBI vide its circular CIR/MRD/DP/16/2013 dated May 21, 2013 and

CIR/MRD/DMS/34/2013 dated November 19, 2013 as part of periodic system audit required to be conducted by an independent system auditor, SEBI prescribed terms of reference (TOR) cover the need to certify that change process has been followed. For details of terms of reference refer sub point 17 of attached file “TOR.doc”



As a part of ALGO approval process, trading member has to submit an ALGO Undertaking wherein the Trading member undertakes to unconditionally and irrevocably comply with various terms and conditions pertaining to the use of Algorithmic Trading facility.

Additionally, half yearly system audit has been prescribed for stock brokers who use Algorithmic Trading or provide their clients with the facility of Algorithmic Trading as per SEBI Circular CIR/MRD/16/2013 dated May 21, 2013. Further SEBI vide its circular CIR/MRD/DMS/ 34 /2013 dated November 6, 2013 has prescribed guidelines for Stock Broker Audit Framework.

The auditor in its report shall specify compliance / non-compliance status with regard to areas mentioned in ToR (terms of reference) mentioned in the SEBI circular. The auditor shall also take into consideration the observations / issues mentioned in the previous audit reports and cover open items in the report. This shall ensure that any changes to ALGO trading facility are captured and non-conformities are reported.



Algo
Undertaking.doc



SEBI_System audit
Framework_NOV6, 2(System audit_MAY21,



Sebi circular on Algo

9.5 BEST PRACTICES INTERNATIONALLY FOR ANY MEMBER WANTING ACCESS TO ALGORITHMIC TRAINING



As per the understanding gathered from market participants who operate in multiple jurisdictions, information regarding process/practices followed by international exchanges is not available in public domain. However, as given to understand by the trading members, in most Asian exchanges there are no separate process/requirements for algo trading. In some of the exchanges, for approval of member's system, members share the testing results and logs generated from the exchange provided test cases. Test cases cover the overall risk management prescribed by the exchange. Exchange verifies the testing results and upon satisfaction provides necessary approval.



Based on feedback from some vendors who are providing products to international exchanges, there is no algo certification required in other exchanges. However there is vendor certification required. Eg. Vendors are provided a facility to test their products in CME, based on which vendors are approved.

9.6 QUALIFICATION REQUIREMENT FOR MEMBERS INTENDING TO DO ALGO TRADING



As prescribed by SEBI vide circular CIR/MRD/DRMNP/36/2012 dated December 19, 2012, any trading member intending to use algos is required to furnish the highest applicable Base Minimum Capital of Rs. 50 lakhs on which the member is not provided any trading exposure. At the time of registration as a member itself, Trading members are required to fulfil certain criteria prescribed by SEBI/ Exchange such as minimum capital, minimum networth, minimum security deposits etc. Further, designated directors of the member are required to fulfill certain criteria like minimum age, education qualification, total experience in dealing in securities etc. Further, the member is required to appoint an appropriately qualified compliance officer holding a SEBI mandated certificate. Also, for issuance of user id for trading purpose, a valid certificate issued through SEBI approved certification programme is required to be furnished by trading member.



Currently members intending to do algo trading require BMC (Base Minimum Capital) requirement of Rs.50 lakhs (Financial requirement) which is required to be maintained by member with the Exchange (as per SEBI requirement). This is higher than the normal BMC requirement for Trading members not using ALGO trading facility.

9.7 EXCHANGE ENSURE ROBUSTNESS OF ALGORITHMS ON AN ONGOING BASIS



As per SEBI circular CIR/MRD/DP/24/2013 dated August 19, 2013 algo members are required to test their algorithms in mandatory monthly mock sessions scheduled by Exchange. Exchange checks member's participation subsequently and any non-compliance is considered for appropriate action. Additionally, as per SEBI circular CIR/MRD/DP/16/2013 dated May 21, 2013 and CIR/MRD/DMS/34/2013 dated November 06, 2013 algo members are required to conduct half yearly system audit as per SEBI prescribed Terms of Reference (TOR).



TOR.docx

Are results of these simulations validated to identify robustness of existing algorithms? As per SEBI, adherence to monthly mock participation is part of half yearly system audit requirement. For details, refer sub point 17 of attached file “TOR.doc”



Algo approvals are granted to Trading Members based on the certification provided by qualified system auditors. The auditors are required to certify the Algos based on the checklist provided by the Exchange (as per SEBI guidelines). In addition, the certification by the qualified system auditors, also confirms

the algos compliance with Exchange risk management systems during mock trading sessions or testing in simulation environment.

Exchange has various technical and functional checks to prevent rogue algos. There are order flow controls or throttles for controlling the order flow from a member. Functionally, there are price bands and price reasonability checks (dynamic price bands) in place to prevent cases of high volatility. Other functional checks like Self Trade Prevention Check (STPC) and Reverse Trade Prevention Check (RTPC) to prevent the same user(s) from manipulating trades, are also applied. Exchange also levies 'Fair Usage Charges' on members for inefficient execution of the order flow.

Exchange does a daily check on Order to Trade Ratio (OTR) for Equity Derivative/Currency Derivative and levies charges for High Order to Trade ratio (OTR) in Algorithmic Trading for Equity Derivative segment (circular no : 20130529-6) and Currency Derivative segments (circular no : [20141010-26](#)).

Exchange does monthly checks for the following:

- i. Fair Usage Charges levied on members BSE Equity, Equity Derivatives and Currency Derivatives circular no: [20161027-14](#).
- ii. Order Flow Rate in Equity Segment circular no*: [20161019-35](#), Currency derivative Segment circular no*: [20160930-3](#), Equity Derivative Segment circular no*: [20160503-22](#).

*Circulars are attached in point ii

Are results of these simulations validated to identify robustness of existing algorithms?

All checks done in mock or simulation environment are validated by system auditors and certified, before making an application with the Exchange.

9.8 ALGO TESTING LAB



Algo Lab is an optional facility developed and provided by the Exchange. It provides a near live market simulator designed for testing of algorithms. It provides actual market feed for testing and acts as a comprehensive analytics environment for strategy refinement. Algo Lab environment provides a replica of actual market conditions by creating a similar co-located environment for dealers to test their strategies/algorithms against a dedicated market feed. Some of the benefits of algo lab is given below:-

- Assess the performance of algorithms
- Test new strategies without incurring financial risk
- Train new dealers



The algo test lab is a test bed for trading members to test their algos before moving to the Exchange Simulation/Mock/ live environments. This is helpful to members to validate the logic of algos in simulated market conditions, based on BSE market data.



Chapter-10

CONCLUSION

10.1 ALGO TRADING AND ITS COMPOSITION IN INDIAN MARKETS

- a. Algorithms have become such a common feature in the trading landscape that it is unthinkable for a broker not to offer them because that is what clients demand. High-frequency trading (HFT) is a subset of automated trading. Here, opportunities are sought and taken advantage of on very small timescales from nanoseconds up to milliseconds.
- b. Composition
We found that around 50% plus of total orders at both NSE and BSE are algo trades -client side. Prop side algo trades are 40% plus of total orders placed at both the exchanges. 80% plus orders are generated from colo at BSE (of total algo orders)

10.2 EXTENT OF ALGO TRADING IN INDIAN & FOREIGN MARKET AND ORDER TO TRADE RATIO

- a. In India, Algorithmic trading to Exchange turnover has stabilised around 47%. In developed markets it stands at about 80%.
- b. Order to Trade Ratio in Indian Market
In the year 2016-17, order to trade ratio for NSE across all segments was 11.2. It has increased from 7.07 in 2014-15. In BSE: Order to trade ratio for equity segment has decreased to 218 (2016-17) from 321.57(2014-15), for equity derivatives decreased to 3597 (2016-17) from 8162 (2014-15), for interest rate derivatives decreased from 884 (2014-15) to 132(2016-17) however for currency derivative it has increased from 111(2014-15) to 195(2016-17). In case of high order to trade ratio, NSE makes calls and alert trading members. BSE has issued circulars to keep a check on high order to trade ratios. Penalty is imposed on both the exchange for high to trade ratio.

10.3 ADVANTAGES DISADVANTAGES OF ALGO TRADING, COLOCATION AND HFT

Algo trading, colocation and HFT offer various advantages and disadvantages. It is observed that with algo trading and HFT there have been improvements in transactions costs, volatility, and buy-sell imbalance. Market prices have become more efficient and they have facilitated price discovery. Colocation also reduced latency and levels the playing field among competing HFT market makers. However, Technical sufficiency and resources are required for advanced technology. Lack of control has led to systemic risks. Fat finger or faulty algorithms can cause huge deviations from healthy prices HFT is playing against investors who are willing to invest fundamentally. HFT firms leverage special services such as co-location facilities and raw data feeds. The odds of a sudden liquidity drain go up. HFT can give rise to price fluctuations and short term volatility. Colocation facility can be expensive and gives rise to market inequity

10.4 MARKET MANIPULATION USING ALGO TRADING

It has been proved in the past that Algo trading and HFT can be used to manipulate markets using techniques like quote stuffing, layering (spoofing) and momentum ignition. Evidence suggests that because of quote stuffing stocks experience decreased liquidity, higher trading costs, and increased short term volatility. Layering can impact performance and fill rates. Momentum ignition events can result in massive price moves backed by false volume

10.5 MEASURES ADOPTED BY SECURITIES MARKET REGULATORS IN DIFFERENT COUNTRIES

Minimum resting time, frequent batch auctions, random speed bumps or delays, randomization of orders during a period (1-2 seconds), max order message to trade ratio requirement, market maker pricing are some of the measures adopted. HFT transaction tax is implemented in France and Italy. The SEC has undertaken following steps: Market Access Rule, Regulation SCI and registration of entities. In May 2013, Germany enacted the Act on the Prevention of Risks and Abuse in High-Frequency Trading (HFT Act)

10.6 SURVEILLANCE METHODS AT NSE & BSE

Currently both NSE and BSE have its own methods and levels of sophistication to manage surveillance. However, in our view harmonization of surveillance mechanism would bring about uniformity in exchange action towards harmful HFT. There is a definite need to invest in advanced technology to automatically detect harmful HFT and market manipulative trends/algorithms. Exchanges hardly have advanced mechanisms to detect harmful HFT.

10.7 PROS AND CONS OF REGULATORY MECHANISMS BEING CONSIDERED BY SEBI:

a. Minimum resting time for orders

Pros

- It offers advantages like :
- More stability in limit order book
- Reduces fleeting order
- Can increase the likelihood of a viewed quote being available to trade
- Reduces the excessive level of message traffic currently found in electronic markets

Cons

- It may lead to more order being pumped into the system and longer queues and waiting time
- It may raise transaction costs as well as volatility

b. Frequent batch auctions

Pros

- It will lead to reduction of the speed of trading and the elimination of the arms race for speed
- Eliminate Sniping

Cons

- It may impede price discovery and increase execution risk
- It may reduce liquidity and incentives to supply liquidity

Implementation in Markets

- Taiwan Stock Exchange (TWSE) used to have continuous auction mechanism

c. Random speed bumps or delays in order processing/ matching

Pros

- All orders including non-colo orders will be impacted by the delay
- nullify latency advantage and
- stops arms race for speed

Cons

- However a cushion can be provided against bumps
- It can cause reduced / withdrawal of liquidity

Implementation in Markets

- TSXA – Toronto Stock Exchange (1-3 ms) and ParFX – interdealer OTC broker (20-80ms) impose randomized order processing

d. Randomization of orders received during a period (1-2seconds)

Pros

- It inherently has the ability to offer a chance to non-Colo orders even if the ratio of Colo to non-Colo orders is huge. It reduce Latency Advantage, profits available to fast traders will reduce

Cons

- It will lead to increased uncertainty and lower liquidity
- It reduced cross market arbitrage

Implementation in Markets

- ICAP EB (wholesale FX electronic trading platform) Market Matching platform has introduced Latency floor

e. Maximum order to trade ratio requirement

Pros

- This will ensure that orders translate to trades more effectively
- It Reduces the number of economically excessive messages
- Increase Market depth
- Curtail market manipulation strategies

Cons

- It may lead to reduced liquidity
- Withdrawals during volatile periods
- Increase bid ask spread

Implementation in Markets

- NSE and BSE are currently implementing maximum order to trade ratio and penalties
- The ICAP has a monthly fill ratio (MFR)

f. Separate queues for co-location and non-co-location orders

Pros

- This can potentially provide fair chance for non-Colocation orders
- No impact on trading members software
- Algorithms can be applied to change the fairness when order rates between Colo and non-Co-location are skewed

Cons

- This will lead to two markets for two sets of investors
- Withdrawal of liquidity

g. Review of tick by tick data feed

Pros

- More transparency
- Members to access full order book and
- Real time access to TBT data

Cons

- It can reduce the level of transparency if the data feed is anything other than real time feed



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REFERENCES

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The graphic features a light blue document with a folded top-right corner, centered within a solid blue rectangular frame. The word "QUESTIONNAIRE" is printed in a large, bold, blue serif font in the center of the document. Below it, a white horizontal band contains the text "QUESTIONNAIRE ON ALGORITHMIC TRADING AND CO-LOCATION SERVICES" in a smaller, bold, blue sans-serif font.

QUESTIONNAIRE

**QUESTIONNAIRE ON ALGORITHMIC TRADING AND
CO-LOCATION SERVICES**

QUESTIONNAIRE ON ALGORITHMIC TRADING AND CO-LOCATION SERVICES

Section 1: Algorithmic Trading

1. What is the composition of algo trading/ high frequency trading taking place in your exchange – client and proprietary?
3. How many of the algo orders come from co-location?
4. What is the procedure for gaining algorithmic trading approval?
5. Are algorithms checked at a business logic level by the exchange? Is there any kind of versioning system to capture the algorithms used by participants in a secure location?
6. Is there any mechanism to capture change in algorithms at the participants end? How do you detect if the participant is changing an algorithm?
7. Is it the responsibility of the participant or the exchange pro-actively checks versioning of algorithms used by participants?
8. Internationally, what are best practices for any member wanting access to algorithmic trading? What are the qualification requirements?
9. Do we have any such qualification requirement for members intending to do algo trading? How can we improve training and qualification of members?
10. How does exchange ensure robustness of algorithms on an ongoing basis? For instance, are any simulated/mock trading sessions done?
11. Are the results of these simulations validated to identify robustness of existing algorithms or only for macro risk management checks?
12. How does an algo testing lab help in active risk management by the exchange? If not, what is the purpose of the algo lab?

Section 2: Algo market demographics and order-to-trade ratio

13. How many algorithmic trading players are currently registered? What is the ratio of active participants?
14. Who are the top 20 algo participants and what is the contribution to average daily turnover?
15. What is the average order to trade ratio for all algo participants in the last 3 years (year-wise bifurcation)?
16. What are the ratios of order-to-trade for the top 10 participants (by turnover) across the last 3 years (year-wise bifurcation)?
17. What are the order-to-trade ratios for efficient vs inefficient members across the last 3 years (year-wise bifurcation)?
18. What has been the trend of order-to-trade ratio over the last 3 years?
19. Has the exchange been pro-active in controlling the order-to-trade ratio? If yes, how?
20. Are there any penalties or structures in place to curb high order-to-trade ratios?
21. How do you penalize repeat offenders of high order-to-trade ratio?
22. What causes a very high order-to-trade ratio?
23. Specifically, what category of HFT algorithms could lead to high order-to-trade ratios?
1. Section 3: Co-location
24. What are the costs of setting up co-location servers?
25. What are the additional costs that would be typically incurred by members for setting up co-lo (apart from rack space)?

26. What are the requirements to be met by members for algorithmic trading? And co-location?
27. Are there different types of co-location services for different types of participants?
28. If yes, what are the differentiated costs for different services?
29. Are there any benefits to members to setup co-location services at multiple exchanges? If yes, explain how?

Section 4: Technology for co-location

30. Is there any technological standardization for co-location services? Or are there differentiated levels (eg, rack space, wire connecting co-lo servers to exchange, etc)?
31. If yes, explain the differentiated levels of service along with associated costs.
32. What is the length of the wire used? What is the quality of wire used? Is it same for all members?
33. Which system (unicast/multicast) has been in existence for the last 5 years? Kindly explain the workings of the system (eg TCPIP sequential access for unicast).
34. Can some participants gain undue advantage due to sequential access due to early log-in? Explain using examples.
35. What is the difference between main server and back-up server? Is the back-up server used as a parallel processor sometimes? Is there any preferential treatment on back-up server and additional charges if applicable?
36. If yes, why access given to only a few participants on back-up server and not to all participants in co-lo? If given, why?

Section 5: How do you capture data (order/trade information)

37. What is the format for capturing raw data (order/trade information)? Kindly share the raw data format with us (converting into understandable format giving detailed description of each of the fields)
38. Is this a standardized format that is followed internationally? Please describe the format. Or is there a standardized unified format across all exchanges in India?
39. What is the international best practices for unified data formats? How will this help in Indian markets? What are the benefits of data format harmonization?

1. Section 6: Risk Management and Surveillance

40. What are the best practices internationally for risk management in Algorithmic trading?
41. What are the risk management mechanisms for algorithms employed by the exchange?
42. Are there separate risk management mechanisms for HFT?
43. What are the surveillance mechanisms in place to catch harmful HFT activities? List the mechanisms as well as explain them.
44. How do the surveillance mechanisms change in periods of high volatility?
45. What are kill switches? Who has control of them – exchange or members? Is it manual or automated?
46. Has kill switch been ever employed in trading?

Section 7: Curbing harmful HFT algorithms

47. Kindly share your views on SEBI's discussion paper. Which of the discussed points are relevant for Indian markets?
48. Also, are there additional measures (not discussed in the paper) that could be introduced to curb harmful impact of HFT?

49. If yes, what are the historical precedents internationally for the same?
50. According to your knowledge, what are the harmful HFT algorithms that might cause market disruption such as high intra-day volatility and high order-to-trade ratios?
51. On the above question, how can you think these harmful HFT activities can be curbed? What do you think are some international best practices that can be employed?
52. How do you think having separate queues, one for algo trades and the other for non-algo trades, help in curbing harmful HFT?
53. How as an exchange would you identify such harmful HFT practices and algorithms?



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