

Project Dissertation Report on

Impact of Algorithm Trading on Indian stock markets

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CERTIFICATE FROM THE INSTITUTE

This is to certify that the Project Report titled **Impact of Algorithm Trading on Indian stock markets** is an original and work carried out by **Mr. Aket Singla** of MBA 2016-18 batch and was submitted to Delhi School of Management, Delhi Technological University, Bawana Road, Delhi-110042 in partial fulfillment of the requirement for the award of the Degree of **Masters of Business Administration**.

Signature of Guide

Signature of HOD (DSM)

Place:

Date:

ACKNOWLEDGEMENT

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them.

I am highly indebted to my guides for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project.

I would like to express my gratitude towards my parents for their kind co-operation and encouragement which help me in completion of this project.

I would like to express my special gratitude and thanks to industry persons for giving me such attention and time.

My thanks and appreciations also go to my colleague in developing the project and people who have willingly helped me out with their abilities.

Being an area where a restricted research has been conducted and debated, the Research 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-specialized 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.

DECLARATION

I Aket Singla Pursuing MBA from Delhi School of Management, New Delhi have successfully completed the Project Report in the organization on the topic titled, "Impact of algorithm trading on Indian stock markets.

I have expressed all research result and company related information and resources to the best of my knowledge and used genuine and trusted source of collaboration of it. All the analysis done is based on the research result and the feedback received from the users and is only indication of my personal opinion. All the confidential information of the company is kept secure.

AKET SINGLA

PLACE:

PREFACE

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.

EXECUTIVE SUMMARY

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)

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.

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.

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.

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 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.

ABBREVIATION

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
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

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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)

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



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. 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**.

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.

a) 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.

b) 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.

c) 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.

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.

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

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.

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.

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

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

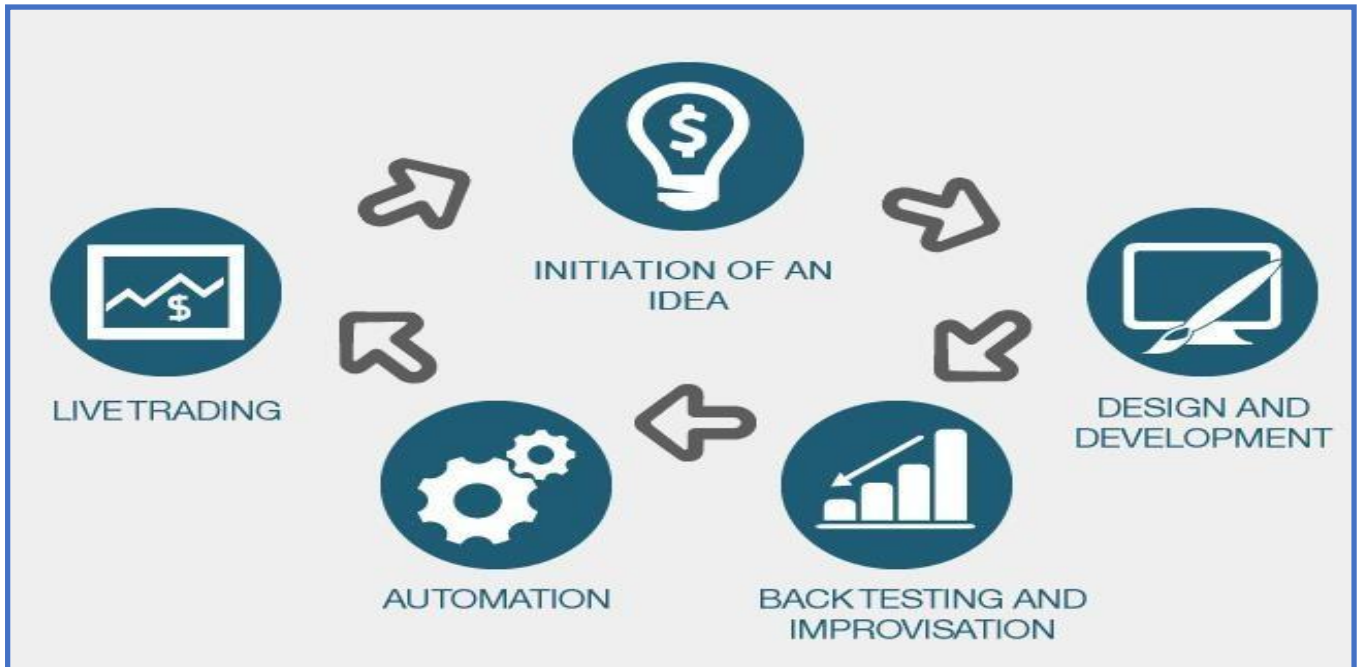
Interconnections between markets, which may be amplified by algorithms programmed to operate on a cross-market basis, may allow for a shock to pass rapidly from one market to another, potentially increasing the speed at which a systemic crisis could develop. This was illustrated by the Flash Crash event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

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.

LIFECYCLE OF AN ALGORITHM

Following is a typical life cycle of an algorithm



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., 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.

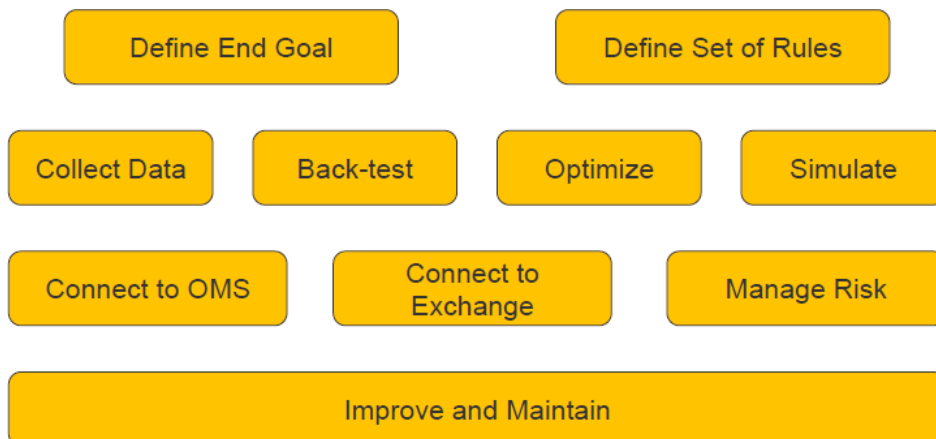
Execution

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:



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.

4. 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.

5. 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.

6. 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.).

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

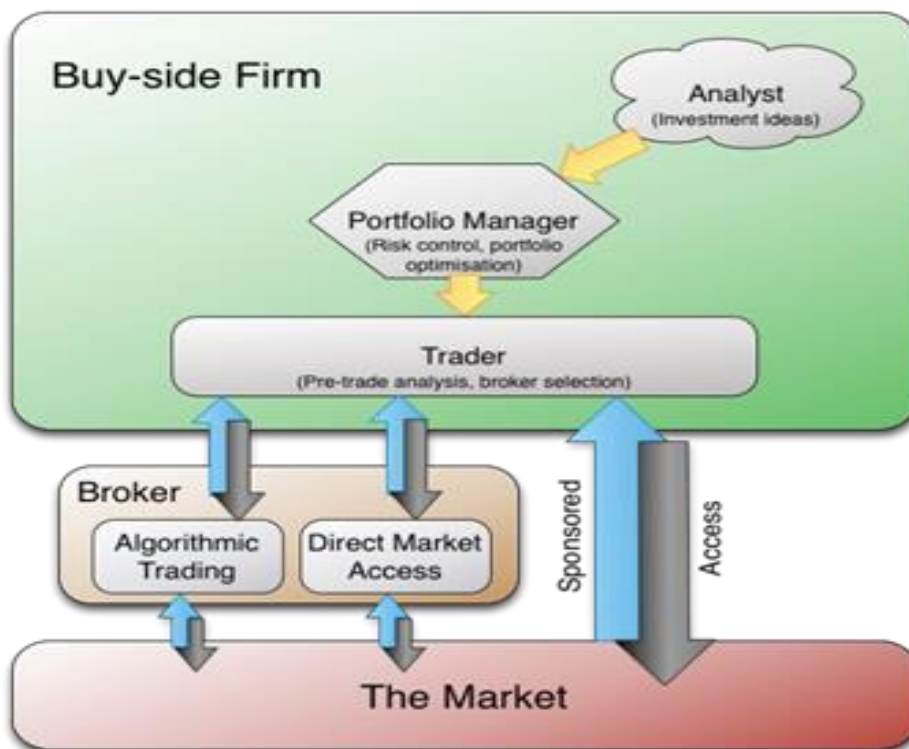
Since backtesting for algorithmic trading strategies involves a huge amount of data, especially if you are going to use tick by tick data. So, you should go for tools which can handle such mammoth load of data.

7. 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

EXECUTION ALGORITHMS AND DEVELOPMENT

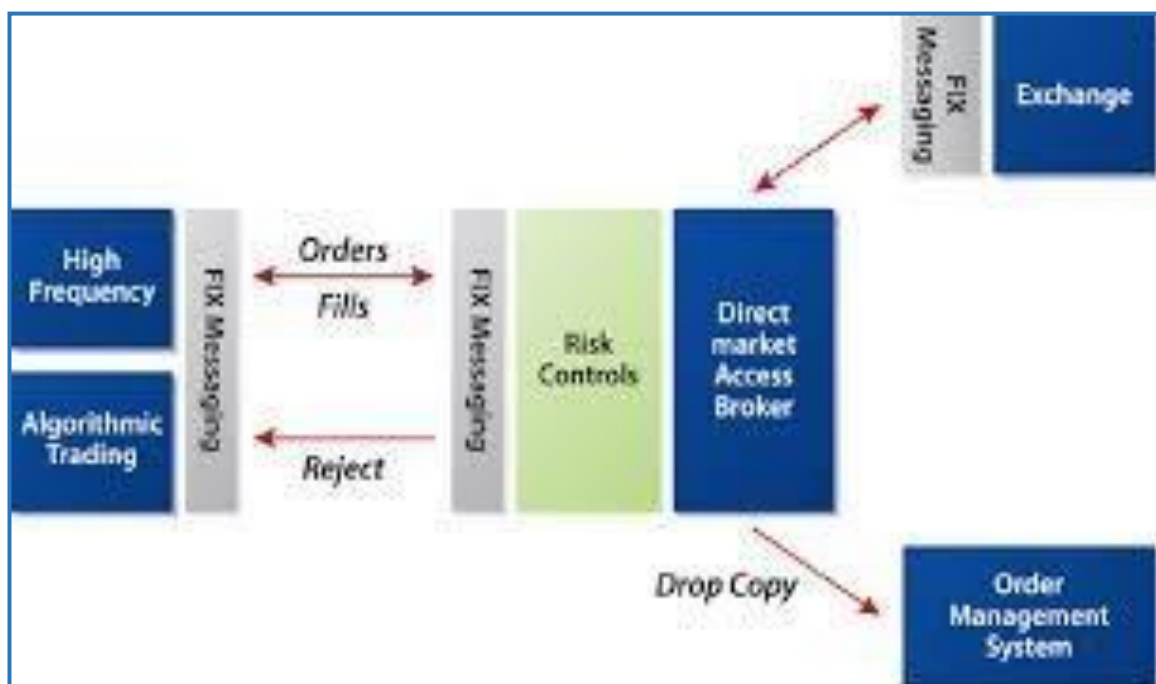
- a) Algorithmic trading refers to trade execution strategies that are typically used by fund managers to buy or sell large amounts of assets.
- b) They aim to minimize the cost of these transactions under certain risk and timing constraints. Such systems follow preset rules in determining how to execute 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 minimize the impact of trading. This is done by slicing orders and dynamically reacting to market events.



EXECUTION AND DEVELOPMENT

HFT ALGORITHMS AND DEVELOPMENT

- a) 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) 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.
- c) Other strategies invoke methods from time series analysis, machine learning and artificial intelligence to predict movements and isolate trends among the masses of data.
- d) Specifics of the strategy aside, for HFT, monitoring the overall inventory risk and incorporating this information into pricing/trading decisions is always virtual



HFT ALGORITHM

COMPOSITION OF ALGO TRADING TAKING PLACE IN INDIA- 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:

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.

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

CURRENTLY REGISTERED ALGORITHM TRADING PLAYERS



Currently, there are 251 trading members as on February 2017 registered for Algo trading with the Exchange.



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

TOP 20 ALGO PARTICIPANTS AND THEIR DAILY TURNOVER



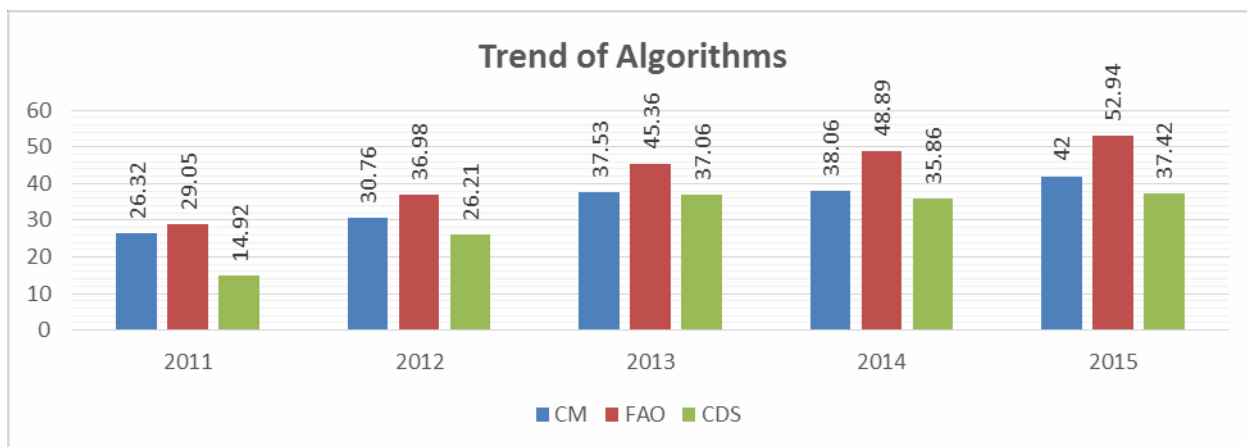
Top 20 participants (trading members) ranked based on algorithmic trading turnover irrespective of colocation or non-colocation across segments (CM, F&O and CDS) for the period FY 16-17 (Apr'16 to Feb'17) and their contribution to total Exchange turnover is provided below:

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%

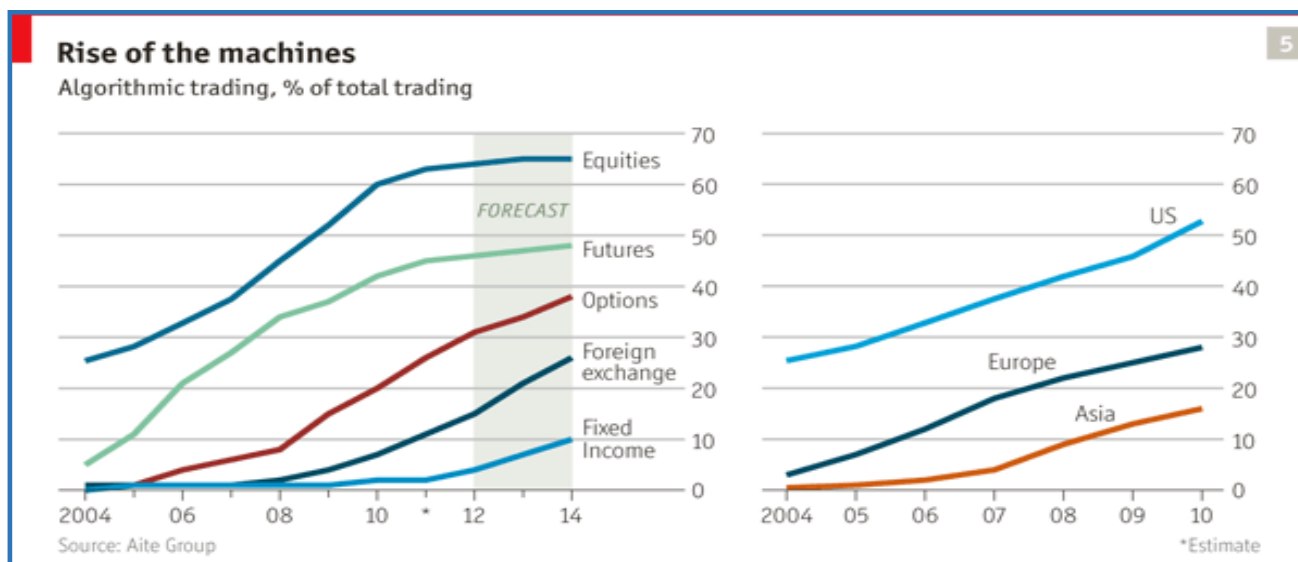
ALGORITHMIC TRADING TRENDS AND THE EXTENT TAKING PLACE IN INDIAN MARKETS VIS-À-VIS GLOBAL MARKETS

- After the initial spurt the share of Algorithmic trading to Exchange turnover has stabilized 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 scripts/contracts



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.

II. LAYERING

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.

III. MOMENTUM IGNITION

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.

IV. LIQUIDITY REBATE TRADING

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.

CO-LOCATION

In a sign of the rush for speed in trading, exchanges are building huge data centers 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."

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.

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).

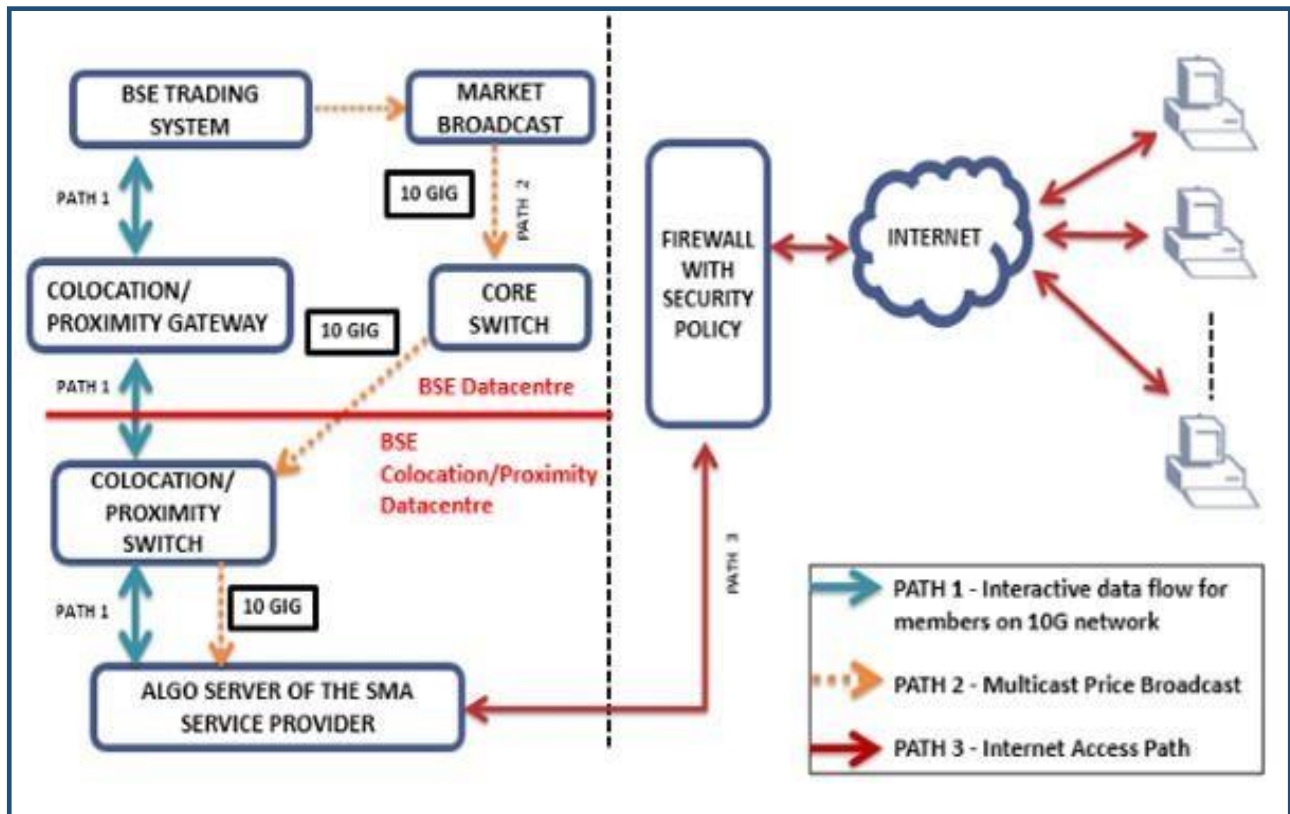
AT BSE, there is equitable distribution of market data to all members by usage of same length cables for all members. Also, Full order book (EOBI) multicast is provided to Co-location members at no cost.

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.

CO-LOCATION ARCHITECTURE



CO-LOCATION

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

'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.

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

- 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-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. 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.

CONNECTIVITY



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

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

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.

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.



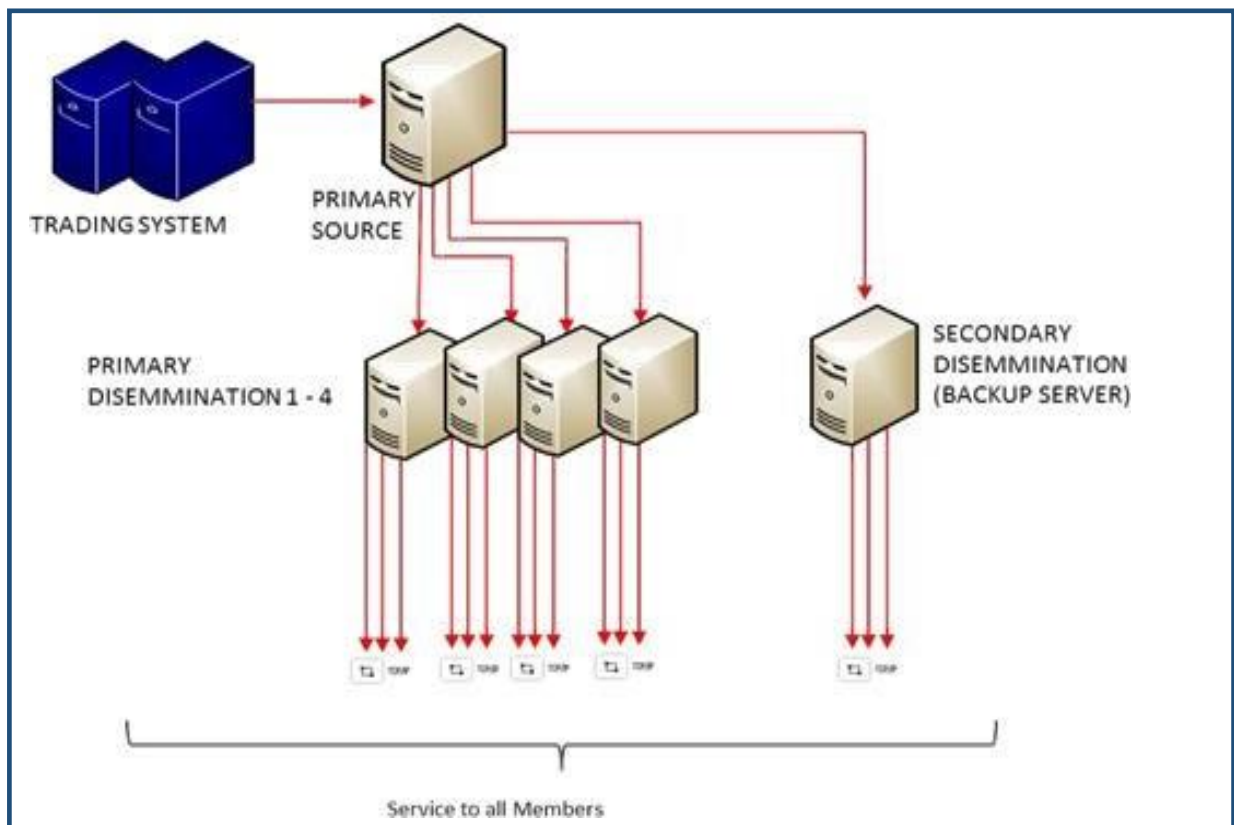
Yes, the wire quality and length is same for all the members located at co-location. The wire length is 20 meters (from Colocation switch to Members' servers in colocation racks) and the wire type is Cat6 Multimode Fiber optic.

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



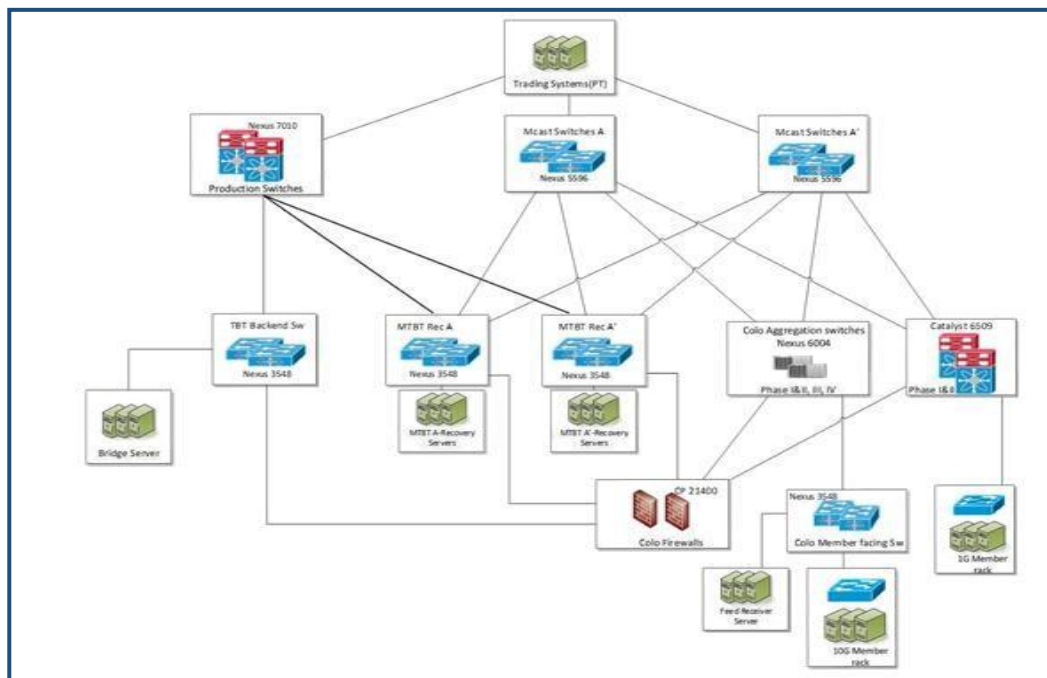
The market data (TBT) system was available in unicast (TCP/IP) till December 2016. At present only multicast TBT is available which was introduced in May 2014.

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



SYSTEM UNICAST

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.



SYSTEM 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.

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.

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.

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ORDER-TO-TRADE

INTRODUCTION

Order-to-trade (or order-to-execution) ratios involve financially penalizing 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.

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:

Average Order to Trade Ratio for all active Algo Participants

FY	Average of Order to Trade Ratio
2014-2015	8.91
2015-2016	26.4 4
2016-2017 (Apr'16 to Feb'17)	12.2 6

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

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

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:

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

FY	Efficient Members	Non Efficient Members
2014-2015	0.53	223 0
2015-2016	0.85	459 1
2016-2017 (Apr'16 to Feb'17)	0.85	164 7

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-colo / 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.

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). 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.

IV. HFT Transaction Tax

SEBI'S DISCUSSION PAPER

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

Minimum resting time for orders

- (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.

Benefits

- a. **Reduces the excessive level of message traffic currently found in electronic markets**
- b. **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.**

Cost and Risks

- a. **Picking off stale orders**
- b. **Raising transaction costs**
- c. **Will hurt retail investors because of increased bid ask spread**

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.

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.

ii. 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.

REVIEW OF TICK-BY-TICK DATA FEED

i. Introduction

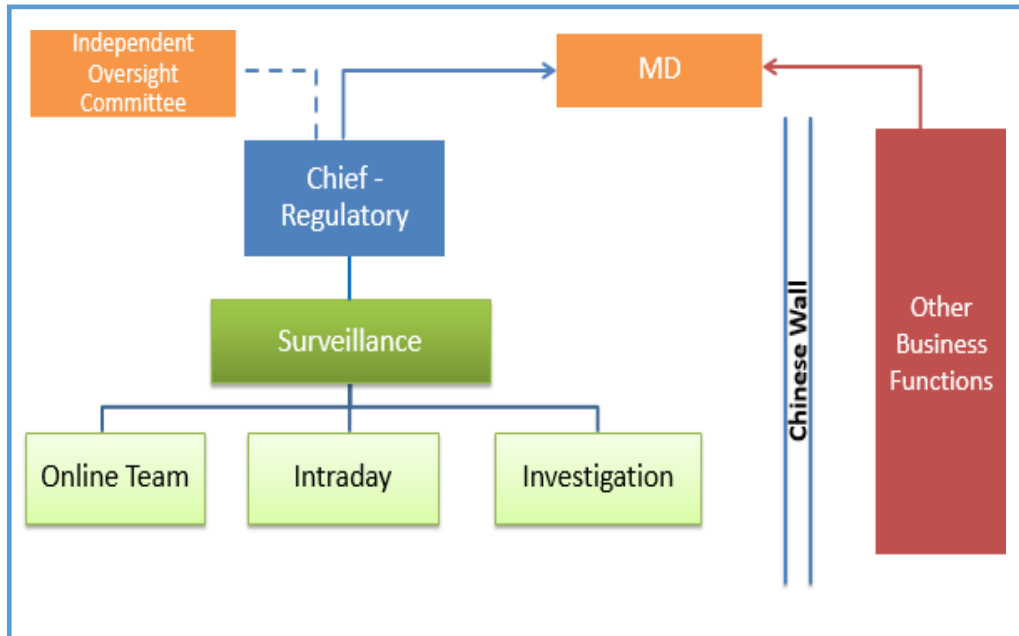
- a. Tick-by-Tick (TBT) data feed provide details relating to orders (addition + modification + cancellation) and trades on a real-time basis. TBT data feed facilitates a detailed view of the order-book (such as depth at each price point, etc.).
- b. At present, the exchanges provide TBT data feeds to 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).

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.

SURVEILLANCE SYSTEM

CURRENT SURVEILLANCE STRUCTURE AT NSE

Below given diagram illustrates the functional architecture



SURVEILLANCE FUNCTIONS COVERED AT NSE

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



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

Monetary Penalty levied in last 3 Financial Years

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

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
At Client Level :		
3	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"
4	Automated Execution Check	Algo to account for all executed, unexecuted, and unconfirmed orders placed by the system before releasing further orders..

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.

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

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

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
The price of any single order should not be more than the applicable price bands

CONCLUSION

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 at BSE (of total algo orders)

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

- c. In India, Algorithmic trading to Exchange turnover has stabilized around 47%. In developed markets it stands at about 80%.

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.

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)

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.

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

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

b. 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

c. 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

FI UNIVERSITY, SWEDEN SURVEY

During the fall of 2011, FI conducted an investigation into high frequency and algorithmic trading on the Swedish equity market and how Swedish participants have perceived it to have impacted trading.

The investigation consists of two parts. The first part summarizes the Swedish industry's view on algorithmic and high frequency trading. The basis for this section of the report comes from two surveys conducted by FI during the autumn/winter of 2011 pertaining to companies' perception of algorithmic and high frequency trading and the risks these firms see for the functioning of the market

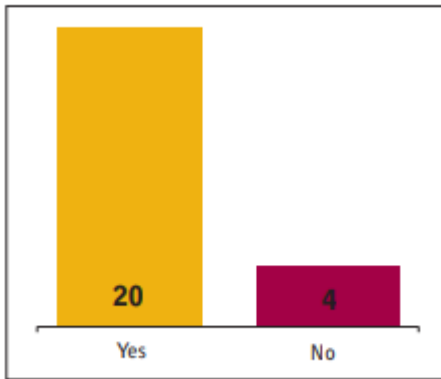
Summary of the surveys

High frequency trading (HFT) is very limited among the actors on the Swedish market. Only three of the 24 companies surveyed state that they use HFT in their operations. However, 20 companies respond that they use different types of algorithms.

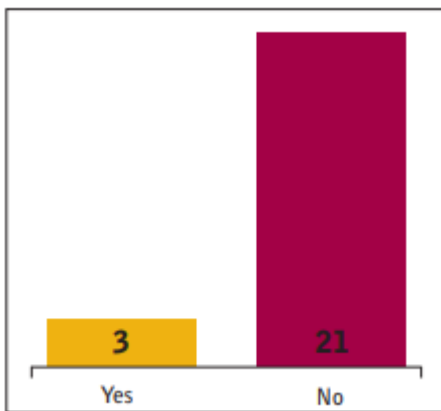
A total of 22 companies believe that unfair trading practices related to algorithmic trading and HFT are present on the market. The strategies mentioned most often include:

- **Spoofing/layering:** a strategy of placing orders that is intended to manipulate the price of an instrument, for example through a combination of buy and sell orders.
- **Quote stuffing:** the submission of a large volume of orders to a marketplace with the intention of slowing down the trading systems of other actors or hiding one's own strategy.
- **Momentum ignition:** initiating or enhancing a trend through the aggressive placement of orders in the hope that others will follow, which creates an opportunity to reverse a position.
- **Last second withdrawal:** the cancellation of orders at the final second of a call procedure.

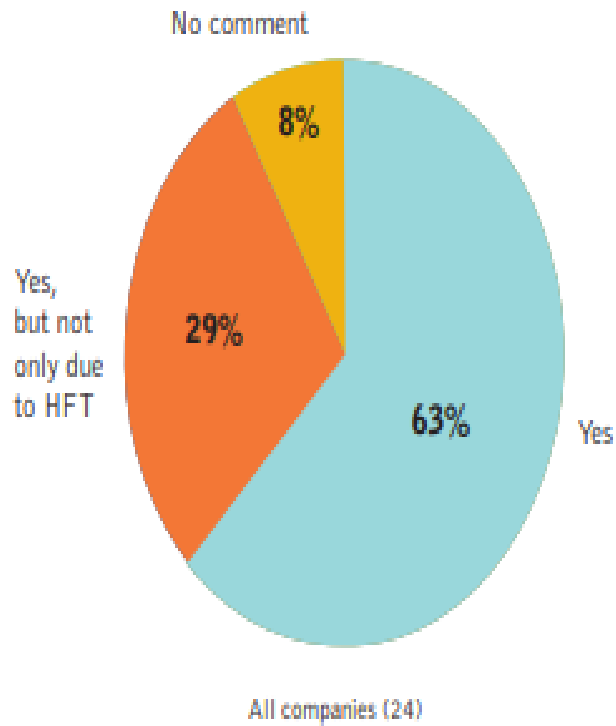
DO YOU USE ALGORITHMS?



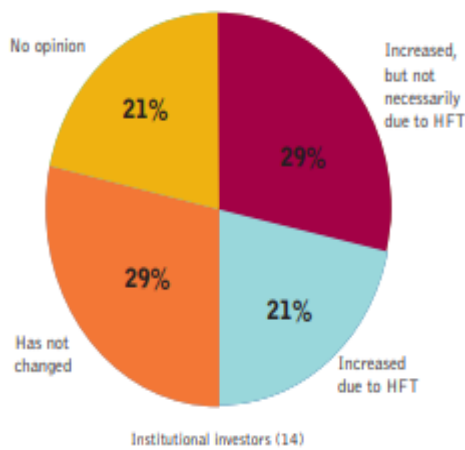
DO YOU USE HFT?



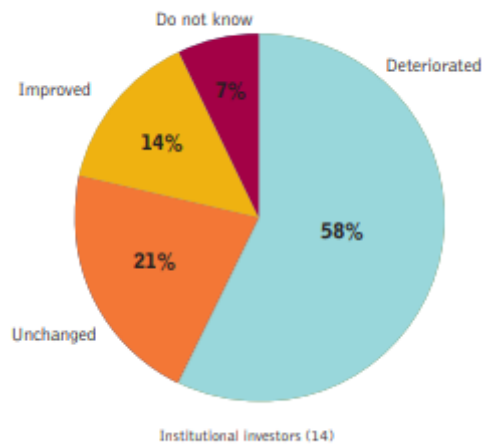
UNFAIR TRADING STRATEGIES?



HAS VOLATILITY CHANGED?



HAS LIQUIDITY CHANGED?



REFERENCE

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