
# ALGORITHIMIC TRADING

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## Contents

# Module – 1: Introduction and Overview of Algorithmic Trading

## What is Algorithmic Trading?

Before we define it let us see how oxford defines these two words.

*Al-go-rithm (noun)*: a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer

*Trade (noun, verb, adjective):* the action or activity of buying and selling goods and services

Algorithmic trading is using computer programs to take buying and selling decision based on simple set of rules which are executed by the computer program

So, simply put algorithmic trading is defining a set of rules for the purpose of buying, selling or exchanging goods. Once you have a set of rules defined, we use machines to follow these rules. They have the advantage of high computational power which is much faster than an average human brain and will also be able to follow the rules on a strict level eliminating any chances of human error or misjudgment.

## Why Algorithmic Trading?

While there are a lot of opportunities that the field of algorithmic trading has to offer, there are a lot of misconceptions in terms of application, risks and scalability. Most people think of it as very complex quantitative models which require high level programming skills, are very expensive to implement and it is only the big investment banks which have the capacity to do it, but as the reality is – they can be simple, inexpensive and can easily be of importance to even a single trader.

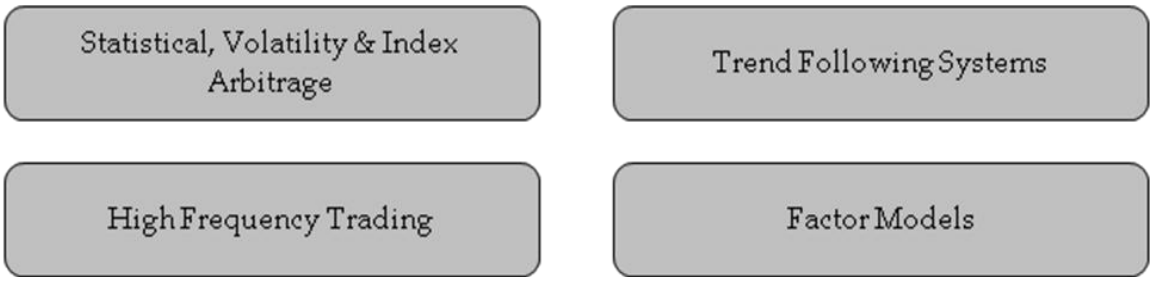
While the field of algorithmic trading is on very advanced stage in international markets, in Indian markets it is still a relatively new and unexplored field. The field of algorithmic trading can only grow from here and there are numerous reasons why this field is now more lucrative and promising than ever

- It's the buzz word and everyone in and around the industry is talking about it, enquiring about it and experimenting with it. It is just a matter of time before the big players jump into it
- It offers you a new potential stream to the user widening the array of products one can offer to the investors and thus can strengthen the foundations of a business. While offering a wider range of services, one can not only give a value added service to existing clients but will also be able to attract new clients as there are currently limited businesses which can offer services and products in the field of Algorithmic Trading
- With more and more people getting into this field, all those who have gained an expertise in this area will definitely have an advantage over their competitors

## The Participants

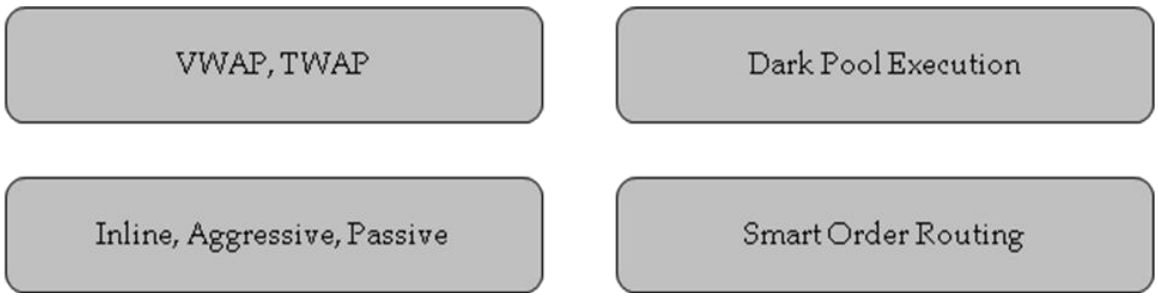
*Proprietary Trading Groups*

These are prop trading houses which have in-house strategies in which they deploy their own capital to generate profitability. These are trading strategies which are mainly an automation of the different strategies that have proved to be profitable to the firms in the past. A lot of these firms tend to trade heavily on the Statistical Arbitrage and Index Arbitrages strategies. The most commonly used Prop strategies are listed in the blocks below.




*Agency Trading Groups*

The other players in this field which are very large in terms of volumes are the brokerage houses. These are the firms which offer execution and brokerage services to their client orders and use agency execution algorithms to execute the huge volume of trades on behalf of their clients minimizing slippages and execution costs. Some of the large brokerage houses are also involved in high frequency market making. The most common agency algorithms are listed in the blocks below.




## The Building Blocks

So now we are ready to do some algorithmic trading but how do we start? What technology would I have to use, what is the risks that a strategies we have, how do we know if an algorithm is actually working or not or may be the most basic question of all, how do I know what strategy to use? As defined earlier algorithmic trading is defining a set of rules to be a followed by a computer program. So, it is the responsibility of the user to define those set of rules and then test them in different situations against

different parameters before once can feel confident enough about the performance and the risks to make it into an automated program. For this, the development of an algorithm has to go through various stages:

*Define the end goal*

This is where one tries to define the core nature and purpose of the algorithm and decide the aim that we are trying to achieve through this strategy.

- Nature of the Algorithm
  - Proprietary Trading
  - Agency Execution Trading
  - Clients Trading (Wealth Management)
- Frequency
  - Low Frequency
  - Medium Frequency
  - High Frequency
- Assets Under Management (AUM)
  - Higher AUM, longer term return
  - Lower AUM, Daily Profits
  - Non correlated fresh strategies

*Define the set of rules*

Once we know the end goal, the next thing we should concern ourselves with is the method and the strategy that should be used to achieve the defined purpose. There is no fixed thumb rule for this and is very much dependent on the end user. Some of the things which may help in coming up with a reasonable strategy:

- Logical and business senses:
- Simple trading rules and indicators
- Talking to traders and analysts
- Simple observations in markets

- Experience

*Strategy Formulation and development*

Once we have the initial set of rules that define the strategy, then it needs to be developed into an algorithm and tested for various scenarios. This is where we can test the strategy and see how it might perform in real time market. The various stages of testing of the algorithm can be listed as follows:

- Data Collection: Collect clean and accurate historical data to back-test the strategies. If the data is consistent and accurate, the back-test results would be more reliable

- Back-testing: After collecting the data, we try to see how the strategy would have performed historically and thus it gives a measure of how the strategy behaves in different market conditions and how effective the strategy is in solving our purpose

- Optimize: As we get the back-test results, one should try to identify the relevant parameters which have a significant impact on the performance of the strategy and then try to optimize them to get the maximum performance out of the algorithm. The process of back-testing and optimization runs in a loop till the optimal performance parameters for the strategies are achieved

- Simulation: Once we are confident with the strategy and the back-test results, it is important to run the strategy in a simulation mode, where the algorithm tracks the markets in real terms and does virtual trades. The period of simulation can help us analyze if the real time performance is consistent with the results of the back-test

*Trading live and maintenance of the model*

At this stage the model should be ready to trade in live markets and then this is where we expect to reap the benefits.

- Connect to the Order Management System (OMS)

- Connect to the exchange

- Manage the risk of the model

- Maintain and continuously improve the system

# Module – 2: The Mathematics of Algorithmic Trading

The basic mathematics and advanced financial engineering mathematics forms the key element which distinguishes a normal technical trading from the core of algorithmic trading. The key fact to consider is that though most of the formulas in algorithmic might look complex the basic framework and practical usage of these factors are simple and can be used with ease in algorithmic trading.

## Importance of Statistical Analysis

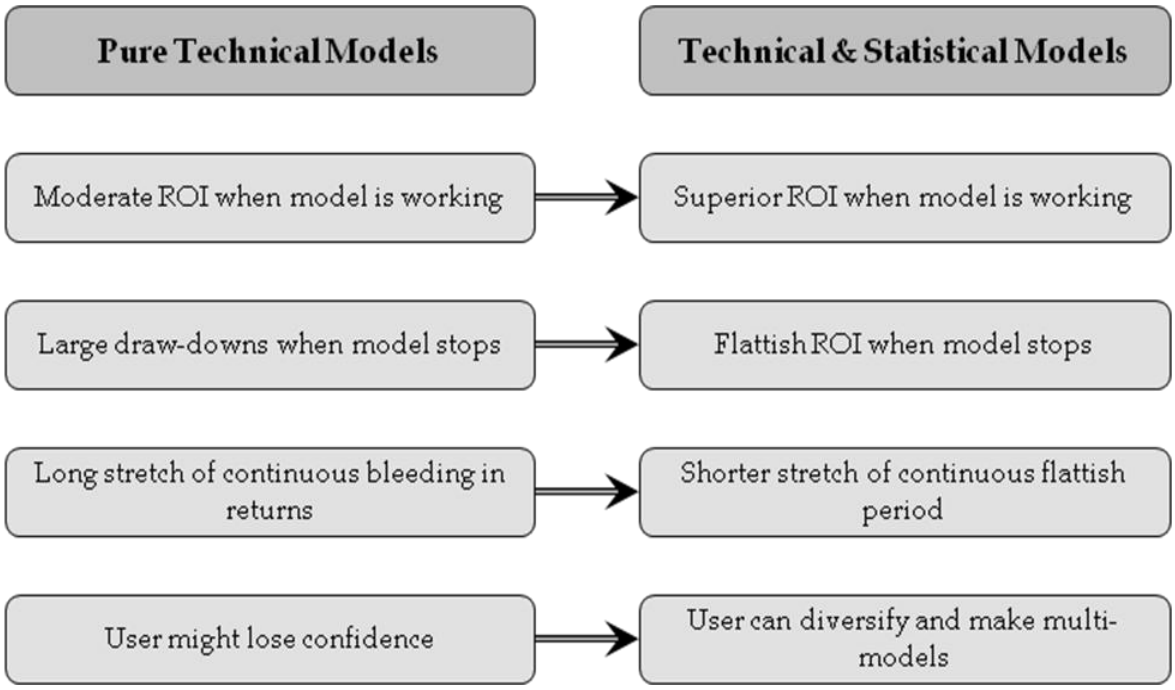



Fig: The advantage of using Statistics along with technical

The main elements of financial mathematics can be listed as:

- Data distributions
- Time series modeling
- Market microstructure

## Data Distributions

*Normal Distribution*

It is the most popular data distribution that is widely used. This data distribution gives us the probability distribution of for a random variable that tends to move around a mean variable. When the mean is zero

and variance is 1, it is called a standard normal distribution curve

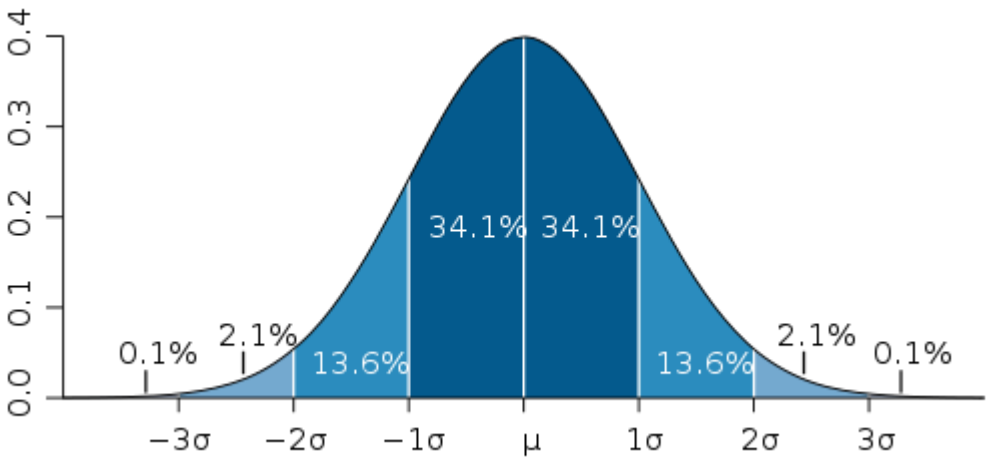



Fig: Standard Normal Distribution Curve

To understand the data distributions, lets us look at some of the important mathematical functions formulas

- Mean (μ): It is the sum of all the data points in a sample space divided by the total number of data points and gives us the average of the sample space. For a sample data x1…xn the mean is represented by the formula:

$$\mu = \frac{\sum x_i}{n}$$

- Standard Deviation (σ) : It is a measure of variation of the data points from the mean. Higher standard deviation indicates the data points are spread over a larger range of values. For a sample data x1…xn the standard deviation is represented by the formula

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}$$

- Variance ($\sigma^2$): It is also a measure of how far the data points tend to be with respect to the mean and is the square of the standard deviation. For a sample data x1…xn the variance is represented by the formula

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2$$

- Correlation (r): It is a measure of how two different data sets tend to move together. If the two tend to move in the same direction together correlation is positive where negative correlation indicates that the two sets tend to move opposite to each other. For 2 sets of sample data x1…xn and y1…yn the correlation between the time series is represented by the formula

$$r = \frac{Cov(x, y)}{\sigma_x \sigma_y}$$

- Beta (β): Beta of a portfolio or a stock is defined as the percentage change in the value of the portfolio/stock with 1% change in the benchmark. For 2 sets of sample data r(s) and r(p) the beta of r(s) series w.r.t to the r(p) series is represented by the formula

$$\beta_s = \frac{Cov(r_s, r_p)}{Var(r_p)}$$

Some other popular distributions

- Cauchy Distribution
- Binomial Distribution
- Poisson Distribution
- Exponential Distribution
- Laplace Distribution
- Chi-square Distribution

**Time Series Modeling**

The time series modeling is used to understand the nature of the time series of data points for the past period and then try to classify it as mean reverting, trending or random walk. More than 50% of the times the series is a random walk and we tend to concentrate and identify the patterns at the other

50% times. The key elements to identifying these patterns are mean and variance

- Mean reverting
- Non-mean reverting
- Constant Variance
- Increasing Variance

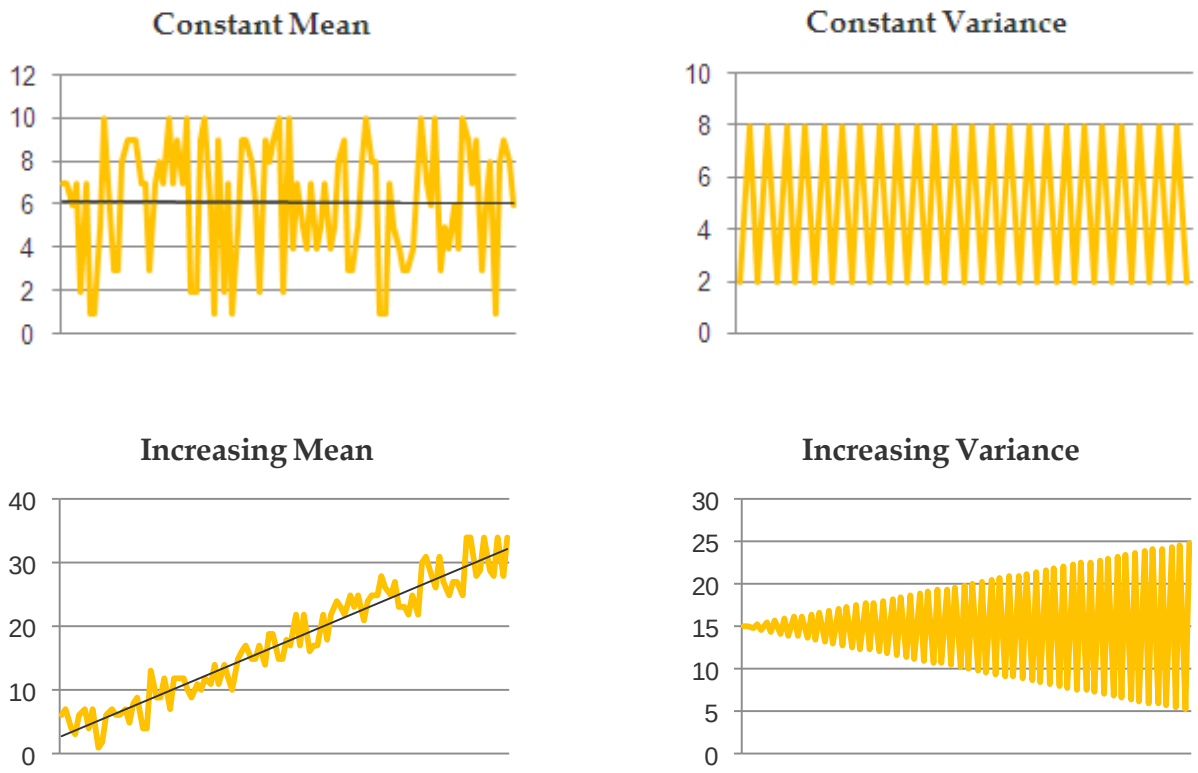



Fig: The mean and variance relationship in a time series

*Mean Reversion Modeling*

Con-integration: It is a method used for mean reversion modeling. It considers a data series to be stationery. The time series is called to be stationary when:

- The mean is constant
- The variance is constant

Variance Ratio test: This test is used for variance alone and does not take mean into account and so is very useful when mean is varying with respect to time

$$VR(k) = \frac{Variance(r_{k\Delta t})}{k \times Variance(r_{\Delta t})}$$

Ornstein-Uhlenbeck Process: This test is used for mean reversion only and is useful when only the mean reversion rate is important

$$dx_t = \theta(\mu - x_t)dt + \sigma dW_t$$

Cluster Analysis and PCA: It is used to identify similar data and patterns and then cluster them together. This kind of strategy is very useful in factor modeling.

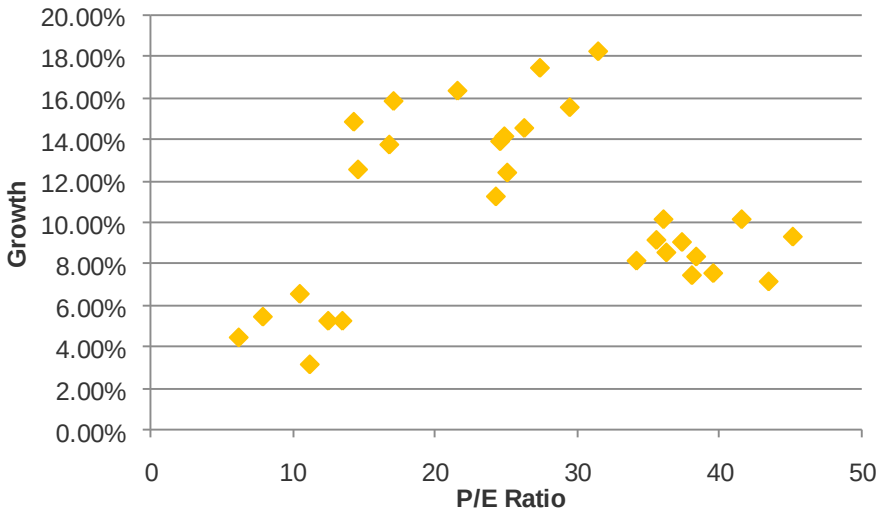



Fig: The cluster analysis showing regions of high growth and value as clusters

Regression: Regression techniques are used to model and analyze several variables to derive a relationship between a dependent variable and other independent variables. It is an important technique to identify the alpha generating factors in a trade. Regression analysis is represented in the simplest formula as:

$$y = mx + c$$

A graphical representation of the regression to explain the dependent Y variable w.r.t. to the independent X variable is as shown in the figure below.

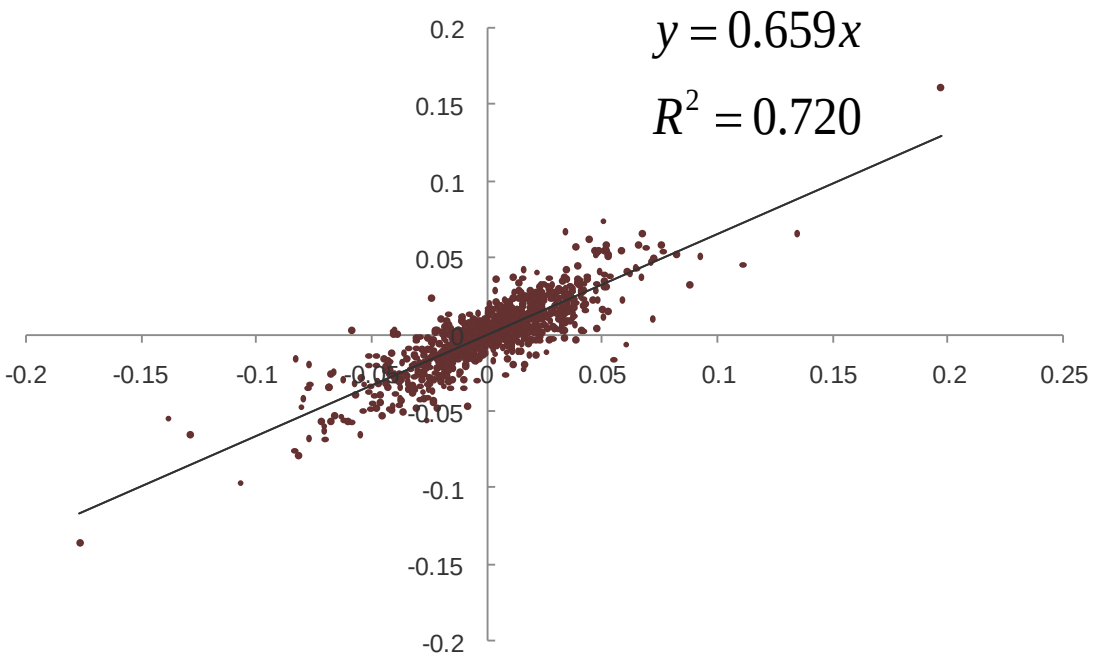



Fig: A graphical representation of regression. Usually *Trade Return is Y* and Factors like co integration, correlation, beta etc are the X Variables in algorithmic trading

## Market Microstructure

Market microstructure is most widely used in high frequency and ultra high frequency trading. The major thrust of market microstructure research examines the ways in which the working processes of a market affects determinants of transaction costs, prices, quotes, volume, and trading behavior. Analysis on order book, bid-ask spreads and short term volatility in the mid-prices forms the corner stone of market microstructure.

Some of the commonly used terminologies in market microstructure are:

- The Order book: An order book is the list of orders (manually and now electronically) that a trading venue (in particular stock exchanges) uses to record the interest of buyers and sellers in a particular financial instrument. A Trading Engine uses the book to determine which orders can be fulfilled i.e. what trades can be made. The order book in the most common form comes with 5 levels of bid and asks price and 5 levels of bid and asks volumes. Although some high frequency strategies uses 10 or more levels of order book depth for trade analysis.

- Spread: Spread is defined as the minimum difference between the bid and the ask price of a security or asset. Spreads can be defined as BP (Basis Points) or can be defined as absolute price term as difference between bid price and ask price.

$$Spread(BP) = \frac{(BestAsk - BestBid)}{(BestAsk + BestBid)/2} \times 10000$$

$$Spread(Ticks) = BestAsk - BestBid$$

- The volume curve: The volume curve is defined as the percentage of volume being executed historically for a particular stock in a given time frame (say 5 Min.) w.r.t to the entire day's volume. The formula for Volume curve is

$$VolumeRatio = \frac{BucketVolume}{DaysTotalVolume}$$

- Volatility: Short term volatility often in 30 sec, 1 min, 5 min etc. is calculated w.r.t to the mid-price of the stock [Mid Price: (Bid+Ask)/2]. The volatility in the buckets is by far one of the most important criterions used to identify the movement and the short term direction of the order book. It also helps in defining the risk limits – as a measure of deviation from normal returns incase a high frequency trade goes against the algorithm prediction.

- Ticks: The trade ticks hold in the tick data holds information on the quantity traded, last price of the trade, time etc. By analyzing the number of trades which occurred on the bid or ask price, the distance between the trades and number of consecutive trades on bid or offer – very valuable information on the short term direction and movement of the stock can be recognized. This is used by the passive liquidity sucking high frequency trading strategies to generate alpha.

# Module – 3: Global Trends in Algorithmic Trading

The field of algorithmic trading has got a strong foothold in the international markets. There are algorithms everywhere, in all markets, all asset classes and across the globe. Investment banks, prop trading desks, hedge funds, all the big players in the market are very active in the field of algorithmic trading and are now spending billions of dollars to build the infrastructure to be a step ahead of their competitors. Some of the facts relating to the global trends:

- TABB group reported in Aug'2009
  - 300 securities and large quant funds
  - Recorded $21 billion in profits in 2008!
- Pure high-frequency firms represents
  - 2% of the 20,000 trading firms in US
  - Account of 67% of all US volumes
- Total AUM of high-frequency trading funds
  - $141 billion
  - Down 21% from the high
  - Compared to global hedge fund shrinking by 33% since 2008
- Volume Characteristics in US
  - In 2005 less than 25% of volume was from high-frequency
  - 2/3$^{rd}$ of daily US volume now from high-frequency strategies
  - HFT Strategy grew by 164% between 2005 and 2010
- Trading volume (Non-US)
  - Europe: 40% of trades
  - Asia: 5-10% (Growing extremely rapidly)

## Flash Trading

Flash trading is by-far one of the most controversial form of high-frequency trading globally. It gives undue advantage to high frequency traders who can see the “flash orders” of an exchange for up to 500 milliseconds before the orders are passed to other exchanges for execution. The exchange under pressure to generate volume and not letting its volume being passed to a competitor displays flash order for HFT traders to fill the order. A real time example of flash trading order and how it works is explained in the diagram below.

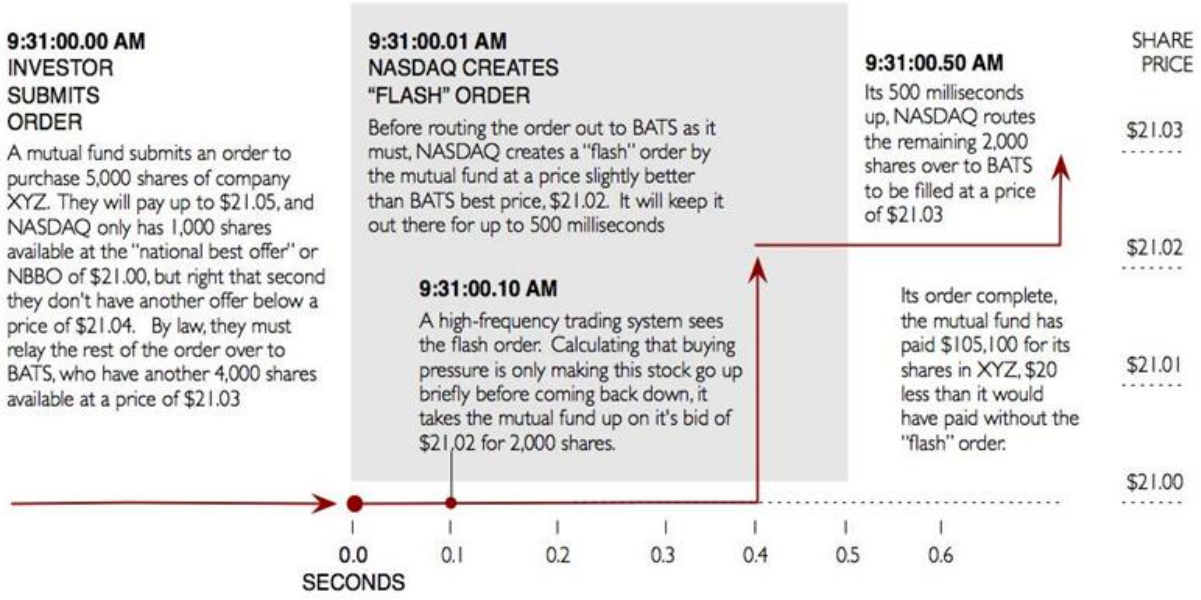



Fig: Flash trading on NASDAQ (Source: *www.thefinanser.co.uk)*

## Smart Order Routing

Smart order routing enable investors choose execution destinations based on the best price, costs, speed, likelihood of execution and settlement, size, and the like. Although in the nascent stages in India, in developed markets like Japan and USA the algorithms has a choice of more then 5 to 10 separate exchanges, ECN’s and inter-broker networks to choose the best price for execution. An example of how an algorithm chooses and changes the order based on Primary exchange (TSE) and Secondry Exchange (Kabu PTS) is shown in the figure below.

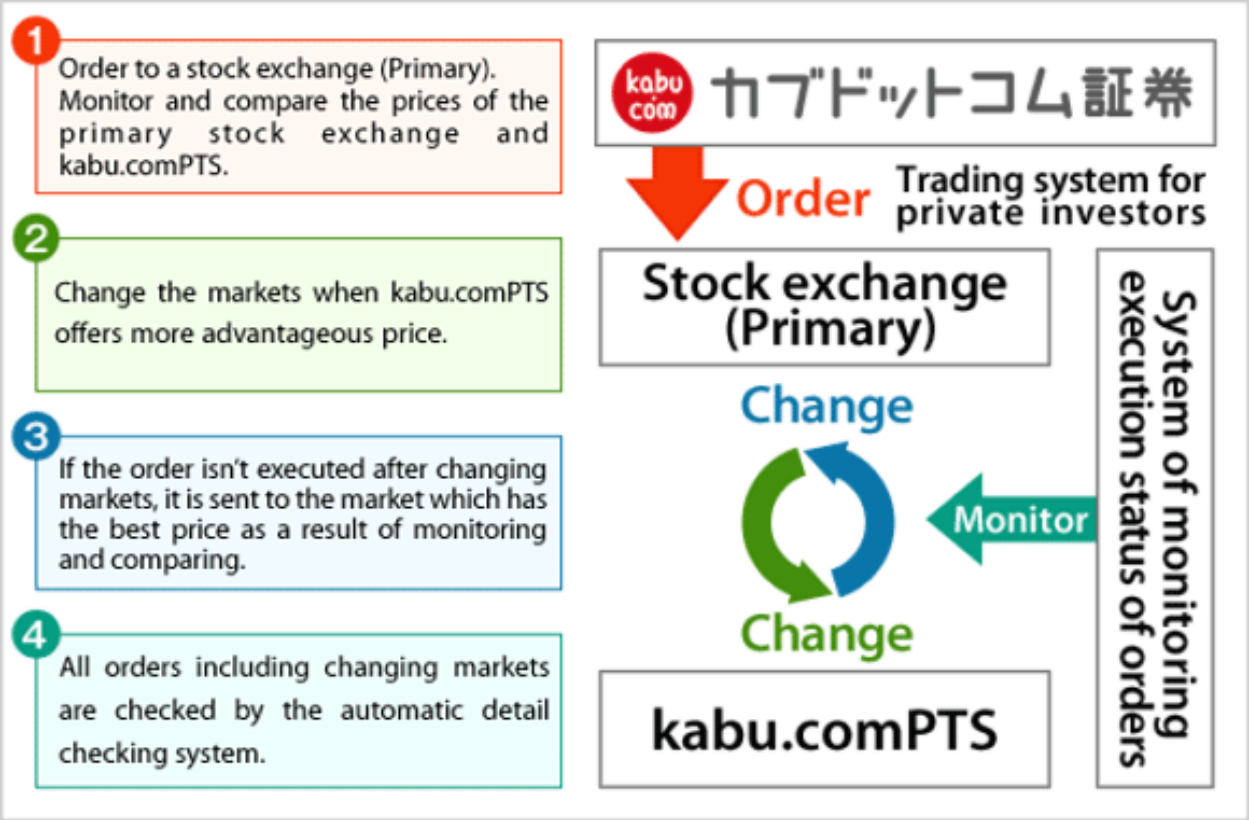



Fig: Smart order routing algorithm between TSE and Kabu (*Source: www.kabu.com*)

**Regulatory Structure in the US**

In the US, the top 2% of the high frequency trading firm trades 60-70% of the volumes. Most of the activities are unregulated and provides massive advantage to larger institutions which can beat latency in the networks and order to the market. The US regulators, following the 6th May'2010 Intra day crash, has started tightening the regulations and making sure the high frequency and algorithmic traders operate well within a level playing ground available to all investors for trade execution. Some of the most common regulations and problems which US regulators face and their attempt to crack it down is shown in the figure below.

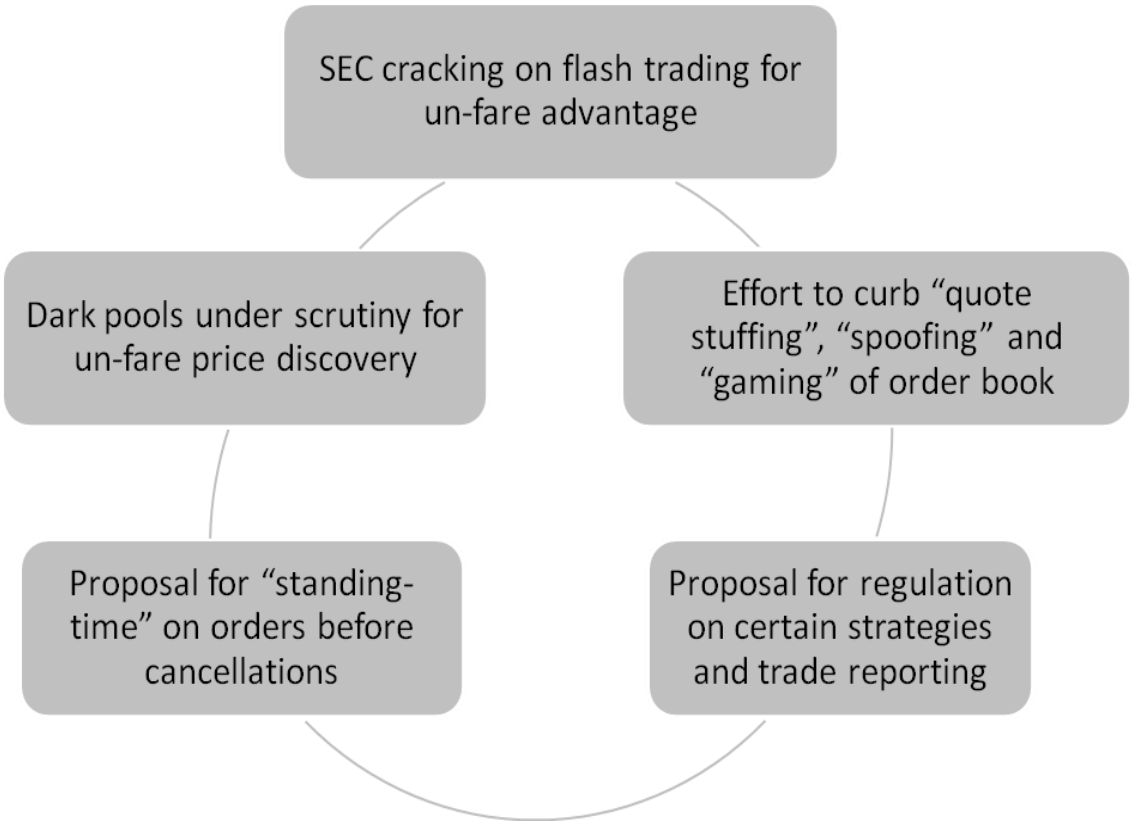



Fig: The US regulatory structure and what the SEC is thinking?

**Conclusion**

While India embattles to understand and take mini-steps in the field of algorithmic trading the global trends are over-spilling and regulators and governments across the world are trying to pin a level laying ground. With the expansion of Indian market its just a matter of time before global algorithmic traders of 1st grade begin to trade the Indian markets aggressively and hence leading to higher volume, liquidity and competition.

# Module 4: Lifecycle of Algorithmic Trading

The various stages in the lifecycle of algorithmic trading can be listed as follows:

- Strategy / Pattern recognition
- Data collection and data cleaning
- Back-testing
- Factor optimization
- Monte Carlo Simulation (Parameter Optimization)
- Trade/ Portfolio result analysis
- Simulated trading and risk management
- Live trading and execution

This is the complete life cycle of a developing a profitable trading model that uses a proven strategy that has the potential to generate profits which is confirmed in the back-test. With the help of Monte Carlo simulation we are able to optimize the relevant parameters and enhance the profitability and efficiency of the model. By the time the model is ready to trade in the live market, the model is well tested for different market conditions and for different risk measures. Let us discuss the mains steps involved in the process of development of the model in a little detail.

## Identifying trading patterns

The trading strategy is the heart of any algorithm and is the basic set of conditions on which the whole model is bases. It is important to identify a trading idea that is capable of generating profit. So how can we find such trading patterns?

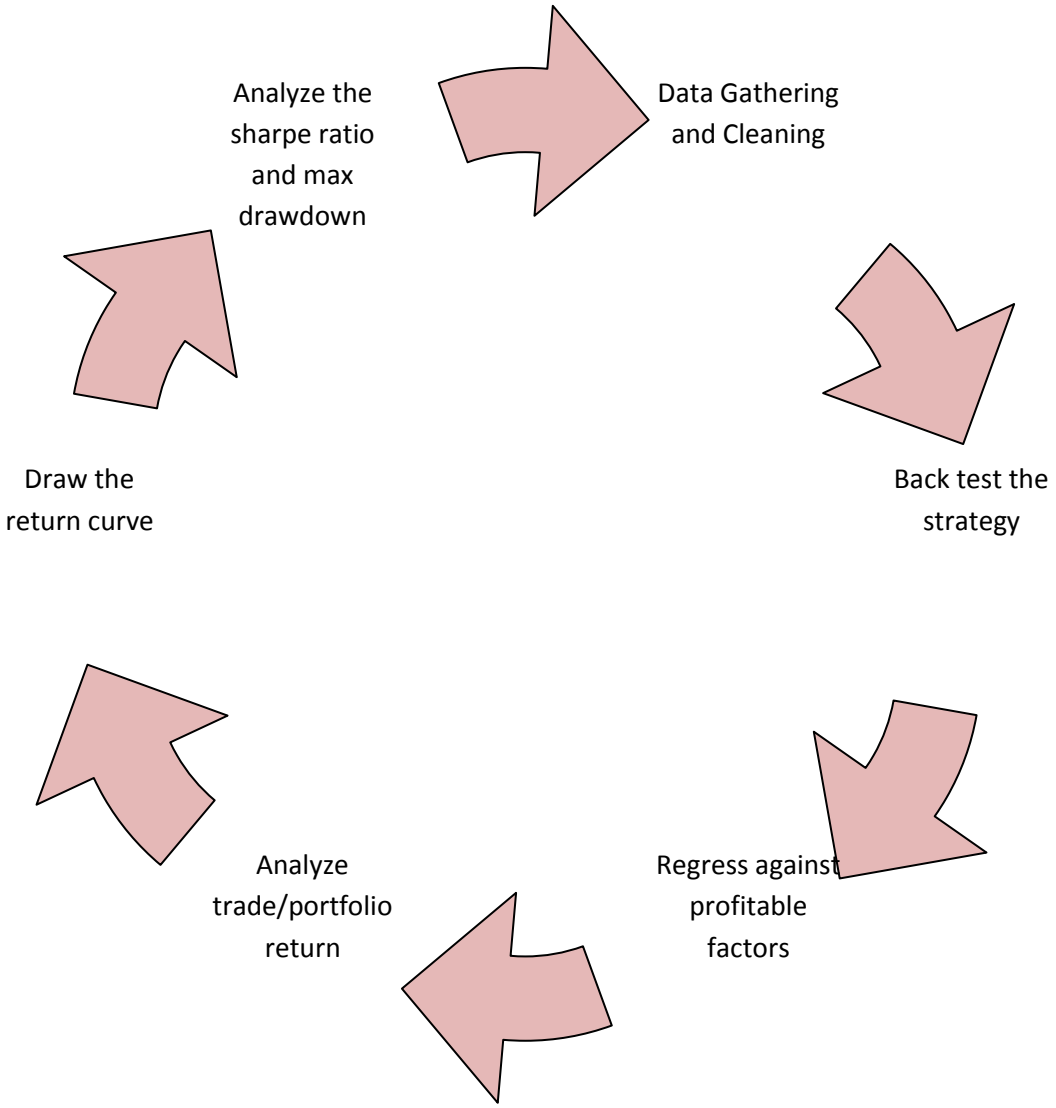
- Talk to experience traders and clients to identify the patterns and strategies that are profitable
- Watch intra-day and daily market movements to identify certain trading patterns which is something which becomes better with experience
- Test simple technical indicators and patterns and see how well they work
- Brainstorm about the new ideas amongst the team

## Back-testing

Back-testing is the most critical stage in the development of a trading model. This is where the strategy is put to test again and again till the time it is optimized to its capabilities. So why is back-testing considered to be so important?

- Back-testing helps you identify any mistakes that may happen and helps u avoiding them in the future
- During the process of back-test, there are certain patterns that are repeated and as these patterns identified they can be helpful in understanding the performance of the model and improvising it further
- It helps us look at the rewards and the risks that the model is exposed while in the markets and thus makes us aware of the pit-falls and the shortcoming of the model
- Through back-testing we can test how the model performs in different market conditions and how the model might behave in rare market events
- Back-testing the strategies over different time intervals can be a good check for the consistency of the performance of the model

The platform for back-testing has to be developed on a coding platform. The commonly used programming language on which the back-testing platforms are build are Excel, VBA, Java, C++. Matlab and R are also very widely used for this purpose.




## Alpha Generation

This is the stage where we try to identify the significant factors to improve the profitability of the model eg. Co-integration and beta are very significant factors in pair trading, bid to offer ratio for short term high frequency trading positions. A wide range of mathematical and statistical factor can be used as factors which in a way might have a significant impact on the profitability of the trade. As we discussed earlier, that time series is random on more than half of the occasions and so we try to recognize this pattern and break the price pattern into deterministic and random components and then try to model the deterministic components of the times series. Now, we regress the trade return against the various statistical factors. Although the factors and mainly mathematical and statistical in nature and should make logical and business sense.

## Monte Carlo Simulation

Monte Carlo Simulation is a type of an optimization algorithm which uses random sampling to compute results and find the optimum values for different factors from these random samples for which the results is optimized. So, in terms of improvising the trading model we can use the Monte Carlo Simulation to identify the optimal parameters for each factor. So we carry out the test across multiple values for one or more factors. For example, in pair trading a Monte Carlo Simulation can be run on different values of Z-score for which we get best turns to find the best suitable Z-score. The optimal solution should be tested on different factors and parameters. Some of the most important factors which need to be identified in a back-test are as follows.

- Annualized percentage return

$$R = r \times T$$

- Annualized Sharpe ratio

$$SH = \frac{r - r_0}{\sigma} \times \sqrt{T}$$

Where
R = Annualized percentage return
r = Average Daily Return
$r_0$= Daily risk-free rate of return
T = No. of Trading days in the year
σ = Std Dev of Daily Returns

- Max peak to trough drawdown
- Average peak to trough drawdown
- Maximum on-performing period

**The Equity Curve**

Equity curve is a graphical representation of the growth of a portfolio or the AUM in terms of profit returns achieved

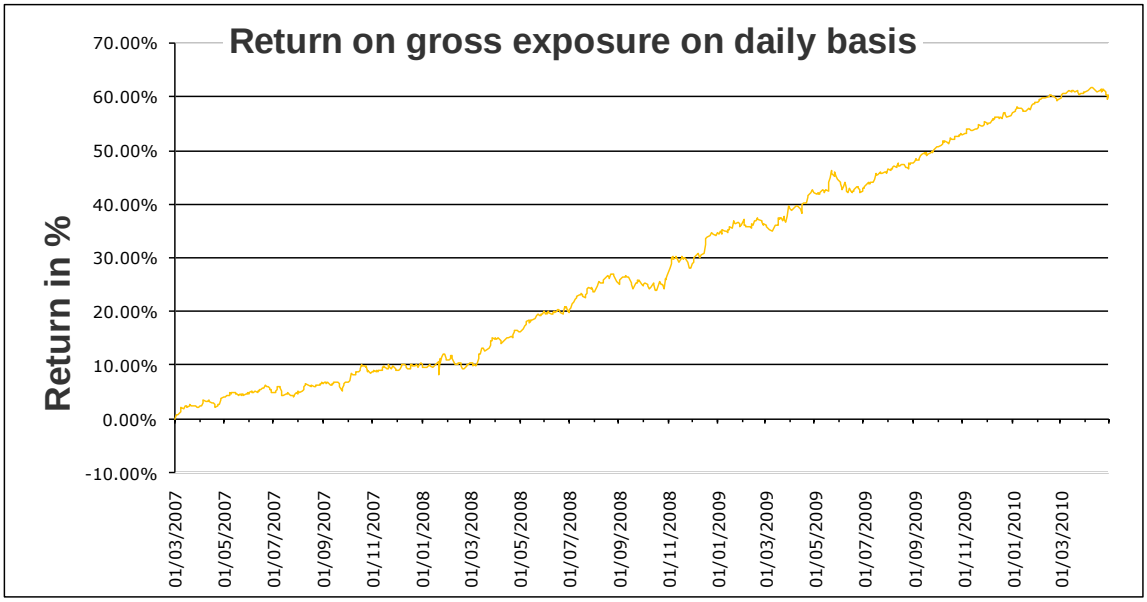



Fig:The back tested equity curve of the portfolio on a daily basis

It plots the everyday return of the portfolio and shows the return of the total portfolio on a daily basis. This helps us in analyzing how robust and stable the growth has been and what are the draw down and down times for the model

**Simulated Trading**

Some of the trading strategies perform really well in back-test but are not able to replicate the performance in live trading and fail miserably. One can not infer from this that there is a problem with the strategy as their might be other reasons behind this

- Lack of execution know-how
- Gaps between back-test and real life execution
- Slippage, transaction costs and other charges
- Increasing the size and quantity of the model beyond its capacity

This is why simulation trading is an important part of model testing so that the performance can be judged in real time and see if the performance of the model is consistent with the back-test

- Trade signals are generated at the right time
- Execution pit-falls are ironed out
- Slippages with respect to the signals are minimized

- Real-life trading is consistent with the back-test

## Automated Execution

Once the signals are generated by the model, they need to be executed. It is considered best to have an automated execution of the trades as it reduces the time between signal and execution. It also non-emotional and systematic approach with any personal views and eliminates the possibility of any human errors. The orders can be executed in the following ways

- A manual execution guy to punch the order manually into the system
- CTCL connectivity of NSE provided by 3rd party vendor software
- DMA platform provided by institutional brokers
- DSA platform provided by institutional brokers
- FIX protocol (global standard) for information exchange
- In future Agency algorithms for execution may also be use

# Module 5: Risk, Costs and Roles in Algorithmic Trading

## Understanding the Risks

*What is risk?*

Risk can be quantified as the probability of deviation from the expected return. Since in terms of returns, only downward deviations pose a risk so it would be considered as a downside risk. If we look at the graph of data distribution the higher is the probability of extreme deviations, higher would be the risk. Fatter tails in the distribution represent greater amount of risk.

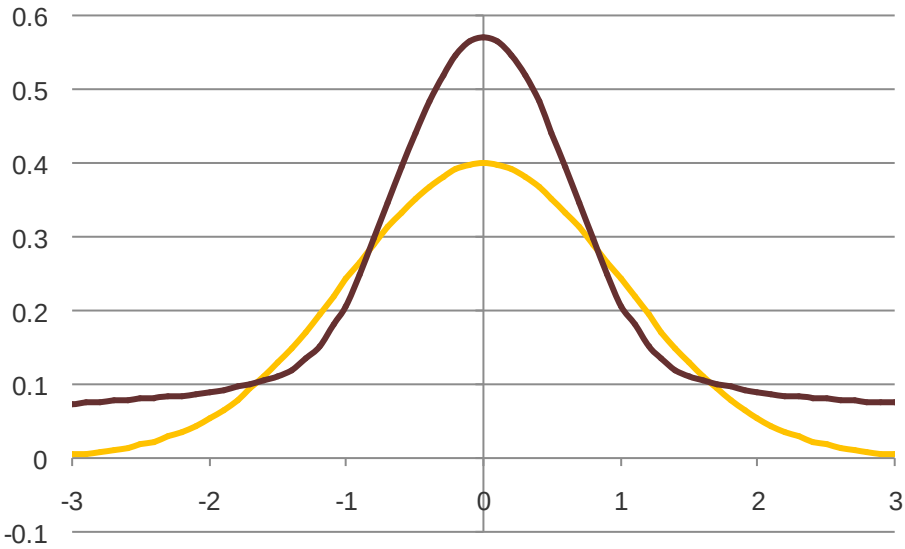



Fig: The anomaly in normal distribution and fat-tails leads to risk

Risk can be classified as systematic risk and unsystematic risk.

Systematic Risk: It is the risk associated with aggregate market returns which can be mitigated through diversification. We can foresee and prepare for this kind of risk. There can be different reasons for this kind of risk

- Exposure to market direction
- Exposure in terms of net rupee value
- Sector risk
- Single Stock risk (e.g. Satyam)
- Slippage risk

- Execution risk (Software crash, Power Failure)

Systematic risk mitigation

- Certain measure can be taken while designing the system to mitigate risk
  - Market direction neutral strategies
  - Limit the exposure to a single sector in the portfolio
  - Limit the exposure to a single stock in the portfolio
- To mitigate the risk exposure during execution
  - Design to take order book into account for execution
  - Limit on daily turnover of the system
  - Limit on max rupee value for a single trade to be executed
  - Limit on number of trades in a day
  - System to should be able to recover power failures and software crashes
- When the system is running live to monitor and minimize the risk
  - Live monitoring by the IT team on connectivity, restart
  - Switching the model off for rare market conditions

Unsystematic Risk: It is the component of risk which is uncorrelated to overall aggregate market returns and cannot be mitigated through diversification. Examples of suck risk are:

- Event risk like Indian election results 17$^{th}$ may 2009
- Crowded high frequency, US intra-day crash on 6$^{th}$ May, 2010

## The costs

The cost structure in India for various instruments is given in the table below. Costs are an important factor in algorithmic trading as the costs associated with execution and transaction can eat away a huge amount of profits that the strategy can generate. The spread in India is lowest among the Asian markets at 5 BPS, but Indian markets lack the order book depth and stock beyond the top 70-80 lack liquidity. As large orders are executed, it results in a lot of slippages and thus decreases the profitability

**Securities Transaction Tax**

| Product | Transaction | STT rate | Charged on |
|---|---|---|---|
| Equity-Delivery | Purchase | 0.125% | Turnover |
| | Sell | 0.125% | Turnover |
| Equity-Intraday | Purchase | - | - |
| | Sell | 0.025% | Turnover |
| Future | Purchase | - | - |
| | Sell | 0.017% | Turnover |
| Option | Purchase | 0.125% | Settlement price, on exercise |
| | Sell | 0.017% | Premium |

**Other Charges on Futures**

| | |
|---|---|
| SEBI Turnover Charges | 0.0001% |
| Transaction Charges | 0.002% |
| Total Charges on Futures (Buy & Sell) = 1*1.7 BP+2*0.01 BP+2*0.2 BP | 2.12 BP (0.0212%) |

Table The securities taxation structure in India

## Roles in Algorithmic Trading

*Trader*

- Identifies trading patterns and strategies
- Watches market movement and opportunities
- Works closely with IT and quantitative team
- Checks the back-tests and historical performance closely
- Monitors the live trading risks and positions

*Quantitative*

- Converts the normal trading ideas into mathematical language
- Collects and clean data
- Back-test the strategies
- Identifies the alpha generating factors using statistical tools

- Build the simulated trading environment
- Test strategies in the live market
- Takes feedbacks and risk-control measure from traders

*Programmer and Developer*

- Converts the mathematical language into computer language
- Supports the quantitative team in building the IT system
- Develop the processes to store, clean and manage huge amount of market data
- Develop the platforms for back-testing and simulation
- Develop system to manage order execution and automation of orders
- Support the end-to-end lifecycle of algorithm development

*Risk and compliance Manager*

- Risk assessment on strategy level and daily VAR levels
- Analyze correlation between various strategies
- Assess limits and exposures in each strategies
- Ensure compliance with SEBI and exchange regulations
- Ensure that trades send to the market uses standard connectivity protocols
- Ensure provision in system to restrict certain stock
- Inform higher management towards unforeseen risks

## Module – 6: The trading strategies

The algorithmic trading strategies broadly get categorized in 2 sections:

- Agency Trading: Strategies built to enhance client's trading performances
- Prop Trading: Strategies built to trade on proprietary account of the firm

## Agency Trading

Agency trading is buying and selling by an agent, usually a stock broker, on behalf of a client. Agents are paid a commission for performing the trade.

Most of the agency algorithms are built by analysis on the market microstructure, which encompasses the use of bid-ask volumes, order book depth, analysis on the trades executed at bid or offer and volatility in the mid-price.

### *Agency Trading Algorithms*

Some of the most common and widely used agency algorithms are:

- VWAP (Volume Weighted Average Price): VWAP is often used as a trading benchmark by investors who aim to be as passive as possible in their execution. Many pension funds, and some mutual funds, fall into this category. The aim of using a VWAP trading target is to ensure that the trader executing the order does so in-line with volume on the market. VWAP can be measured between any two points in time but is displayed as the one corresponding to elapsed time during the trading day by information provider.

  VWAP is often used in algorithmic trading. Indeed, a broker may guarantee execution of an order at the VWAP price and have a computer program enter the orders into the market in order to earn the trader's commission and create P&L. This is called a Guaranteed VWAP execution. The Broker can also trade in a best effort way and answer to the client the realized price. This is called a VWAP target execution; it incurs more dispersion in the answered price compared to the VWAP price for the client but a lower received/paid commission. Trading algorithms that use VWAP as a target belong to a class of algorithms known as *volume participation algorithms*.

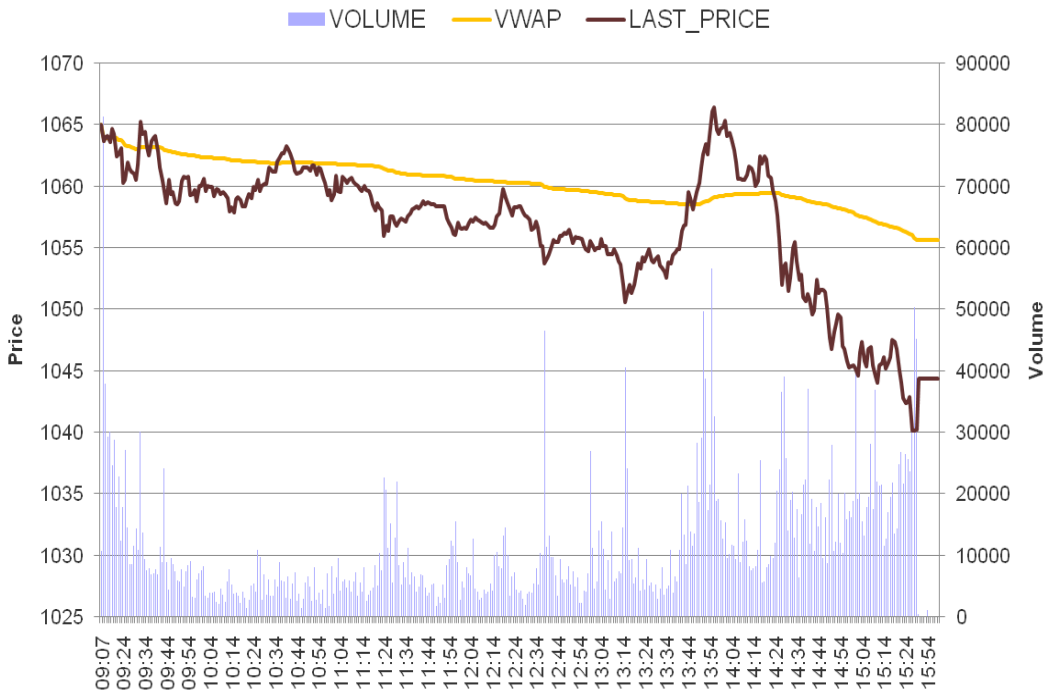



Fig: An example of the intraday VWAP Price of the Reliance

- TWAP (Time Weighted Average Price): TWAP is a strategy that will attempt to execute an order and achieve the Time Weighted Average Price or better. A TWAP strategy underpins more sophisticated ways of buying and selling than simply executing orders en masse: for example, dumping a huge number of shares in one block is likely to affect market perceptions, with an adverse effect on the price. High-volume traders use TWAP to execute their orders over a specific time so they trade to keep the price close to that which reflects the true market price. TWAP orders are a strategy of executing trades evenly over a specified time period. VWAP balances execution with volume.

- Aggressive: These strategies are designed to take quick action and buy or sell, irrespective of the prices. Usually when the market shows strong signs of up or down moves, these strategies are used by the brokers to place orders aggressively.

- Passive: Passive strategies usually send order at limit prices and waits for the execution to take place. During the times of lower volatility in the market passive strategies are used by agency desks to get orders filled slowly.

- Inline: Inline strategies get the orders executed inline w.r.t to the incoming prices and volume and hence trades the markets at or about the average price.

- MoC strategies: Market On Close beating strategies are often used by the clients who have sensitivity of their strategies to the market closing prices. Usually the main objective of such a

strategy is to identify the approximate closing (average of last 30 min. etc) and hence trade aggressively or passively in the last few minutes to mimic the market on close prices.

### *The algorithmic techniques*

Most of the VWAP algorithms uses the market volume curve to slice the volume of the order to be distributed and executed all throughout the day. An example of the market volume curve is shown in the figure below.

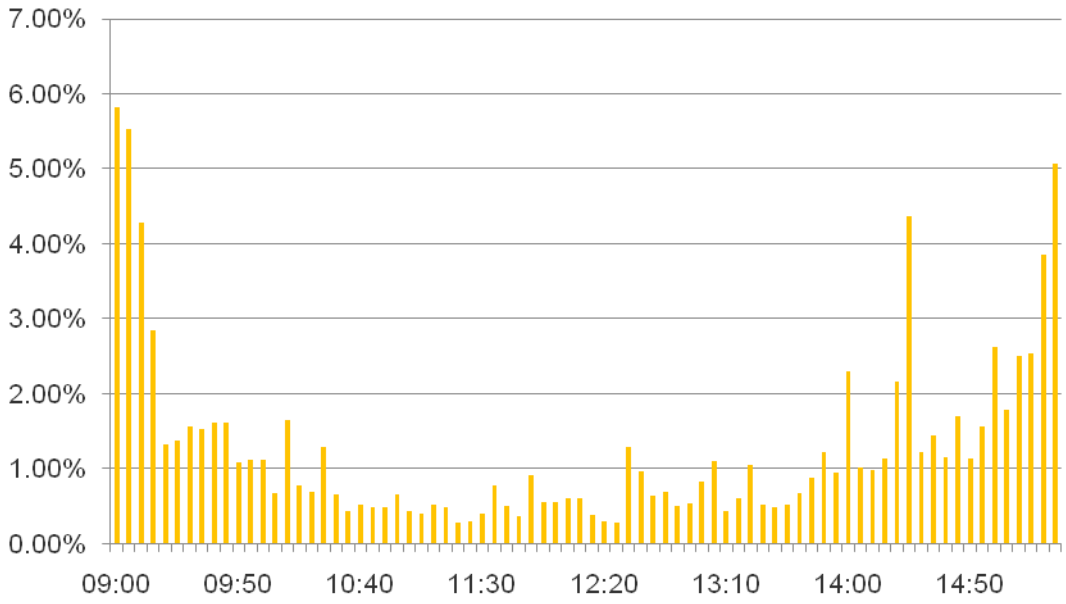



Fig: Volume curve of the market for an intra-day VWAP volume slicing algorithm

The aggressive and passive strategies use the dynamics of the order book like

- Bid to Ask volume ratio
- Number of trades on the offer or bid
- Distance between the trades
- Number of consecutive trades on the offer or on the bid
- Bid-Ask spread
- Volatility of the buckets in 1min, 5 min. etc.

To decide the trading strategy. An example of the order book and its sampling is shown in the figure


Fig: Order book and its dynamics forms the key technique for Agency algorithms

**Alternative Execution Venues**

Alternative to the primary exchanges, large institutional brokers use the Agency algorithms to execute their orders in many alternative avenues available for execution. The alternative execution is driven by the fact that clients wants execution with hidden orders and want a better price then the primary exchanges. Some of the alternative execution platforms which agency algorithms use are:

- Primary exchange
- Secondary exchanges: Alternative recognized exchange
- ECN (Electronic Communication Network)
- Inter-broker dealer
- Dark-pools
- Internal crossing

The Agency algorithms uses technique called SoR (Smart Order Routing) to identify the best price available amongst all the possible avenues and then sends the order into the right venue for trading. The smart order routing has to take care of lots of factors like, queue size, mid-price available, volume on bid or offer etc. before deciding the right venue for trading.

**Prop Trading**

Just like agency algorithms Prop algorithms uses the mix of technical and statistical factors to come with strategies which are profitable and can deliver enhanced alpha. However, where agency algorithms are designed to reduce the losses in execution the Prop algorithms are designed with a focus to enhance profitability and can choose to do or not-do a trade based on various factors.

***Prop Trading Algorithms***

The most common and widely used algorithms in Prop trading are:

- Arbitrage: Arbitrage exploits the price difference two markets, exchanges etc. on the same security. Most of the arbitrage if executed simultaneously is considered risk-free. For e.g.: simultaneous buying and selling of a Reliance share in BSE and NSE might help the arbitrageurs make profits in tiny pieces between the 2 exchanges. Risk free arbitrage is however very sensitive to execution costs and are becoming tougher in the current market environment.

- Statistical Arbitrage / Pair Trading: One of the most popular Prop trading algorithms involves pair trading whereby 2 securities which belong to the same sector are simultaneously bought and sold to make tiny profits from the noise being created in the market. Most algorithms uses sophisticated mean reversion techniques to identify noise in 100's or 1000's of such pairs and take positions at the right time. An example is shown in the figure below:

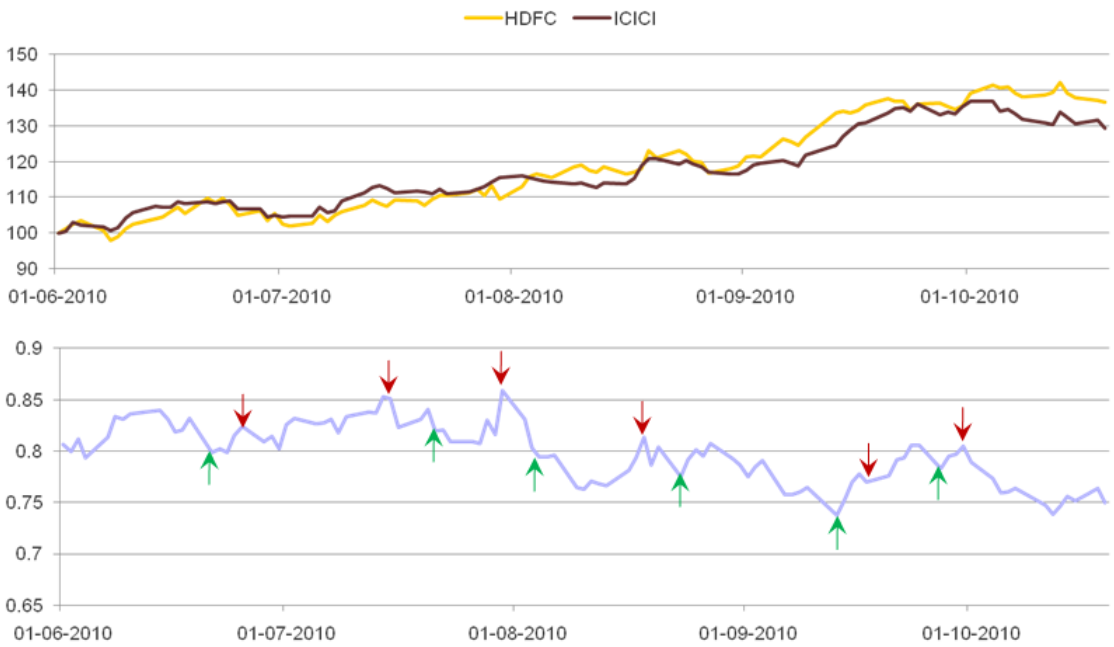



Fig: Example of HDFC Bank and ICICI bank Pair Trading

- Trend Momentum: Trend following strategies are mirror-images of pair trading strategies. They try to capture information (in the form of trends) and continue to follow the trends as long as the market moves in their direction. Most trend following systems uses some kind of moving average (simple, exponential, weighted etc.) to stay in or identify the trends. The profits can be really large on capture of good trends but however, long period of whip-saws can cause massive draw-downs in the trend following systems.

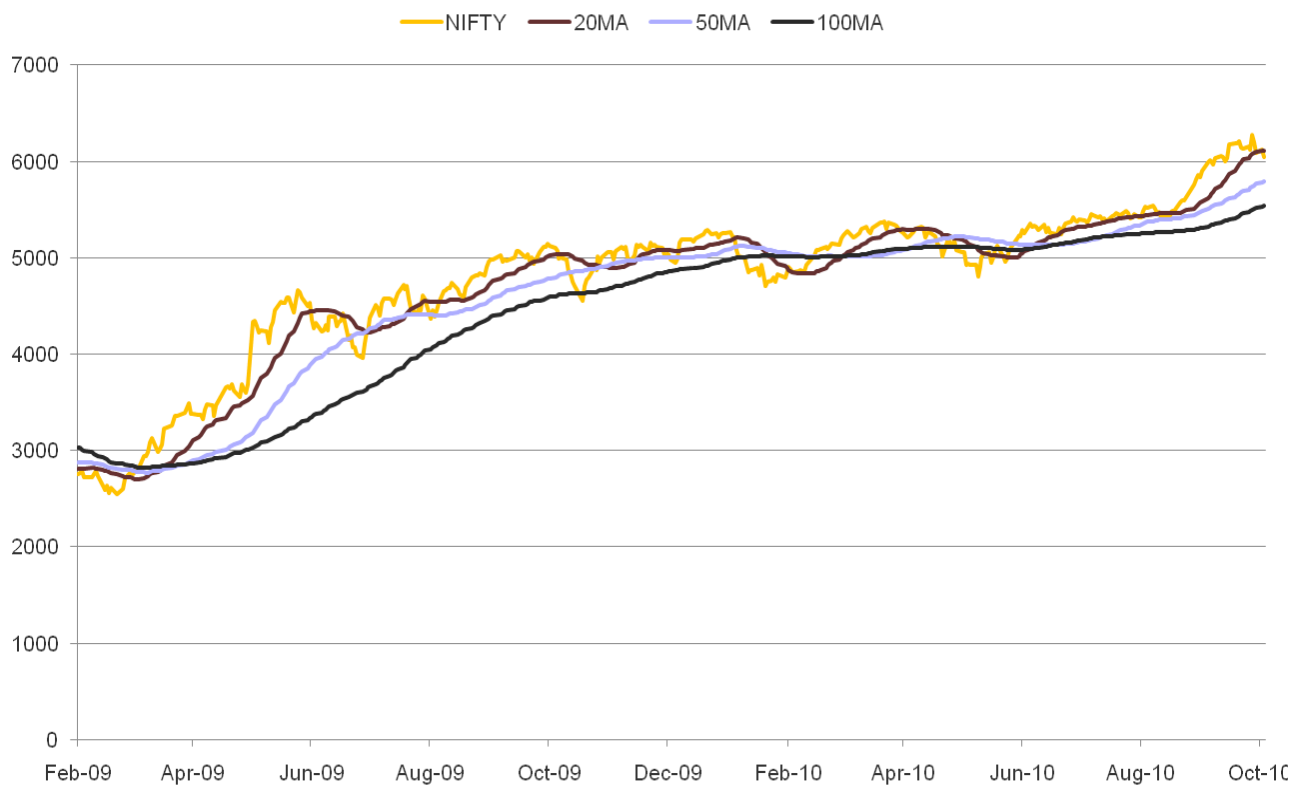



Fig: Example of trend following system on Nifty using 20, 50 and 100 SMA

- High Frequency Strategies: High-frequency trading is quantitative trading that is characterized by short portfolio holding periods. There are four key categories of high-frequency trading strategies: market-making based on order flow, market-making based on tick data information, event arbitrage and statistical arbitrage. All portfolio-allocation decisions are made by computerized quantitative models. The success of high-frequency trading strategies is largely driven by their ability to simultaneously process volumes of information, something ordinary human traders cannot do. The figure below depicts an example of high frequency strategy where based on number of upward and downward ticks, the short term momentum in the stock is decided.

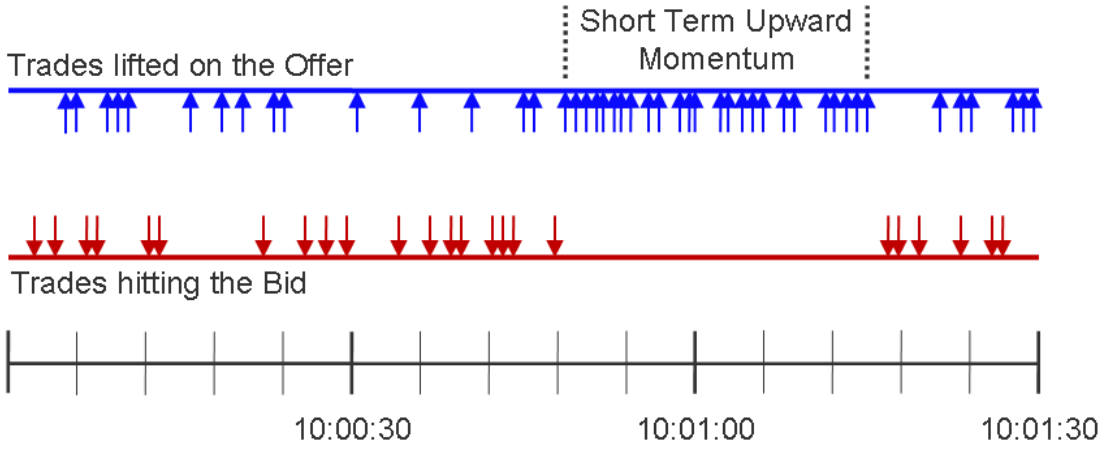



Fig: Example of short term upward momentum in high frequency strategy

- Factor Modeling: Mathematical profile measuring the extent a portfolio of stocks is influenced by a range of economic factors such as changes in interest rates, inflation, and/or oil prices. There are several types of factor models, including a few proprietary ones, but they all are constructed using factor analysis techniques and can be divided into three basic categories: statistical, macroeconomic, and fundamental. Statistical factor models attempt to explain returns from an investment in terms of risk factors such as cash flow risk, currency risk, and purchasing power risk. Macroeconomic factor models attempt to do the same in terms of factors that affect the economy as a whole. And fundamental factor models focus on economic factors that affect a particular industry or market like the book yield, dividend yield and earnings growth. Most factor models on the fundamental side either focuses on Value, Growth or Price action of the stock. A hybrid factor model can also be constructed using the mixture of value, growth and price momentum. The figure below shows an example on how the mixture of various factors can be used for constructing a fundamental hybrid factor model.

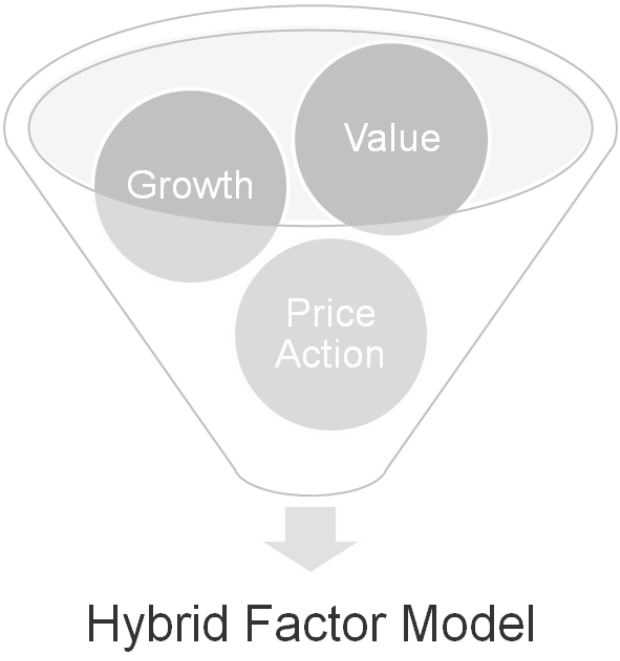



Fig: Hybrid factor model construction using value, growth and price actions

***The algorithmic techniques in Prop trading***

Just like in the agency trading, certain fundamental techniques are used on the prop side of the strategy to construct a sound trading strategy. Some of the techniques are:

- Technical analysis: Simple technical rules like moving averages, z-score, Bollinger bands, RSI etc. can form a good starting point to start decide the entry and exits of the trade
- Statistics: Statistical filters and understanding the time series modeling then becomes an important criterion to further filter out the low probability trades.
- Smart money management techniques like: Bet Sizing and Knowing when NOT to trade a particular system can help overlay and reduce the massive draw downs which might occur on prop trading strategies, when not framed properly.

**Conclusion on trading strategies**

Prop and Agency trading strategy can help capture years of knowledge and know-how on traders and package it into a well formed quantitative strategy which can bear fruits for years for a firm which enters the market first. Care however, should be taken to not over expose the risk limits and keep the portfolio of strategies sufficiently diversified so that the risk return ratio helps in making sustainable wealth and at the same time help the algorithmic trading business grow.

# Module – 7: Business aspect of algorithmic trading

The business aspects of algorithmic trading deals with how a firm can achieve profits and sustained returns while not being over-exposed to risk. It also deals with the cost, business integration and practical issues which firms face in the light of algorithmic trading in India.

Most of the revenue from algorithmic trading is driven from either a client driven or a product driven business. The details of both of these aspects are outlined in the following sections.

## Client Driven Business

The client driven business focuses on providing execution and quantitative intelligence to the clients to make their trades or decision to trade profitable. It can be more precisely classified as client services. Some of the most popular client driven business are:

- Large Institutional clients want superior execution
  - Agency approach: VWAP, aggressive, passive algorithms
  - Provide intelligence on executing large basket orders
  - Use a mix of sales trader execution and partly algorithms based
  - E.g.: BGI wants to trade large MSCI Index basket
- Clients want quantitative intelligence on trades
  - Quantitative research and algorithmic support
  - Support client-decision making
  - E.g.: Marshall Wace requires analyst ranking data
- HNI / Private banking client wants to manage money
  - Internal quantitative hedge fund approach
  - Manage money on profit sharing basis on internal strategies
  - E.g..: Private banking at most major I-Banks

## Product driven

The product driven business requires a lot of R&D and internal spending by the institutions before the returns can be realized. It often requires hiring smart algorithmic traders and forming desks which can gain sustainable revenue for the firm. Some of the popular approaches in the product driven businesses are:

- Internal research and development (Organic route)
  - Product developed first with Prop focus
  - Then AUM deployment holds larger potential
  - Approach clients for deployment of money
  - Enter a profit sharing agreement
  - E.g.: Goldman alpha fund
- Hiring profitable algorithm desks and quant traders (Inorganic route)
  - Expensive at first go
  - Cut-down the research cycle
  - Aim to generate revenue from day-one based on past track record
  - Sometimes risky as the environment might differ
  - Develop multi-strategy group to act under diverse environment
  - E.g.: Goldman prop desk – always on a look-out

## The Costs

The costs in algorithmic trading for a firm can be low to very high and hence care must be taken by the decision makers to make sure that the objective of what the end products should look like is clear in their minds. Be it agency or prop the business revenue, returns and draw-downs should be choked out in clear terms. The cost of the software and the skilled-labor to develop the strategy can engulf most of the costs and hence the spectrum and the scope of the project should be clear and concise before hand. The figure below lists some of the critical costs and overheads which business units face in the light of development of algorithmic trading strategies.

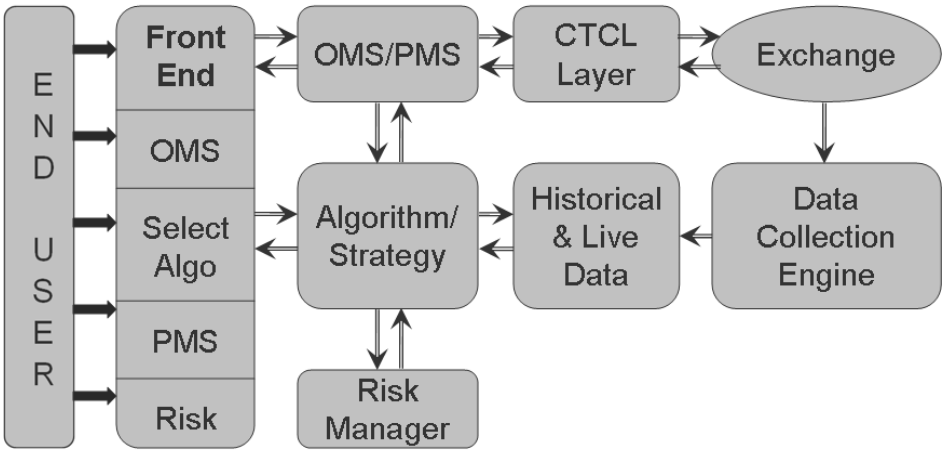
| Cost heads | Per head cost in INR |
|---|---|
| OMS/PMS system | 0 – 10 L |
| Automated order execution | 60 K – 8 L |
| Data (live time, historical, intra-day, tick-data) | 40 K – 3 L |
| Software (Matlab, Excel, Java, C#, R) | 0 – 6 L |
| Quant Analysts (1 to 5) | 2.5 L – 12 L |
| IT Engineers (1 to 8) | 1.3 L – 8 L |
| **Total cost range (Rs. p.a.)** | **4.8 L ~ 47 L** |

Fig: Cost of algorithmic trading strategy can vary widely depending on the project

## The system integration

One of the fundamental challenges in the customization of the algorithmic strategy is the integration of the business system with the algorithmic system so that everything works in sync. Hence, most large institutional banks and broker houses choose to keep their own sets of in-house team members to tightly integrate the business systems and the IT systems alongside the algorithmic framework so that everything works flawlessly. The OMS and PMS systems which is widely used in any broker shop needs to be tightly coupled with the algorithms (including the User interface) – so that the traders on prop and agency side are comfortable on running the strategies and reap its benefit.

In addition, the database comprising of the live time and historical data are readily available to the algorithms so that real time analysis and trade optimization, helps the business reap tremendous benefits. The figure below explains the various system blocks which form the corner stone of the business level integration.




Fig; The algorithmic trading system architecture and its integration

## Vendors and 3rd party in India

The OMS (Order Management System) and PMS (Position Management System) systems forms the

corner stone on top of which the algorithms are designed. Most of the brokers, FII's and traders in India might have at some point in time used one or multiple of these platforms. Most of the OMS and PMS systems in India today come integrated with rudimentary packages on VWAP, TWAP and some basic functionality on Prop trading. However, they require additional level of work and more sophistication to come up with cut-throat and more advanced level of algorithmic trading strategies which can give a business its competitive advantage. Some of the most common OMS/PMS systems and data vendors in India today are:

- OMS systems
  - ODIN by FT
  - Online interface provided by most brokers
- BSE IML & NSE CTCL: Vendors in India
  - 3i
  - Omnesys
  - Greeksoft
  - Financial Technologies
- Data vendor in India
  - Bloomberg
  - Reuters
  - Tickerplant
  - Newswire18

**Revenue models on agency side**

The sources of generating revenue on the agency desk based on algorithms are very promising and widespread. Most of the risk averse institutional investment banks in the world have very aggressive agency trading desk which tries to squeeze revenues in 100's of millions of dollars based on providing superior and bleeding edge execution to their clients. Some of the popular revenue streams on the agency side of the businesses are:

- Brokerages and Commissions on
  - Single large order at WVAP over multiple days
  - Program trading and basket execution (E.g.: Index arbitrage)
  - Clients strategy execution (E.g.: Pair trading: ICICI-HDFC together)
  - Special executions like beating MOC prices (E.g.: Futures 30 min)

  - Desks in US and Japan makes more than $100 Mn. Annually
- Guaranteed VWAP orders
  - Clients off-load execution risk and execute at average price
  - Prop positioning with clients
  - Desks in US and Japan make more than $25 Mn. Annually
- DMA/DSA
  - Client send orders directly to exchange using broker platform
  - Client s chooses the execution strategy (VWAP, Aggressive etc.)
  - Client choose the quantity, price and order type directly

**Revenue models on prop side**

Aggressive firms like Goldman Sachs etc. derive a major portion of their revenues from prop trading algorithms. To generate superior alpha, take higher risk and yet generate returns is a dream of most of the institutional banks. The challenge lies in being on top of the competition and constantly renovating the strategies so that superior risk adjusted returns can be achieved. Some of the salient features of Prop trading strategies, across the global desks are:

- A good strategy can yield cumulative 25-50% p.a. return
- A good strategy Sharpe ratio is > 2.5
- Diversified strategy
  - Frequencies (High, Medium Low)
  - Strategies (Mean reversion, Momentum)
  - Fundamentals (Growth, Value)
  - Asset classes: Options, Equities, Commodities, Currencies
- Run money
  - In-house
  - Close business associates and friends
  - Clients (usually on a 2/20 hedge-fund model)

## Competitive Factors

To stay on top of the competition is one of the foremost priorities of algorithmic trading. With latency to the markets being counted in nano-seconds and alpha generation becoming more and more creamier asset – most firms choose to stay tight lipped about their revenue generating models. The risk arises when most people are running same or similar strategies and all are tight-lipped about it. Once a certain firm decides to unwind its large position the snow-ball effect impacts all other firms which have been following a similar trading strategy. Some of the important factors which needs to be considered in terms of competitiveness on the algorithmic trading side are:

- Algorithms (Superior alpha factors)
- Execution
- Diversification
- Speed and co-location
- Brokerage and transaction costs
- Quantitative & IT team
- Global outlook and reach to multiple geographies / markets

# Module – 8: India in algorithmic trading

India although on the nascent stage continues to be at the threshold of the algorithmic trading and the next 3-5 years in India will see a good growth in various businesses and institutional banks competing cut-throat to make algorithmic trading a corner stone of their business. The costs and exchange approvals although are hindrances and bottlenecks at times – but with markets opening and foreign banks getting regulatory approvals, its just a matter of time before Indian markets sees the flood of volume emerging out of algorithmic trading.

## The existing regulatory structure

The existing regulatory structure in India as compared to the global exchanges like NYSE and TSE are far more controlled and regulated. Some of the salient features of the current regulatory environment in the country are:

- Exchanges has throttling control on number of trades per second
- Approval process for algorithmic trading
- Multi-exchange algorithmic strategies is not legally allowed by NSE
- Cross-exchange arbitrage and SOR cannot take place
- STT applicable to all transactions

## The potential in Indian markets

The Indian market is poised to grow tremendously in algorithmic trading – mostly owing to the market microstructure which continues to be one of the dominant forces. The spreads in the India equities are one of the lowest in the world at about 5 BP. The numbers of trades are amongst the highest in the world. Some of the salient features of the India market microstructure are:

- 10th largest in dollar value
- Huge potential as in “number of trades” – 3rd largest!
- Worldwide median per trade: $10 K
- India median per trade: $500
- All exchanges offer co-location facilities
- Spreads are amongst the lowest in the world at 5-6 BP

## The cost structure pros and cons

One of the biggest deterrent to high frequency trading and liquidity to the Indian markets is the STT or the

Securities Transaction taxes. Whereas globally trades are executed at less then 0.5~1 BP of cost in India every transaction has i8nherent costing of more then 2~3 BP. The 3 fold cost structure acts as a detrimental to increase in liquidity and market makers who thrive on tiny but assured profits.

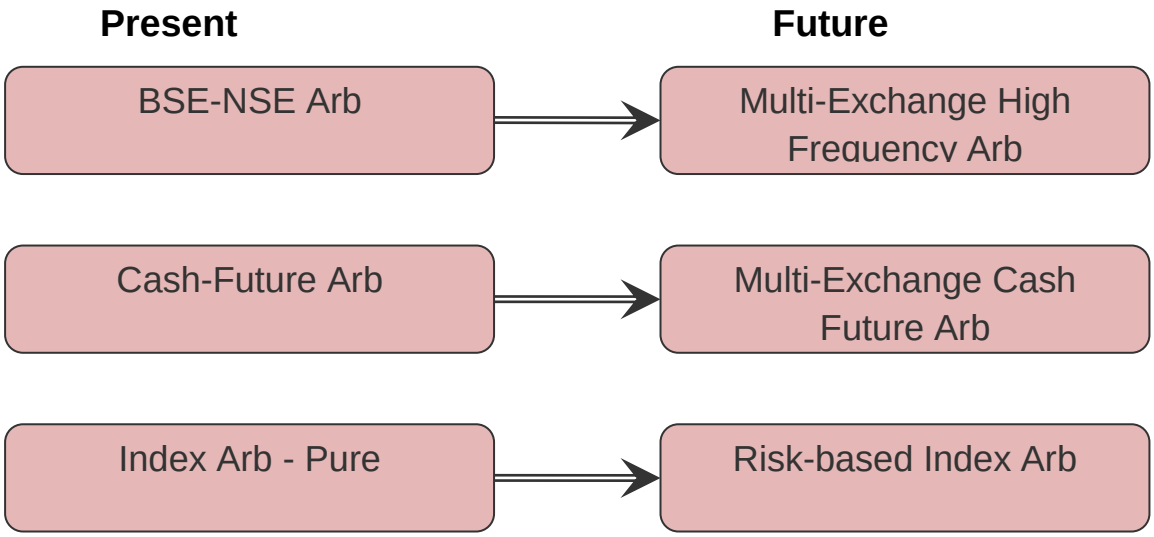
Secondly the order book in the India markets lacks depth. A million dollar transaction in a particular stock can more its price several percentage points. On the positive side India market offers to the invertors lots of breadth. A signal which once appears keeps re-appearing for multiple times and hence giving an opportunity to the investor to spread their trading volume to all through the day rather then some fixed time of the day. This also helps in reduction of the overall transaction costs and enhances the execution capabilities of the investors and the brokers.

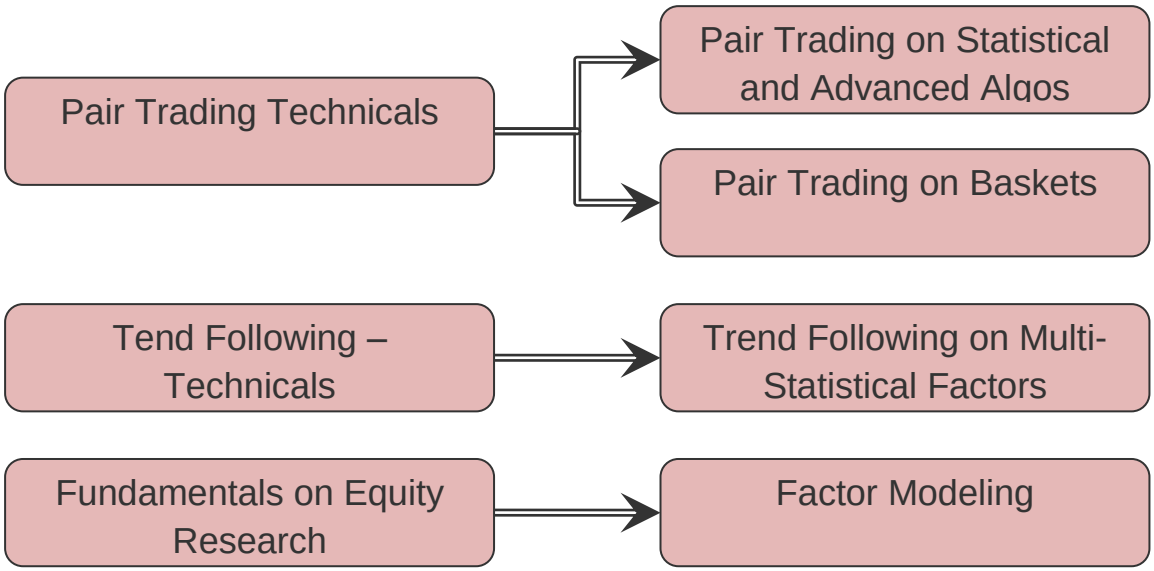
**Trends in Indian market**

As the Indian markets mature the modus operandi on which most of these algorithms and their back-bones lies will also develop and continue to mature. The jargons might stay the same but the sophistication levels on Agency and Prop side of the business will see new lights. Some of the trends which might be noticeable in the Indian markets in the next few years are depicted in the diagrams below.

**Prop Trading trend change in India**

The diagram below depicts and current and future state of changes in the prop trading scenario in India.

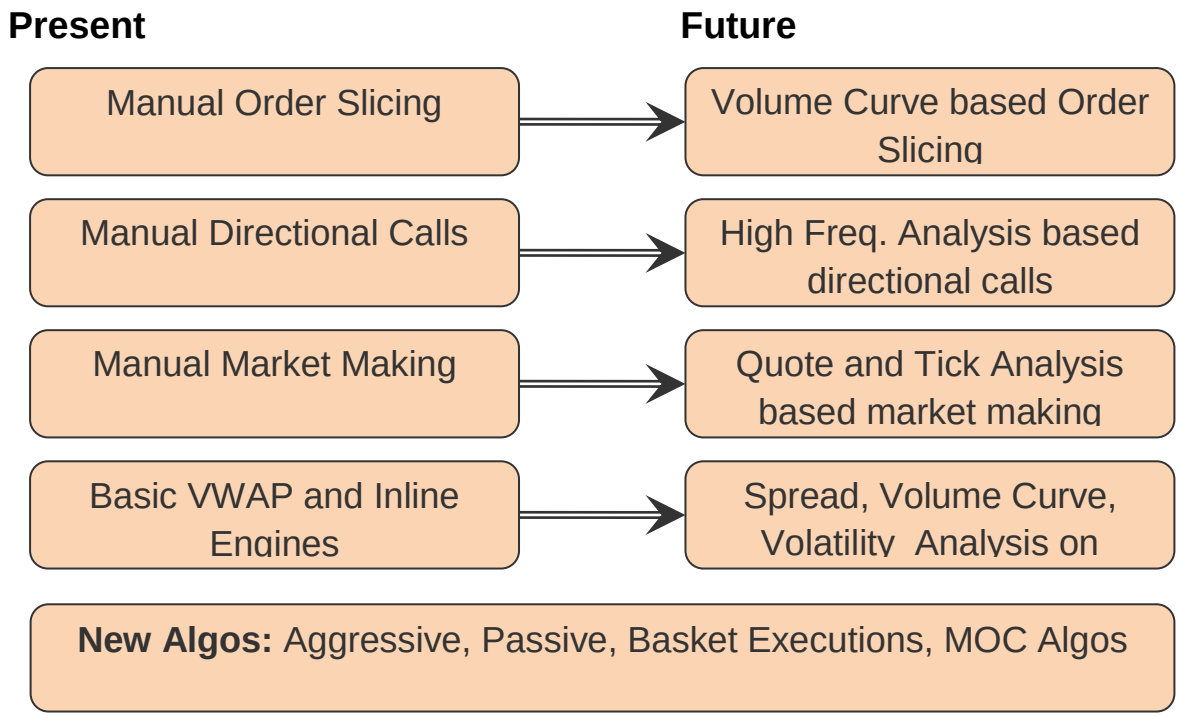





Fig; Change in the trend in the Indian market on the Prop algorithms

**Agency Execution Trend change in India**

The diagram below depicts the changes in the agency execution algorithms and their trends in the Indian markets.




Fig; Change in the trend in the India market on the Agency algorithms

**The retail clients**

No discussion on the India markets can be completed without a note on how the retail client can benefit or take advantage of the new revolution in the India markets. Smart portfolio management and smart strategies can help rope new and high volume clients to an institutional business. The details below describes some of the salient features which can be used in algorithmic trading strategies to rope in and enhance value of the existing retail clients.

- Smart execution strategies
  - E.g.: Client wanting to buy 1000 shares of Reliance over the day
  - E.g.: Client wanting to execute a HDFC-ICICI pair at ratio of 2.21
  - E.g.: A client wanting to beat the MOC by last 30 min. execution
- Smart portfolio management
  - E.g.: Advising clients on Buy, Hold, Sell based on technical
  - E.g.: Advising clients based on analyst rankings on the stock
- Smart Trade Selection
  - E.g.: Developing automated Intra-day momentum strategies
  - E.g.: Automated Pair-trading strategy which advises 1 or 2 signals in a day

## The challenges and positive sides

The exchanges and SEBI in the country faces lots of issues which comes as challenges and also as opportunities in the India market. Some of the key issues and advantages which Indian market holds at this stage are:

- The challenges
  - Serious lack of skilled man-power
  - Most experienced people are sitting in foreign I-Banks
  - STT (Securities Transaction Tax)
  - Lack of awareness and widespread acceptance
  - Mindset of quick Return on Investments
  - Paying huge upfront costs, getting nothing, leading to frustration
- The positive side
  - Huge pool of IT resources

- Street smart traders: Good fundamental and technical know-how
- New generation willing to accept change
- Tough competition and feeling of left-out on missing an opportunity

## The challenges to the Indian exchanges

Change brings with itself lot of dimensions and hence at times it becomes imperative for people and organization to change and accept the new path. The exchanges in India namely BSE and NSE and the regulatory structure are standing at one such juncture whereby they have to ensure that they become a facilitator of the growth story of India and at the same time does not allow undue advantage to the big organization at the cost of smaller players. It is also imperative for exchanges to provide flexibility to the algorithmic trading and take into consideration some of these factors.

- As markets develop – number of algorithms will explode
- Highly trained personnel required for evaluation
- Algorithms might change often and can be very dynamic
- Exchanges might not be able to keep track
- Intellectual property issues will become prevalent
- Exchanges might end in invidious position (blame sharing)
- Strong multi exchange competition
- High pressure on network and bandwidth
- Will require new and strong IT system (E.g.: Japan Arrowhead)
-

Hence the exchanges and regulator structure should keeping all these factors in mind provide flexibility and required control to create level playing filed for all participants involved.

## The growth projections

Indian growth in algorithmic trading could be steady or explosive – based on the enthusiasm of regulatory bodies, the Government and the exchanges. A steady growth will see us being put on the world map as a preferred destination to do algorithmic trading in the next 5 years and an explosive growth could shorten the same path to 2 years. The figure below details the time line and rough projections on the growth path which India is likely to notice in terms of Algorithmic trading.

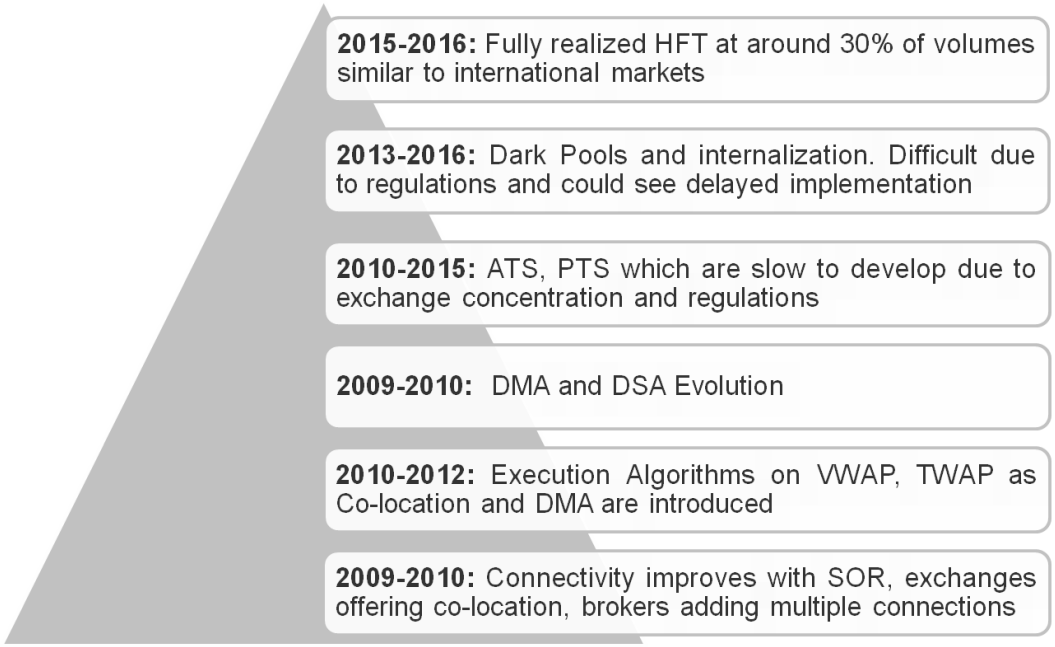



Fig: Projection on the adoption of algorithmic trading in India (*Source: Celent Research*)

## Conclusion

Evident from the figure above the steady race to catch the developed markets in terms of percentage turnover has just started. Much depends on the regulatory structure, exchange regulations, competitiveness and awareness – as to how the next 3-5 years to going to shape. Looking at the global trends it is however evident that India cannot be left far behind in the search for its own space on liquidity generated by Algorithmic trading and sooner or later the big boys of algorithmic trading globally will turn their heads on getting their hands wet with a pie of the growth in the markets. It remains to be seen and sensed whether the domestic players and exchange members are well prepared to take the challenge and compete with the larger players head on to grab a pie of the lucrative business called Algorithmic Trading.

## About Samssara Capital Technologies LLP

Samssara Capital Technologies LLP ("Samssara") is an investment solutions firm focused solely on developing automated algorithmic and quantitative trading and investment strategies. It was launched in 2010 by a team of IIM Ahmedabad and IIT Bombay graduates - Rajesh Baheti, Manish Jalan and Kashyap Bhargava. Samssara caters to its clients' needs of providing an alternative asset management vehicle, with the focus on 100% automated and quantitative trading strategies.

Samssara's products vary from pair trading (statistical arbitrage), factor models, Nifty Index beating products to very high frequency trading strategies. The team at Samssara works on mathematical models and statistics that identify repetitive patterns in equity, commodity and currency markets. The addressable market for Samssara is global - as the firm can develop and build models which can function in both developing markets with limited competition and developed markets with strong competition. Samssara's client base includes the leading international and domestic banks, international and domestic stock brokers, family offices, corporate treasuries and HNIs.

### *Profile of Manish Jalan*

Manish Jalan is the Chief Strategist and Director of the Algo trading firm Samssara Capital Technologies LLP. Prior to his new found Indian venture, Manish was a Quantitative Prop Trader in Tokyo, with Merrill Lynch Prop Desk handling USD 100 Mn. portfolio. Manish has worked closely with many Indian brokers and numerous International banks in algorithmic trading, trend following strategies, statistical arbitrage, factor modeling and back testing. Manish is a B.Tech and M.Tech from IIT Bombay in Mechanical Engineering.

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