Algorithmic Trading Basics

Contents

GLOSSARY

Quantitative Trading: Quantitative trading involves identifying trading opportunities and applying trading strategies using quantitative analysis which rely on mathematical computation and number crunching.

A quantitative trading system consists of four major components:

- Strategy Identification - Finding a strategy, exploiting an edge and deciding on trading frequency
- Strategy Backtesting - Obtaining historical data and analysing strategy performance and to remove biases
- Execution System - Linking to a brokerage, automating the trading and minimising transaction costs
- Risk Management - Optimal capital allocation, "bet size".

Quantitative trading strategies include the following:

1. High Frequency Trading
2. Algorithmic Trading
3. Statistical Arbitrage

Technical Analysis: In the world of finance, it is a tool for forecasting future movements of the price of a security through the analysis of historical market data. Technical analysts do not attempt to measure a security's intrinsic value, but instead use charts and other tools like technical indicators and oscillators to identify patterns that can suggest future activity.

The field of technical analysis is based on three assumptions:

1. **The market discounts everything**: Technical analysis assumes that, at any given time, a stock's price reflects everything that has or could affect the company – including fundamental factors.

2. **Price moves in trends**: It is assumed that after a trend has been established, the future price movement is more likely to be in the same direction as the trend than to be against it.

3. **History tends to repeat itself**: The repetitive nature of price movements is attributed to market psychology; i.e. market participants tend to provide a consistent reaction to similar market stimuli over time.

Algorithmic Trading: Algorithmic trading is a system of trading which facilitates transaction decision making in the financial markets using advanced mathematical tools and computer programming. The algorithm is a defined set of rules based on timing, price, quantity or any mathematical model to identify profitable trading opportunities while maintaining market liquidity and making trading more systematic by ruling out emotional human impacts.

High Frequency Trading: It is a type of algorithmic trading that uses powerful computers to transact a large number of orders at very fast speeds. It is mainly characterised by highly sophisticated algorithms to move in and out of positions within seconds or fraction of a second, specialized order types, co-location, very short-term investment horizons, and high cancellation rates of orders. Typically, the traders with the fastest execution speeds will be more profitable than traders with slower execution speeds.

Bid: The bid price represents the maximum price that a buyer or buyers are willing to pay for a security.

Ask: The ask price represents the minimum price that a seller or sellers are willing to receive for the security.

Bid-Ask spread: The difference between the bid and asked prices, or the spread, is a key indicator of the liquidity of the asset - generally speaking, the smaller the spread, the better the liquidity.

Types of orders: A trade order instructs a broker to enter or exit a position. This can be executed in several different ways with different conditions which make up different types of orders. The most popular order types used are listed below:

1. **Market Order**: It is an order to buy or sell a security immediately. This type of order guarantees that the order will be executed, but does not guarantee the execution price. Ideally, a market order to buy is filled at the ask price, and a market order to sell is filled at

the bid price (not necessarily at the last traded price). A market order is the fastest and most reliable way to get in out of a trade. A market order is appropriate if **getting filled is more important than getting a certain price**.

2. **Limit Order**: It is an order to buy or sell a security at a specific price or better. A buy limit order can only be executed at the limit price or lower, and a sell limit order can only be executed at the limit price or higher. A limit order allows precise order entry. A limit order is appropriate if **getting a specific price is more important than getting filled**.

   Example: An investor wants to purchase shares of stock XYZ for no more than $50. The investor could submit a limit order for this amount and this order will only execute if the price of stock XYZ is $50 or lower.

3. **Stop Order**: It is an order to buy or sell a stock once the price of the stock reaches the specified price, known as the stop price. A buy stop order is placed *above* the market, and a sell stop order is placed *below* the market and once the stop level is reached, a stop order becomes a market order. A stop order is appropriate **when it is important to confirm the direction of the market before entering a trade**.

4. **Conditional Order**: These are advanced trade orders that are automatically submitted or cancelled if specified criteria are met. Two common conditional orders are the order cancels order (OCO) and the order sends order (OSO). An OCO allows traders to place several orders simultaneously. When one is filled, any remaining orders in the group are automatically cancelled. An OSO order can further automate trade management by sending orders to the market once a trade entry order is filled. An OSO consists of a primary order that will send one or more secondary orders if the primary order is filled, and is used frequently in conjunction with an OCO to streamline the trade management process.

Market Impact: It the impact that a market participant has on the market when it buys or sells an asset. It is the extent to which the prices move in response to buying or selling of a certain quantity by market participants. If we buy huge

quantities of a stock in market, it will push the price up due to high demand, on the other hand if we sell huge quantities of a stock in the market, it pushes the price down due to increased supply/liquidity. Trading and execution strategies should aim to cause minimal market impact.

Slippage: It is the difference between the expected price of a trade, and the price the trade actually executes at. To be more precise it is the difference between where the computer signalled the entry and exit for a trade and where actual clients, with actual money, entered and exited the market using the computer's signals. There is a high probability of Slippage when the market has high volatility. Placing 'market orders' puts the trader at higher risk for slippage since the prices may change by the time the order actually executes; especially if volatility is high. To reduce slippage Algorithmic trading is often used; algorithms can be back-tested on past data to see the effects of slippage but it cannot be completely eliminated.

Volatility: Volatility is the amount the stock price fluctuates, without regard for direction. There are two forms of volatility: Historical Volatility and Implied Volatility.

Historical volatility is simply the annualized standard deviation of past stock price movements. Implied volatility on the other hand is not based on historical stock price data, instead it is the future volatility implied by the marketplace based on the price change in option. Hence, for an option trader implied volatility is more useful than the historical volatility since its forward looking. Implied volatility can be derived from an option's cost. Option pricing formulae have current stock price, strike price, time to expiration, interest rate and implied volatility as variables. Implied volatility can easily be calculated by feeding in the option prices from the market into the option pricing formula (the most commonly used being Black Scholes).

Alpha: Alpha is a measure of performance on a risk adjusted basis. It compares the risk adjusted performance with that of a benchmark index. The excess return of the fund over the benchmark index is the fund's alpha. An alpha of 1 means the fund has outperformed the benchmark index by 1% and an alpha of -1 means the fund underperformed by 1%. If the Capital Asset pricing Model (CAPM) calculates the fund's returns to be 10% and the fund actually gives 15% returns; then the fund's alpha is 5%.

Beta: Beta is a measure of the volatility or systematic risk (non-diversifiable risk-risk that cannot be reduced by diversification of a portfolio) of a security or a portfolio with respect to the market. It is used in the Capital Asset Pricing Model to calculate the expected returns of an asset based on the market returns and the beta of the asset.

Below is the expression for CAPM:

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f)$$

where:

- $E(R_i)$ is the expected return on the capital asset
- R_f is the risk-free rate of interest such as interest arising from government bonds
- β_i (the *beta*) is the sensitivity of the expected excess asset returns to the expected excess market returns, or also $\beta_i = \frac{\operatorname{Cov}(R_i, R_m)}{\operatorname{Var}(R_m)}$,
- $E(R_m)$ is the expected return of the market
- $E(R_m) - R_f$ is sometimes known as the *market premium* (the difference between the expected market rate of return and the risk-free rate of return).
- $E(R_i) - R_f$ is also known as the *risk premium*

β =1, means the asset returns are same as market returns and β>1 indicates that the returns on the asset are greater than market returns.

Statistical estimation of β:

Beta is estimated by linear regression. Give an asset and a benchmark that we are interested in, we want to find an approximate formula

$$r_a \approx \alpha + \beta r_b$$

where r_a is the return of the asset and r_b is return of the benchmark.

Since the data are usually in the form of time series, the statistical model is

$$r_{a,t} = \alpha + \beta r_{b,t} + \varepsilon_t,$$

where ε_t is an error term (the unexplained return).

Click here for the definition of Alpha α

The best (in the sense of least squared error) estimates for α and β are those such that $\Sigma\varepsilon_t^2$ is as small as possible.

A common expression for beta is

$$\beta = \frac{\mathrm{Cov}(r_a, r_b)}{\mathrm{Var}(r_b)},$$

Where Cov and Var are the covariance and variance operators.

This can also be expressed as

$$\beta = \rho_{a,b}(\sigma_a/\sigma_b)$$

where $\rho_{a,b}$ is the correlation of the two returns, and σ_a and σ_b are the respective volatilities.

$\sigma_a=\sqrt{[\mathrm{Var}(r_a)]}$, $\sigma_b=\sqrt{[\mathrm{Var}(r_b)]}$, $\rho_{a,b}=\mathrm{Cov}(r_a, r_b)/\sqrt{[\mathrm{Var}(r_a)\cdot\mathrm{Var}(r_b)]}$

OHLC Data: Open-High-Low-Close data is the price movement data with time.

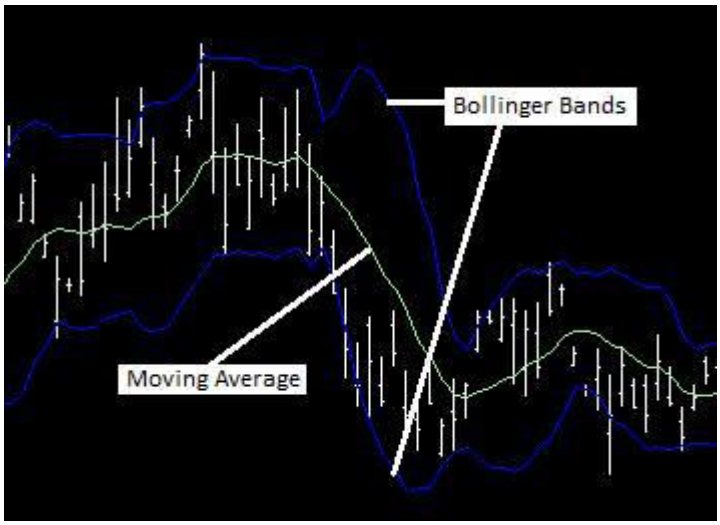
O: Opening price

H: Highest traded price

L: Lowest traded price

C: Closing price

It is most conveniently represent in the form of a chart as shown below:



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In the OHLC chart above, each vertical line on the chart represents the price range (the highest and lowest prices) over one unit of time (e.g., one day or one hour). Tick marks project from each side of the line indicating the opening price

(e.g., for a daily bar chart this would be the starting price for that day) on the left, and the closing price for that time period on the right. Further analysis of the graph helps us look at the moving average and Bollinger bands:

Moving Average: The line joining the averages for each unit of time represents the moving average line. A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles. Note that moving average is a trend following or lagging indicator as it is based on past data. The table below shows sample closing price of security for 15 days. 10-day SMA is the 10-day simple moving average calculated based on the closing price data.

Day	Closing Price	10-day SMA	Value used for SMA
1	10		
2	11		
3	13		
4	15		
5	14		
6	17		
7	12		
8	13		
9	14		
10	16	13.5	Average of day 1 to 10
11	18	14.3	Average of day 2 to 11
12	18	15	Average of day 3 to 12
13	17	15.4	
14	15	15.4	
15	18	15.8	

Bollinger Bands: Bollinger Bands are volatility bands place above and below a moving average. Volatility is represented by standard deviation and the bands are plotted two standard deviations away from the moving average. As volatility increases the gap between the bands widens and when it goes down, the bands come closer.

