Algorithmic Trading

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What is Algorithmic Trading?

I.   Trading Basics

A.   Instruments

The term **securities** refer to stocks and bonds. **Stock** refers to a share of ownership in a corporation. A **bond** is a debt security, in which the issuer owes the owners debt and is obligated to pay interest, or the coupon, on specified dates, until the bond matures, at which time the issuer must repay the principal.

A **derivative** is any instrument whose value is based upon an underlying instrument. **Options** are derivative instruments that convey the right, but not the obligation, to engage in a future transaction on some underlying instrument, usually stock or futures. Buying a call option grants the owner the right to buy a specified number of shares at the strike price at some time on or before expiration. Buyingh a put option provides the right to sell. At the option holder's whim, he may exercise the option, at which time the counterparty, who sold, or wrote, the option is obligated to fulfill the terms of the contract. A **forward contract** is an agreement between two parties to buy or sell an asset at an agreed-upon future date. A **futures contract** is a standardized forward contract, traded on a futures exchange. A futures contract can be for delivery an underlying financial instrument or index or physical commodity on the delivery date and at the settlement price. **Backwardation** is a situation in where the price of a futures contracts is lower than the spot price. **Contango** is where the price of a futures contract is higher than the spot price. A **swap** is a derivative contract where two parties agree to exchange one stream of cash flows for another stream.

Some stocks and most bonds trade in the **OTC market**. Many derivatives trade in an OTC market, where an **over-the-counter (OTC) derivative contract** is a non-standardized, non-exchange-traded agreement between two parties. Also, all manner of exotic derivatives trade OTC, which are generally governed by an International Swaps and Derivatives Association agreement. Some derivatives exchanges have created clearing mechanisms for commonly traded OTC derivatives which allows counterparties to eliminate the credit and performance risk of counterparties. The **interbank market** for forex enables currency trading.

Exchanges provide for continuous quoting of bids and offers in contracts listed on the exchange. From an automated trading perspective, a quote consists of seven things: the symbol, the quantity on the highest bid price, the highest bid price, the lowest ask price, the quantity on the lowest ask price, the last price traded, and the quantity of the last traded (or the sum of the quantities of the consecutive trades on that price).

Symbol	Bid Qty	Bid Price	Ask Price	Ask Qty	Last Price	Last Qty
ES	195	125025	125050	456	125025	33

Some quotes may also include total daily volume and/or open interest. The tick size is the minimum price increment, the minimum **bid-ask spread**, the difference between the highest bid and the lowest offer. In the example above the inside market (i.e. the highest bid and lowest ask) is 1250.25 to 1250.50, where the tick size is .25. The value of the minimum tick increment is not, in fact 25 cents; the contract size is much larger. For the S&P 500 E-mini contract the value of .25 tick is $12.50. The whole-point value is often referred to as the **handle**. In the above example, 1250 is the handle. If the contract increases to 1254, we say the price is up four handles. In the case of this contract, a tick is a quarter handle.

B.   Institutions

Many financial instruments are listed on **exchanges**. An exchange, or bourse, is a corporation or mutual organization which provides facilities for traders to trade securities and derivatives. Stocks trade on exchanges such as the NYSE or the LSE.   Stock options trade on exchanges such as the CBOE or the ISE. Futures and futures options trade on futures exchanges such as Eurex or the CME. Bonds usually do not trade on exchanges. Many exchanges now list stocks and options, or options and futures. Consolidation in the exchange industry means that exchanges no longer focus on only one type of tradable instrument. An **electronic communication network** (ECN) is a computer-based system that facilitates trading of financial products outside of exchanges, primarily for stocks and currencies. In order to trade with an ECN, one must be a subscriber or have an account with a broker that provides direct access to the ECN.

Exchanges provide liquidity pools. **Market liquidity** refers to the ability to buy or sell a tradable instrument without causing a significant movement in the price.

A **broker-dealer** is a firm that trades in securities (i.e. stocks and bonds) for customers as well as for its own account. In the United States, a broker-dealer has to be registered with a regulatory agency. When executing trade orders for customers, the institution is said to be acting as a broker. When executing trades for its own account, the institution is acting as a dealer.

Clearing refers to all activities from the time a commitment is made for a transaction until it is settled. It is necessary because the speed of trades is much faster than the cycle time for completing the underlying transaction. Clearing involves the management of post-trading and pre-settlement credit exposures to ensure that trades are settled in accordance with market rules, even if a buyer or seller should become insolvent prior to settlement. Derivatives exchanges often make use of **centralized clearing**, a process by which financial transactions in equities are cleared by a single counterparty. The Options Clearing Corp. is an example of centralized clearing. A **clearing house** is a financial services company that provides clearing and settlement services for financial transactions, usually on a futures exchange, and often acts as central counterparty. A clearing house may also perform other services, for example substituting a new contract for an old one as well as other credit enhancement services to its members.

A **self-regulatory organization** (SRO) is an organization that exercises regulatory authority over its industry. The regulatory authority could be applied in addition to or in place of some form of government regulation, though the ability of an SRO to exercise regulatory authority does not necessarily derive from a grant of authority from the government. In the U.S. the NYSE and the NASD are SROs.

The **U.S. Securities and Exchange Commission** (SEC) is a United States government agency that enforces the federal securities laws and regulating the securities industry. The **Commodity Futures Trading Commission** (CFTC) is an independent agency of the U.S. government that protects market participants from fraud, manipulation, and abusive practices related to the sale of commodity and financial futures and options, and to foster open, competitive, and financially sound futures and option markets. **Financial Services Authority** (FSA) is an independent body that regulates the financial services industry in the UK.

Markets in Financial Instruments Directive (MiFID) is an EU Directive to establish and regulate the single market in investment services and activities in the EU. The Directive establishes the conditions under which an investment firm licensed in any EU member state can do business in any other member state without further licensing requirements. The Directive also establishes EUwide standards for the licensing, organisation and operation of investment firms, regulated markets and multilateral trading facilities; establishes regulations for the protection of investors and sets out a framework for cooperation and enforcement among investment services regulators. The **Markets in Financial Instruments Directive** (**MiFID**) as subsequently amended is a European Union law which provides a harmonised regulatory regime for investment services across the 30 member states of the European Economic Area. The main objectives of the

Directive are to increase competition and consumer protection in investment services. MiFID is the cornerstone of the European Commission's Financial Services Action Plan. The **European Commission** (formally the **Commission of the European Communities**) is the executive branch of the European Union. The body is responsible for proposing legislation, implementing decisions, upholding the Union's treaties and the general day-to-day running of the Union.

C.   Margin

The term **margin** means different things in different markets. Margin in the securities industry enables a customer to buy securities with cash borrowed from a broker. This has the effect of magnifying any profit or loss made on a securities position. Essentially, the securities serve as collateral for the loan. In the U.S. **Reg T margin** is 50%, where the customer must pay for 50% of a securities purchase up front. In the U.S. the **maintenance margin** is 30%, where if the value of the securities falls, and the cash value falls below 30%, the customer will receive a margin call to bring the cash value above 30%. Broker-dealers may also set their own margin requirements in excess of government mandated rules.

In the derivatives industry, **variation margin** is not collateral, but a daily offsetting of profits and losses. Because futures are marked-to-market every day, the profit or loss on a position is then paid to or debited from the position holder by the futures exchange itself. This is possible, because the exchange is the central counterparty to all contracts, and the number of long contracts equals the number of short contracts. In this case, margin is collateral that the holder of a derivatives position has to deposit to cover his own credit risk. The collateral can be in the form of cash or securities, and it is deposited with a clearing firm. **Risk-based margining**, or **cross margining**, attempts to aggregate a trader's total risk, taking into account positions with off-setting risks to calculate the amount of variation margin required.

A **haircut** is a percentage that is subtracted from the par value of the assets that are being used as collateral. The size of the haircut reflects the perceived risk associated with holding the assets. For example, U.S. Treasury Bills might have a haircut of 1%, while for a stock option the haircut might be as high as 30%. Also, with respect to exchange traded instruments, the term haircut is sometimes used interchangeably with maintenance margin, the amount of capital that the maintenance margin level requires to maintain the positions in a trading account. If the haircut exceeds the capital, the broker can make a margin call, or liquidate positions until the haircut no longer maintenance margin.

D.   Orders

An **order** is a message to the market that a trader would like to either purchase or sell a tradable instrument. The price and the timing of the execution of the order are determined in large part by the order's type. Acceptable order types vary by exchange and a CTSD should understand a market's acceptable orders before trading begins. A CTSD should also understand order types and their impact on trading algorithm design, backtesting and performance of trading systems.

A **market order** is an order to buy or sell a security at the current market price. A market order to buy will be executed immediately at the lowest ask price. If at the best asking price insufficient volume exists to fill the market buy order fully, the remainder of the order will be executed at the next, higher ask price. A market order guarantees an immediate fill, but does not guarantee price. Market orders can be dangerous because the market may move significantly given the latency between the time a trade selection decision is made and the time the order hits the exchange order book.

A **limit order** is an order to buy or sell an instrument at price better than the market ask or bid price. A limit order to buy is entered with a price below the lowest ask. A limit sell is entered with a price above the highest bid. The limit quantity entered joins the corresponding bid

or ask price according to the exchange's order matching algorithms, usually either FIFO or pro rata (see below). Alternatively, many automated trading systems use limit orders to execute what are essentially market orders (i.e. buy limit orders with a limit price above the market ask, and sell limit orders with a limit price below the market bid) in order to limit risk should the market move quickly in an adverse direction before the order reaches the exchange. Limit orders guarantee a price, but do not guaranteed execution; a limit order may never be filled.

A **stop order** is an order to buy or sell an instrument once the price of that instrument reaches a specified price, known as the stop price. When the price reaches the stop price, the order will automatically become either a market order (which has the same risks associated with any market order) or a limit order. A buy stop order is entered with a price above the lowest ask. A sell stop order is entered with a price below the highest bid.

A **cancel-replace** order is an instruction to the exchange to cancel an original order and replace it with another order. Cancel-replace has the advantage, over first deleting an order and then sending a new order, of being contained within a single message to the exchange, as opposed to two messages. A **change** order is a third alternative which again will replace one order with another using only a single message.

A **market-on-close** (MOC) order is a market order that is submitted with instructions to execute the order at the closing price. Of course, like any market order, there is no guarantee of the fill price. MOC orders are often used to reverse another position or for over-night hedging positions. The market on close can be a buy or sell order. Not all exchanges accept MOC orders.

A **fill-or-kill** (FOK) order is an order with instructions to either fill the order in its entirety immediately or cancel the order. An **all-or-none** (AON) order is similar to a fill or kill order in that the order must be filled in it's entirety, however, instead of canceling the order, the order remains open until an opportunity presents itself to filling the entire order. An **immmdiate-or-cancel** (IOC) attempts to fill an order immediately or cancels it. Not all exchanges accept FOK, IOC or AON orders.

In addition to the order types listed here, combinations of these parameters can also be entered, for example a stop-limit order or limit-on-close order.

E.   Position Selection

A **market maker** is a firm who continuously quotes both a buy and sell price for a particular instrument. Market makers typically exist in exchanges where the liquidity is not guaranteed. A market maker provides liquidity in the absence of other orders or volume.

Swing trading is where a trader holds a particular position for a period of time, generally between a few days and two or three weeks, and close the position based on intra-week or intra-month oscillations.

The term **spread** means many things in the markets. With respect to orders and positions a spread is any combination of two positions, long one and short the other. We will look at many spread trades over the course of this study guide.

The term **leaning** means, in its most basic form, to rely on external information. So, for example, a trader may quote passive bids and offers in one market, say the back month contract, based upon prices in another market, say the front month contract. We say that the trader is leaning on the front month.

The term **fading** also has different meanings. Fading is a contrarian investment strategy used to trade against the prevailing trend. A fade trader would sell when a price is rising and buy when it's falling. In a dealer market, fading is the failure of a dealer to honor a quote when a customer or another dealer wants to trade. For example, if a better bid is posted on another exchange for a security and a market maker is unwilling or unable to match it for a client order, the market maker may offer to trade with the other market maker (with the better price). The

market maker offering the better price must accept the offer and trade at the price offered or adjust the bid price.

F.   Exit Rules

As important as the position selection algorithm is the position termination algorithm, i.e. the exit rules. Four rules for exiting a position can be defined: stop loss, profit target, time and breakdown conditions.

A **stop loss** condition exits a position closing order when a certain loss level is achieved. Stop loss levels could be either static or trailing, where the stop price changes as a position becomes more and more profitable. A trailing stop could be either a percentage amount or a specified number of ticks, or price levels in the adverse direction. A stop loss condition may take the form of a continuous stop order in the market or may exist only in the trading algorithms, where an order is sent upon reaching an internal stop price. A **profit target** condition exits a position when a position reaches a certain level of profitability. Profit targets a generally static, either as a percentage amount or a specified number of ticks, or price levels, in the favorable direction. A profit target may exist as a limit order in the market or only in the trading algorithms, where an order is sent upon reaching an internal limit price. A **time condition** closes a position after a specified amount of time. A time condition is held internally within a trading algorithm. Before reaching a stop loss, profit target or time condition, the rationale for holding a position may breakdown. A **breakdown condition** should be calculated within the trading algorithm.

G.   Execution

Limit orders at the exchange are held in one of many forms. The two main types of exchange order matching algorithms are: first-in-first-out (FIFO) and pro rata. To better understand how a trade is going to be executed by the exchange, it is imperative to know the exchange order matching system. In any case, whenever any order is executed, or filled, at the exchange, the exchange will send a message containing minimally the order number, the time, the instrument, the price and the quantity.

A **FIFO matching algorithm** keeps limit orders in a queue at each price level. When new limit orders arrive at a price level, they are added to the "back" of the queue. All orders and their quantities are held in order of arrival. When trades come in to execute the other side of the orders, orders in the queue are matched from the "front" of the queue.

In a **pro rata matching algorithm**, all limit orders at a given price level are held with equal priority weighted by volume. When trades come in to execute the other side of the orders, orders are matched by volume. For example, if two limit buy orders each for 10 contracts exist at a price level and an order to sell 10 at that price level arrives at the exchange, each limit buy will receive a partial fill of 5 contracts each. Orders that move the market may be given special priority at a new price level. For example, if an order to sell 30 arrives at the exchange, each limit buy will receive a fill of 10 contracts, leaving the seller with an open order to buy 10 at the new bid. Assuming the sell order was a limit order, the remaining 10 contracts may have priority over new bids at that price level, because the seller of 30 moved the market. Also, some markets may be subject to regulations which require preference to small orders.

A **fungible** instrument is one that can be traded on multiple exchanges. For example, one can buy IBM calls on the CBOE and sell them on the ISE. However, the S&P E-mini futures contract can only be traded on the CME.

Automated execution algorithms are often benchmarked. Two common benchmarks are the **VWAP** over a time period and **implementation shortfall** between timing decisions and the market impact. **Trade cost analysis** (TCA) will compare what the actual cost of execution was

versus pre-trade estimates. Often, trading system developers automate the monitoring of execution algorithms versus the implementation shortfall pre-trade, during the trade and post-trade. TCA data often feeds back into execution management processes. **Slippage** is the difference between estimated execution price and the price at which an order is actually executed. Lowering latency in an automated system generally reduces slippage. Many statistics are calculated with respect to TCA, including:

- **Spread (bps).** Performance should always be judged relative to the bid-ask spread. 12 basis points off VWAP does not look good for a German stock with 3 basis point spread, but does look good for a Swedish stock with 36 basis point spread.
- **Relative Order Size.** Viewed as a % of historic MDV and actual % of full day volume. Gives indication of liquidity demanded by trade.
- **Percent of Interval Volume.** How much liquidity was demanded from the market. Helpful if percent of historic interval volume is also available.
- **Interval Return.** Measured from mid point of spread when order began to mid point when order completed. Gives an idea of trend, but bear in mind markets do not move in straight lines. Note normally expressed as a negative meaning stock moved against you (up for Buys, down for Sells) and positive if stock moved in your favour (down for Buys, up for Sells).
- **Execution Price.** Average overall execution.

An **iceberg** order is a large order that has been divided into smaller orders, usually through the use of an automated execution algorithm, for the purpose of hiding the true order quantity. By hiding the true larger size, an iceberg order mitigates price movements otherwise caused by a large single change in an instrument's supply or demand.

1.   Volume Weighted Average Price (VWAP)

Volume weighted average price (VWAP) execution algorithm attempts to execute a large order as close as possible to, or better than, the historical volume. If, for example, over the past 3 months, say 10% of an instrument's trading volume occurs in the first hour of the day, then an automated execution algorithm to buy or sell may cease entering orders in that particular hour if that 10% level is achieved, the remainder to be traded in subsequent periods. A VWAP order should remove any appearance of heavier than normal volume, which might otherwise negatively impact the price at which the order is executed when other market participants realize what's going on.

Volume Weighted Average Price (VWAP) is a trading benchmark used especially in pension plans. VWAP is calculated by adding up the dollars traded for every transaction (price multiplied by number of shares traded) and then dividing by the total shares traded for the day.

$$VWAP = \frac{\sum_{i=1}^{n} q_i p_i}{\sum_{i=1}^{n} q_i}$$

Where:

- q is the quantity of contracts, or shares, in each trade, and,
- p is the price each trade was executed at.

The theory is that if the price of a buy trade is lower than the VWAP, it is a good trade. The opposite is true if the price is higher than the VWAP.

–Advantages: Easily observed, easy to compare performance between brokers

–Disadvantages: Time Interval is an integral part of the benchmark
–An optimal benchmark should be responsive to available liquidity

Consider an order to buy 297,354 shares of DEF, instruction VWAP from the open till noon. Performance 5 basis points away from VWAP is half the spread, which looks reasonable against the interval move of 2.8% against us (i.e. we are buying and stock moved up)

- Strike Performance is disappointing – almost 100BP away is equal to over a third of the interval move
- Interval move explained by growing bid speculation in stock over recent days
- Relatively small order size suggests plenty of scope to have completed order earlier
- Note reversion stats indicate trend continued up after our trade

Order Attributes					
Market Cap	**Executed Shares**	**Executed Value**	**Start Time**	**End Time**	**Annualized Volatility**
$81.15bn	297,354	$3,135,357	08:15	12:00	11.10%
Trade Statistics					
Spread (bp)	**% MDV**	**%Full Day Volume**	**% Interval Volume**		**Interval Return**
10	0.46%	0.19%	1.20%		-2.80%
Performance Measures					
Strike Performance (bp)	**Interval VWAP Performance**	**Reversion 5 minutes**	**Reversion 15 Minutes**	**Reversion 30 minutes**	**Residual Shares**
-97	-5	11	18	22	0

2.   Time Weighted Average Price (TWAP)

Another technique is **time weighted average price** (TWAP). A TWAP algorithm trades based on the clock, slicing up a trade up over time, which makes sense for illiquid instruments where volume analysis is of little use. TWAP is the average price of contracts or shares over a specified time. TWAP 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. Often, whereas a VWAP trade will buy or sell 40% of a trade in the first half of the day and then the other 60% in the second half of the day, a TWAP trade would most likely execute an even 50/50 volume in the first and second half of the day.

3.   Other Execution Strategies

==Participation strategies== are used when an market participant wishes to keep up with the volume that's going on. If interest in a particular instrument increases, then the execution algorithm will become more aggressive. If less trading is going on, it becomes less aggressive. Obviously, this is a momentum technique.

A **guerrilla** execution algorithm works an order without signaling the presence of a buyer or seller to the marketplace. It slices big orders into smaller unobtrusive sizes and uses a variety of trading techniques to disguise its footprint. Guerrilla algorithms often trade on alternative trading networks and are particularly effective in mid-cap and small-cap stocks.

A **sniper** is a very aggressive type of execution algorithm that executes until either it completes the trade in full or reaches a specified limit price. A sniper looks at all the data and attempts to find smart ways to pick off little pieces here and there. A sniper never shows a bid or offer, but tries to pick spots of hidden liquidity.

Sniffer algorithms try to sniff out the competition's algorithmic trading activities. A sniffer tries to understand the software's algorithm and pick out trading opportunities, either by trading with it or against it. Sniffers bait other software and use information about counter parties to hook into big moves. **Gaming** is the practice of using small orders to uncover large orders in the market for the purpose of transacting against those larger orders at a favorable price.

Dark pools of liquidity are private trading networks where buyers and sellers remain anonymous until trades are executed. They do not show their orders in the market. Their orders are matched internally according to software that dissects brokers' order books looking for better prices than available on the exchanges and public trading networks. They inform the exchange of the cross only after it has been done privately.

A **sweeping order** is an order which if unexecuted on a venue passes through to be allocated to another venue. **Sequential scanning** is a sweeping order which scans venues in sequence with full slice or order size. **Simultaneous scanning** is a sweeping order which scans multiple venues simultaneously by splitting order into smaller probing orders, and then reallocating unexecuted orders to venues where liquidity has been identified. **Smart order routing** is any algorithm that scans multiple venues, slicing, working and distributing orders according to price and probability of execution.

Implemtation shortfall is Execution Cost + Opportunity Cost, where cxecution cost = all costs associated with the actual implementation of the order, and opportunity cost = residual position at the end of the trading period. Implementation shortfall advantages are that it allows participation rate and interval time to vary in order to provide best performance against Arrival. The disadvantages are that it is not particularly reactive in a volume spike

I. Arbitrage

Arbitrage is an attempt to take advantage of a price discrepency between two or more markets through a combination of simultaneous, off-setting trades. Successful arbitrage results in essentially risk-free profit. Market prices that do not allow for arbitrage are said be **arbitrage-free**. Arbitrage assumes a deterministic outcome, a sure profit obtained from being long some instrument(s) and short others. The no-arbitrage assumption is used in quantitative finance to calculate a unique risk neutral price for derivatives. Arbitrage is possible when one of three conditions is met:
- The same fungible asset trades at different prices in different markets.
- Two assets with identical cash flows do not trade at the same price.
- An asset with a known price in the future does not today trade at its future price discounted at the risk-free interest rate (or, the asset does not have negligible costs of storage; as such, for example, this condition holds for grain but not for securities).

Statistical arbitrage, discussed later, is different than what has been described here, deterministic arbitrage. The more deterministic the trading strategy, the more technological speed becomes the competitive advantage.

II.   Technical Analysis Overview

A.   Introduction

Technical analysis looks at past prices and price movements of an instrument. The premise being that a price reflects all relevant and known information. Technical analysts seek out non-random price patterns and trends and attempt to exploit them. While technical analysis uses various tools (the most relevent for the CTSD being those which are programmable), the study of price charts is fundamental to the discipline. Technicians search for charts for patterns, such as the well-known head and shoulders reversal pattern. They also study indicators as price, volume, and moving averages of past prices. Many technicians also follow indicators of market psychology and market sentiment. Because a price reflects all relevant information, technical analysis does not look at, for example, news events or factors fundamental to the instrument or market. Technicians focus on price actions that often repeat themselves because market participants collectively tend toward patterned behavior.

Technical analysis examines two areas of investing: the analysis of market sentiment, and the analysis of supply/demand (i.e. whether investors have the funds to support their hopes and fears; a bullish investor without funds cannot take the market higher.) Technicians seek to forecast price movements probabalistically, so that gains from successful trades are larger and/or more frequent than losing trades, thereby generating positive returns over time with proper risk control and money management.

There are several schools of thought in technical analysis, and adherents of one may ignore the others, yet most traders combine various tools and indicators. Of course, technical analysts often disagree about the interpretation of the same chart.

B.   Dow Theory

Dow Theory provides a basis for technical analysis and has six tenets:

1.   Markets have trends.

An **up trend** occurs when highs are higher than previous highs and when lows are also higher than previous lows. A d**own trend** occurs when prices make lower lows and lower highs. In line with the Dow Theory, technical analysts study price **trends**—up trends, down trends, or sideways markets. A **correction** is sometimes defined as a drop of 10% to 20% over a short period of time. Corrections differ from a bear market mostly in that they have a smaller magnitude and shorter duration.

A trend line is a bounding line of a price series. A **supporting trend line** is formed when a price decreases and then rebounds, or bounces, up of a specified price level. Similarly a **resistance trend line** is formed when a price increases and then rebounds down. A **breakout** occurs when a price passes through and stays above or below resistance or support. Support and resistance levels may be static prices, lines drawn between intraperiod highs and lows, or relative indicators such as a moving average.

2.   Trends have three phases.

Major trends consist of three phases: accumulation, participation, and distribution. Accumulation is a period when "in the know" market participants are actively buying or selling contrary to the general opinion of the market. During this phase, the price will not change significantly, as these investors are in the minority. Eventually, the rest of the market learns what is going on and a rapid price change occurs in the participation phase. This phase continues until rampant

speculation occurs. At this point, "in the know" participants begin to distribute their holdings into the market.

3. The stock market discounts all news.

Prices quickly incorporate new information as soon as it becomes available.

4. Market averages must confirm each other.

The first stock market averages were indexes of industrial and railroading companies. A bull market in industrials could not occur unless the railway average rallied as well, usually first. According to Dow theory, if manufacturers' profits are rising, they must be shipping more goods. Hence, the performance of railroads should confirm the success of manufacturers, and averages of the stocks in the two industries should be moving higher together. If performance diverges, it is a warning sign.

5. Trends are confirmed by volume.

Volume must confirm price trends. If prices move on low volume, many different explanations could exist. When prices move on high volume, a true market trend is at hand.

6. Trends exist until definitive signals prove that they have ended.

Trends exist despite noise. Markets sometimes move temporarily in a direction opposite to the trend, but soon resume the trend. Short term reversals do not break trends. Determining whether a reversal is the start of a new trend or a temporary movement in the current trend is not easy. Technical analysis attempts to distiguish between short term reversals and the beginnings of new trends.

C.   Cycles

Forecasters of all kinds use cycles predict events. Technicians also use cycle analysis in an attempt to forecast changes in markets. For example, the prices of many commodities reflect seasonal cycles. For other instruments, cyclicality is harder to spot. All manner of theories attempt to explain cyclical patterns—weather, phases of the moon and planets, sun spots, and human psychology—where prices are the market consensus of expectations, which oscillate between overbought and oversold.

Many technical analysis indicators aim to forecast cyclicality in prices. For example overbought/oversold indicators, such as stochastic and RSI, help technicians see boundaries of a cycle as in this chart form MarketScreen.com.
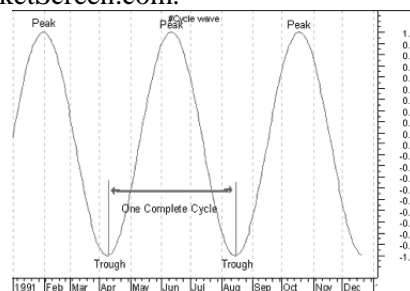
- **28 Day Trading Cycle.** Some research has found 28-day cycles in the wheat market, which may be tied to the lunar cycle. Other markets also appear to have a 28-day cycle.
- **10½ Month Futures Cycle.** Although individual commodities exhibit their own unique cycles, a cycle ranging between 9 and 12 months has been found in the CRB Index.
- **January Effect.** The stock market tends to finish the year higher if prices in January rise and vice versa. Between 1950 and 1993, the January return correctly predicted annual return 38 out of 44 times.
- **4 Year Cycle (Kitchin Wave).** Some research has uncovered 40-53 month cycles in a variety of financial markets.
- **Presidential Cycle.** This cycle predicts that stock prices will decline following a U.S. presidential election, when the new president takes unpopular steps in an attempt to adjust the economy. Mid-term, prices will rise in anticipation of a strong economy by election day.
- **9 Year Cycle (Juglar Wave).** Some research has shown that economic cycles last about 9 years.
- **54 Year Cycle (Kondratieff Wave).** The 54-year cycle has identified swings in prices and economic activity.

A **ranging market** is a market where the price is cycling between a resistance and support level. The range could be small or large. A very small range is called a **choppy market**.

D. Fibonnacci Sequence

Around the 1100s Leonardo Fibonacci discovered his eponymous sequence of numbers, in which each number in the sequence is the sum of the two previous numbers:

$$0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, \text{etc.}$$

Each number, then, is approximately 1.618 times the one before it, and approximately 0.618 times the one after it. Used in financial markets, there are four applications of Fibonacci numbers: **arcs, fans, retracements, and time zones**. Reading the tea leaves of these involves predicting trend changes.

Arcs are trendlines drawn between two extreme points, a trough and a peak. Three arcs, centered on an extreme point, intersect a price or a trend line at 38.2%, 50.0%, and 61.8%. Arcs intend to anticipate support and resistance as prices approach the arcs. This chart, from OptionsOutlet.com, show how arcs can predict support and resistance, at points "A," "B," and "C".
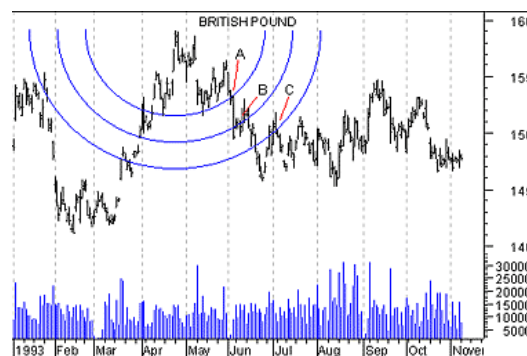
Fan lines are trend lines drawn from troughs and peaks. Three trendlines are drawn from the first extreme point at the Fibonacci levels of 38.2%, 50.0%, and 61.8%. This chart from OptionsOutlet.com shows fan lines which predicted support and resistance levels.

Retracements are also trend lines drawn from troughs to peaks. A series of horizontal lines intersect the trend line at the Fibonacci levels of 0.0%, 23.6%, 38.2%, 50%, 61.8%, 100%, 161.8%, 261.8%, and 423.6%. After a significant move, prices often retrace a percentage of the original move. Fibonacci retracement levels sometimes predict support and resistance as in this chart from OptionOutlet.com.

Time zones are vertical lines spaced at the Fibonacci intervals of 1, 2, 3, 5, 8, 13, 21, 34, etc., which attempt to forcast directional changes in price, as in this chart from OptionOutlet.com.

E.   Systematic Trading

Rule-based trading defines a set of parameters that determine all trades. A **trading/investment system** consists of the interacting position selection and execution algorithms, i.e. the rules and business logic necessary to enter into and exit from positions in the financial markets, as well as the technology required to partially or fully automate the trading, benchmarking, portfolio and risk management processes. Such rule-based systems apply the science of financial engineering to the management of portfolios of securities and derivative instruments. Trading/investment systems can take on the form of traditional long-only mutual funds, hedge funds, and proprietary, high-frequency trading systems.

A **trading algorithm** is the list of instructions for completing trade selection and position management tasks. When given an initial state and continuous market data, it will proceed through a series of successive states, eventually terminating in an end-state resulting a trading

decision. The transition from one state to the next is not necessarily deterministic; some algorithms, known as probabilistic algorithms, incorporate randomness. A **trading strategy** wraps trading ideas, formulas and logic rules into a trading algorithm. Computer models combined with real-time access to market data enable traders to eliminate the emotional aspects of trading. A trading strategy is usually based on historical backtesting and research into quantitative methods.

Program trading generally refers to automated trading of large institutions typically for large index arbitrage or price threshold trades, which can increase volatility. As a result, there are restrictions on times when program trading can be entered.

Complex Event Processing, or **CEP**, is primarily an event processing concept that deals with the task of processing multiple events from an event cloud with the goal of identifying the meaningful events within the event cloud. CEP employs techniques such as detection of complex patterns of many events, event correlation and abstraction, event hierarchies, and relationships between events such as causality, membership, and timing, and event-driven processes.

E.   Exchange Matching

F.   Trading Strategies

Statistical Arbitrage
Pairs Trading
Volatility Arbitrage
Risk Arbitrage
Alpha and Beta
Covered Call Writing
Basket Trading
Index Arbitrage
Cash and Carry Arbitrage
Portfolio Insurance
Portfolio Optimization
Value vs. Growth
Market Neutral
130/30 Strategy
Enhanced Index Strategy
Basic Option Strategies
Collar
Straddle
Strangle
Butterfly
Calendar Spread
Bull/Bear Spread
Diagonal Spread
Condor
Delta Hedging
Gamma Scalping
Jelly Roll
Credit/Debit Spread
Volatility Dispersion
AVP
Implied Index Correlation %
VIX CBOE Volatility Index
Volatility Arbitrage
Fixed Income Arbitrage
Bond Ladder
Barbell
Credit Spread
Convertible Arbitrage
TED Spread
Basis Trading
Swaps
Risk Reversal
Spreads
Variance Swap

Interest Rate Parity
Covered Interest Parity
Triangular Arbitrage
Forex Swap
Currency Swap
Turtle Trading