CHAPTER III
FINANCIAL ANALYSIS

3.1 Introduction

Finance is the science of relationship between business and money. The financial analysis is the computation of analytical ratios from financial statements and interpretation of these ratios to determine their trends as basis for management decisions. Market ratios are the comprehensive means of measurement of a company as they reflect the corroborated influence of risk and profitability financial ratios [106]. These ratios are more important because they echo the general confidence and trust of the market in a company’s management. But the confidence and trust depends upon many economic, social, and political factors. Hence, the investors when taking decisions they take into consideration a variety of indicators along with the following.

- The internal performances achieved by a company which is established by analyzing the information reflected in its financial statements.

Billions of dollars flow through the world's financial markets every day. The market participants are eager to accurately price the financial instruments and understand relationships involving them to predict the stock price.

3.2 An Efficient Market

The concept of efficiency in economics is a general term for the value assigned to a situation by some measure designed to capture the amount of waste or "friction" or other undesirable economic features present. Within this context, it has several quite distinct meanings.
An “efficient” market is defined as a market where there are large numbers of rational, “profit-maximizers” actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants. A contrary perspective of this view is presented below.

3.2.1 The Efficient Market Hypothesis (EMH)

The Efficient Market Hypothesis (EMH) was developed by Professor Fama [21], who is most often thought of as the father of EMH. The EMH proposes two crucial concepts that have defined the conversation on efficient markets ever since.

1. Types of informational efficiency.
2. Joint Hypothesis problem.

3.2.1.1 Informational Efficiency

A market is called informational efficient if prices always fully reflect available information. Informational efficiency is the responsiveness of stock prices to relevant information. It is also called as market efficiency. Informational efficiency of stock market prices proposed by EMH is one of the cornerstones of modern financial theory [82].

The following three elements appear in the production of information.

1. **The expected return** - if the expected return of trading based on the information is “too low”, then the information may not be produced at all
2. **The cost of producing information** with which money has to be earned.
3. **The cost of disseminating the information**, such that the expected return indeed will be realized.

The kind of information that will be produced and the speed of incorporation of the information in prices depend on the above three elements. It is very much like; in the production of ordinary goods, marginal costs and revenues are constantly brought into equilibrium.

In general, the efficiency of information flow to market is the speed and accuracy with which prices in a market reflect new information. The EMH distinguished three major forms of market efficiency [21], [22]:

1. **Weak Form Efficiency** – Prices fully reflect information regarding the past sequences of prices. No investor can earn excess returns by developing trading rules based solely on historical price or return information.

2. **Semi-Strong Form Efficiency** – Prices fully reflect all publicly available information, including financial statement data. No investor can earn excess returns from using trading rules based on any publicly available information.

3. **Strong Form Efficiency** – Prices fully reflect all information, including inside information. No investor can earn excess returns using any information whether publicly available or not.
The Efficient market hypothesis says that past information is already incorporated into today's stock prices. Patterns may be seen in stock prices, but they are neither consistent nor long lasting. It is impossible to continually earn excess returns based on past patterns.

In recent times, however, the possibility of efficiency has been questioned on theoretical grounds. The argument is that if prices fully reflected available information, nobody would be interested anymore in producing costly information. As a result of this, prices could impossibly reflect such information [9].

3.2.1.2 Joint Hypothesis Problem

The Joint Hypothesis Problem states that tests of the EMH are joint tests of market efficiency and the particular asset pricing model used to conduct the test. The concept of "Joint Hypothesis Problem" in EMH is demonstrated as the notion of market efficiency, which could not be rejected without an accompanying rejection of the model of market equilibrium.

The asset pricing model is based on the model of market equilibrium and it is a situation where the supply of any item is exactly equal to its demand. Since neither there is surplus nor shortage in the market and hence, there is no innate tendency for the price of the item to change. This is the general price setting mechanism. This concept has ever since vexed researchers [33].
3.3 Excerpts of EMH

- The Efficient Market Hypothesis [23] demonstrates with various tests, that price changes are independent and therefore, the past history of stock prices cannot be used to make meaningful predictions concerning its future behavior. Moreover, if it is found that there is some dependence, then Fama [21], [22] argues that this dependence is too small to be profitably exploited because of transaction costs.

- According to the EMH, buying and selling of shares is engaging in a game of chance and not a skill. If markets are efficient and current, it means that the prices always reflect all information, so there are no way ever possible to buy a stock at a bargain price.

- The EMH is associated with the idea of a “random walk,” which is a term used in the finance literature to characterize a price series where all subsequent price changes represent random departures from previous prices.
  - The logic of the random walk theory is that if the flow of information is without hindrance and information is immediately reflected in stock prices, then tomorrow’s price change will reflect only tomorrow’s news and will be independent of today’s price changes. But news is by definition unpredictable and hence, consequential price changes must be unpredictable and random. As a result, prices fully reflect all known information. Hence, even uninformed investors buying a diversified portfolio at the outlook
of prices given by the market are able to generate a rate of return as
generous as that is achieved by the experts.

- The Efficient Market Hypothesis is an investment theory and it states that it is
impossible to "beat the market", because stock market efficiency causes
existing share prices to always incorporate and reflect all relevant information.

- The EMH states that the stocks are always traded at their fair value on stock
exchanges, making it impossible for the investors to either purchase
undervalued stocks or sell stocks for inflated prices. As such, it should
be impossible to outperform the overall market through expert stock selection
or market timing and the only way an investor can possibly obtain higher
returns is by purchasing riskier investments. A precondition of this hypothesis
is that the information, trading costs and the costs of "getting prices" which
reflect information, are always zero [33].

  - Based on the ground of assurance of the return, the Investments are
classified as Riskless and Risky. Riskless investments are
guaranteed, but since the value of a guarantee is only as good as
the guarantor, those backed by the full faith and confidence of a
large stable government is the only investments considered
"riskless" and all the others are Risky. Even in that case the risk of
devaluation of the currency (inflation) is a form of risk
appropriately called "inflation risk." Therefore no venture can be
said to be by definition "risk free" - merely very close to it where
the guarantor is a stable government.
3.4 Disbelieves of EMH

The EMH has been the central proposition of finance since the early 1970s. It is also one of the most controversial and well-studied propositions in all the social sciences. Various difference of opinions witnessed in the literature are presented below.

- The markets with perfect informational efficiency are practical impossibility. If markets are perfectly efficient, the returns for gathering information is nil, in that case there would be little reason to trade and markets would eventually collapse [32], [34].

- The perfect efficiency is an unrealistic benchmark that is unlikely to hold in practice [11]. Even in theory, it is shown that abnormal returns exist if there are costs of gathering and processing information. These returns are necessary to compensate investors for their information-gathering and information-processing expenses. Thus the returns are no longer abnormal when these expenses are properly accounted for. In a large and liquid market, information costs are likely to justify only small abnormal returns, but it is difficult to say how small, even if such costs could be measured precisely [32].

- Grossman and Stiglitz [33] argued that the information is costly. Hence, prices cannot perfectly reflect the information which is available. Thus, those who spent resources to obtain it would receive no compensation, leading to the conclusion that an “Informationally Efficient” market is impossible. But according to EMH, the prices perfectly reflect the information.
• EMH theory has been met with a lot of opposition, especially from the technical analysts. Their argument against the efficient market theory is that the expectations of many investors are based on past prices, past earnings, track records and other indicators. The stock prices are also largely based on investor expectations. Hence, it makes good sense to believe that the past prices influence future prices [34].

The EMH is highly controversial and often disputed. Believers argue that it is pointless to search for undervalued stocks. Also the attempt to predict trends in the market through either fundamental or technical analysis is pointless. In the meantime, while academicians point to a large body of evidence in support of EMH, there exist an equal amount of oppositions raised by professional practitioners.

While choosing a certain type of investment, the factor that determines investors’ decisions depends on the horizon of interest pursued in a certain company. Therefore, if the company’s development prospective is pursued in the long-term horizon, the potential investors or majority shareholders, in case of existing investors, shall be interested in the operating result that would generate an increase in the value of shares in the future. Else, if immediate gain is pursued in a horizon of less than 12 months period, (i.e. a gain in the form of dividends distributed and gains from the differences in quotations), the potential investors or minority shareholders, in case of existing investors shall only be interested in the level of this type of gain.

In either case of decision to invest on the capital market, current and potential investors as well as capital market professionals use two categories of analyses, namely: Fundamental Analysis [10] and Technical Analysis [62].
3.5 Fundamental Analysis

Fundamental analysis is the study of a company's "fundamentals" with the aim of calculating exactly what a listed company is worth. Based on that valuation, investors will either buy or sell its share. The Fundamental Analysis is based on the macroeconomic data and the basic financial status of companies like money supply, interest rate, inflationary rates, dividend yields, earnings yield, cash flow yield, book to market ratio, price-earnings ratio and lagged returns [10].

Fundamental analysis is performed by analyzing either in "sell" side for stock-broking or in "buy" side for asset management. There are two broad approaches to fundamental analysis. These are called "top-down" and "bottom-up" investing [106].

3.5.1 Top-Down Approach

The top-down investing looks at a company's operating environment in addition to its own strategies and likely future performance. The techniques can be likened to an inverted pyramid. Taking a top-down approach to a company's earnings' prospects involves first looking at the broad macroeconomic, social and political environment in which the company operates. The focus of the analysis is then funneled and progressively narrowed to look at industry-specific or regional influences on a company's future economic performance. The major benefit of top-down analysis is that it ensures relevant information is included in a consistent way.
3.5.2 Bottom-Up Approach

The Bottom-up fundamental analysis filters the different companies in a sector by looking at the individual “investment story” of each, as well as analyzing many of different numbers. These numbers include both the financial statements published by each company as well as specific ratios that investors calculate from these in a process that is known as “number-crunching”. It also includes an assessment of a company’s management: its credibility, experience and strategic insight. From that the analyst draws conclusions concerning the attractiveness of that specific company as an investment and estimates its true, or intrinsic value.

If the “intrinsic value” is lower than the prevailing share price, analyst rates the stock as a “buy”; if it is lower, then the analyst recommend a “sell”. If intrinsic value is broadly in line with the market price, the share will be labeled a “hold”. These recommendations usually have a one-year time horizon. Share prices declining can either be a buying opportunity or a trap for the innocent investor, as nearly all corporate collapses are preceded by sustained price falls.

Fundamental analysis ensures that an investor knows what they like about a company, how well it is managed and the market in which the company operates. Fundamental analysis has a number of shortcomings. In particular, it is time-consuming and it can limit the range of possible investments through an analyst’s relentless focus on one specialized sector or market. It is not always possible to get the necessary information on time, as a company’s circumstances may have altered – a situation that will be anticipated by the share price. In addition, while an individual’s interpretation of a
set of facts and figures may prove right over the long term it may take some time for the market to truly appreciate your genius.

In many ways, these shortcomings are addressed by technical analysis by arguing that share prices already contain all the information that the market has about a company, including insider knowledge. Another advantage of technical analysis is that it can be applied to virtually any trading medium and investment time horizon.

A technical analyst can analyze shares, bonds, options, mutual funds, commodities and many other forms of investments for buy and sell opportunities and can do so by examining a variety of inputs, including tic-by-tic, intraday, daily, weekly or monthly data – from very short-term to very long-term perspectives. The daily bar data is taken for the study and analysis in this thesis.

3.6 Technical Analysis

Technical analysis is defined [67] as the study of past price movements with the goal to forecast future price movements with the aid of certain quantitative summary measures of past prices such as "momentum indicators" and "oscillators", but without regard to any underlying economic, or fundamental analysis.

The momentum measures the rate-of-change of a security's price. Many leading indicators come in the form of momentum oscillators. As the price of a security rises, price momentum increases. The faster the security rises (the greater the period-over-period price change), the larger the increase in momentum. Once this rise begins to slow, momentum will also slow. As a security begins to trade flat, momentum starts to actually
decline from previous high levels. However, declining momentum in the face of sideways trading is not always a bearish signal. It simply means that momentum is returning to a more median level.

The basis for technical analysis is the belief that stock prices move in predictable patterns. All the factors that influence price movements like company performance, the general state of the economy and natural disasters are supposedly reflected in the stock market with great efficiency. This efficiency, coupled with historical trends produces movements that can be analyzed and applied to future stock market movements [13].

Technical analysis is not intended for long-term investments because fundamental information concerning a company's potential for growth is not taken into account. Trades must be entered and exited at precise times. So the technical analysts may need to spend a great deal of time watching market movements. Investors can take advantage of both upswings and downswings in price by going either long or short term investment.

Another description for technical analysis is given by Pring [77]. It states that as the art of detecting a price trend in an early stage and maintaining a market position until there is enough weight of evidence that the trend will reverse.

The three principles underlying technical analysis are as follows.

1. All the information is gradually discounted in the prices. Through the market mechanism the expectations, hopes, dreams and believes of all investors are reflected in the prices. The best technical adviser one can get is the market itself and there is no need to explore fundamental information.
2. Technical analysis assumes that prices move in upward, downward or sideways trends. Therefore most technical trading techniques are trend-following instruments.

3. The history repeats itself.

In all conditions the investors will react and the same will be leading to a price pattern which can be recognized in the data. Technical analysts claim that if a pattern is detected in an early stage, profitable trades can be made.

In this thesis we confine ourselves to objective trend-following technical trading techniques which can be implemented on a computer. The technical trading strategies are divided in to three different groups: moving average rules, trading range break-out rules and filter rules [1].

Each trading strategy divides the data set of prices into three subsets of periods and these trading periods are classified as follows.

- **"Buy Period"** - The period after the generations of a buy signal till the next trading signal is generated.

- **"Sell Period"** - The period after the generations of a sell signal till the next trading signal is generated.

- **"Neutral Period"** - The period after the generations of a neutral signal till the next trading signal is generated.
The subsets consisting of buy, sell or neutral periods are called as the set of buy, sell or neutral days.

### 3.6.1 The Moving Average Rules

Moving-average (MA) trading rules are the most commonly used and most widely tested technical trading strategies. Moving averages are recursively updated averages of past prices. They yield insight in the underlying trend of a price series and also smooth out an otherwise volatile series. The equally weighted moving averages are represented in equation 3.1.

\[
\text{MA}_t^p = \frac{1}{n} \sum_{j=0}^{n-1} p_{t-j}, t \geq n, \tag{3.1}
\]

where \( \text{MA}_t^p \) is the moving average at time \( t \) of the last \( n \) observed prices. Short term trends can be detected by choosing \( n \) small. Also long term trends can be detected by choosing \( n \) large. The larger the \( n \), the slower the MA adapts and the more volatility is smoothed out. Technical analysts therefore refer to a MA with a large \( n \) as a slow MA and to a MA with a small \( n \) as a fast MA. The Moving averages are recursively updated averages of past prices.

### 3.6.1.1 The Moving Average Crossover

The MA trading rules make use of one or two moving averages. A special case is the single crossover MA trading rule, which is using the price series itself as a base-line over the MA of the price series. The price crossing the MA upward is considered as a “buy” signal and the price crossing the MA downward is considered as a “sell” signal.
The double crossover MA trading rule on the other hand uses two moving averages, a slow one and a fast one. The slow MA represents the long run trend and the fast MA represents the short run trend. A "buy" signal is generated, if the fast MA crosses the slow MA upward. A sell signal is generated, if the fast MA crosses the slow MA downward. The signal generating model is given by equations 3.2, 3.3 and 3.4.

\[ \text{Pos}_{t+1} = 1, \quad \text{if } MA_t^k > MA_t^n, \quad (3.2) \]
\[ \text{Pos}_{t+1} = \text{Pos}_t, \quad \text{if } MA_t^k = MA_t^n \quad \text{and} \quad (3.3) \]
\[ \text{Pos}_{t+1} = -1, \quad \text{if } MA_t^k < MA_t^n, \quad (3.4) \]

where \( k < n \) and \( \text{Pos}_{t+1} = -1, 0, 1 \) means holding a short, neutral respectively for long position in the market in period \( t + 1 \). The single and double crossover MA rules described above is the basic MA trading rules. These basic MA rules can be extended with a %-band filter, a time delay filter, a fixed holding period and a stop-loss. The %-band filter and time delay filter are developed to reduce the number of false signals.

- **The %-band filter** - In the case of the %-band filter, a band is introduced around the slow MA. If the price or fast MA crosses the slow MA with an amount greater than the band, a signal is generated; otherwise the position in the market is maintained. This strategy will not generate trading signals as long as the fast MA is within the band around the slow MA. The extended MA model with, a 100% filter ("b") is given by equations 3.5, 3.6 and 3.7.

\[ \text{Pos}_{t+1} = 1, \quad \text{if } MA_t^k > (1 + b)MA_t^n \quad (3.5) \]
\[ \text{Pos}_{t+1} = \text{Pos}_t, \quad \text{if } (1 - b)MA_t^n \leq MA_t^k \leq (1 + b)MA_t^n \quad (3.6) \]
\[ \text{Pos}_{t+1} = -1, \quad \text{if } MA_t^k < (1 - b)MA_t^n \quad (3.7) \]
• **The time delay filter** - According to the time delay filter, a signal must hold for “d” consecutive days before a trade is implemented. The position in the market will not be changed, if within these “d” days different signals are given.

• **Fixed holding period** - The MA rule with a fixed holding period holds a long or short position in the market for a fixed number of “f” days after a buy or sell signal is generated. After “f” days the market position is liquidated and a neutral market position is held up to the next buy or sell signal. This strategy tests, whether the market behaves different in a time period after the first crossing. All signals that are generated during the fixed holding period are ignored. The positions are always unchanged until the moving averages really cross.

• **The stop-loss** - The stop-loss is based on the popular phrase:

  "Let your profits run and cut your losses short"

The stop-loss will liquidate the position if the price rises from the most recent low with x% while a short position is held in the market. Also the stop-loss will liquidate the position if the price declines from the most recent high with x%, while a long position is held in the market. A neutral market position is held up to the next buy or sell signal.

3.6.1.2 Trading Range Breakout

The Trading Range Breakout (TRB) strategy is also called as “Support and Resistance” strategy. The TRB strategy defines support and resistance levels.
• "Support Level" - The price level is called a support level, if the price does not fall below certain price level during certain period of time. Support is the level that downward prices are expected to rise.

• "Resistance Level" - The price level is called a resistance level, if the price does not rise beyond certain price level during certain period of time. Resistance is the level that upward prices are expected to reach before falling again.

According to technical analysts, there is a "battle between buyers and sellers" at these price levels. The market buys at the support level after a price decline and sells at the resistance level after a price rise. If the price breaks through the support or resistance level, an important technical trading signal is generated. The sellers and buyers have won the "battle".

At support level, the market becomes "Net Seller Market" and at resistance level, the market becomes a "Net Buyer Market". This indicates that the market will move to a subsequent lower or higher level. The support level may change into a resistance level and the resistance level may change into a support level. To implement the TRB strategy, support and resistance levels are defined as local minima and maxima of the closing prices.

In case, if the price falls through the local minimum a sell signal is generated and a short position is taken in the market. If the price rises through the local maximum a buy signal is generated and a long position is taken in the market. If the price moves between the local minimum and maximum the position in the market is maintained until there is a
new breakthrough. The TRB strategy will also be extended with a %-band filter, a time
delay filter, a fixed holding period and a stop-loss. The basic TRB strategy, extended
with a %-band filter, is represented in equations 3.8, 3.9 and 3.10 as follows.

\[\text{Pos}_{t+1} = 1, \quad \text{if } P_t > (1 + b) \max \{P_{t-1}, P_{t-2}, \ldots, P_{t-n}\} \]  
\[\text{Pos}_{t+1} = \text{Pos}_t, \quad \text{if } P_t > (1 - b) \min \{P_{t-1}, \ldots, P_{t-n}\} \leq P_t \leq (1 + b) \max \{P_{t-1}, \ldots, P_{t-n}\} \]  
\[\text{Pos}_{t+1} = -1, \quad \text{if } P_t < (1 - b) \max \{P_{t-1}, P_{t-2}, \ldots, P_{t-n}\} \]

3.6.1.3 Filter rule

The "Filter Rule" strategy generates a buy or sell signals if the price rises or falls
by "x\%" from a previous low or high. The filter rule may be implemented by using
moving stop-loss. In an upward trend the stop-loss is placed below the price series. The
stop-loss will go up, if the price goes up and the stop-loss will not be changed, if the price
declines.

A sell signal is generated, if the price falls through the stop-loss and the stop-loss
will be placed above the price series. The stop-loss will decline, if the price declines. The
stop-loss is not changed, if the price rises.

A buy signal is generated, if the price rises through the stop-loss and the stop-loss
is placed below the price series. The stop-loss will follow the price series at a "x\%"
distance. On a buy signal, a long position is maintained and on a sell signal, a short
position is maintained. This strategy will be extended with a time delay filter and a fixed
holding period.
3.7 Trading Systems

Trading system in the perspective of this thesis refers to the collection of hardware and software applications used in trading. They are used according to the market conditions. A trading system must make complete sense to the trader, since it is acting as the medium of communication. In this viewpoint, a simple analytical graph or a candlestick chart do not make a complete trading system because the trader can not get the full details of the stock and its tradability at a point in time. Thus, it is necessary to bring many analytics together for the trader to assess its tradability at a particular point in time.

The general trading systems can be used under all market conditions and “trend specific trading system” can be used only within well defined market conditions such as up-trending, down-trending and wavering market which has no definite trend. The wavering market wavers up for few days and down for another few days along a flat horizontal line conditions. Important factors to be considered while developing trading systems are discussed below.

3.7.1 Trading Systems and Signals

A trading system is not a simple one time development process, but it is a continuous refinement process of research and development to improve the predictive accuracy. Trading system application developers have to question why my trading system is not able to generate very accurate signals, or why the system is generating delayed signals. It is necessary to confirm the accuracy of a signal within the trading system using
appropriate conditions. A delayed signal represents loss of significant opportunity and hence the signal generation cannot be unduly delayed. Early generation of signals result in loss and is not a good trading system. Late generation of signals also results in the loss of opportunity of significant early price movements. Thus, a trading system represents a compromise between risk and reward.

3.7.2 Trading Systems and Rules

A trading system consists of reduction of a number of rules that are logically composed with comparison, conjunctive and disjunctive conditional operators. Rules are the basic building blocks for trading systems. Rules are derived by obtaining results from fundamental analytics, indicators, stochastic, statistics and oscillators. For example, fast moving average crossing above the slow moving average can be used as a buy signal rule. Similarly, fast moving average crossing below the slow moving average can be used as a sell signal rule. These are two specific rules. Rules could also be composed from candlestick patterns or technical chart patterns as well.

In order to find the right kind of trading rule, one has to test each of the indicators and look at the historic performance. An observer understands a lot about what each analytical value tells. Only by observing, validating the observations by forming rules and back testing the hypothesis can be truly validated. It is therefore essential for the trading system developer to rigorously follow the process of observation, rule formation, developing trading systems, testing and validating as an approach to discovery of the trading systems that work well.
3.7.3 Using of Price and Volume Data

The building blocks of rules are the time-series bar data. Bar data represents a true sample of data at point in time for the given interval it represents and it is day interval in this case. In bar data, there are two fundamental data sets, namely the price data and the volume data. Many of the analytical functions depend upon the price data and give slight importance to the volume data. However, the volume data is also as much important as the price data. Using the price and volume data the supply and demand side of the equation can be determined. The logic presented below, demonstrates the relationship between price and volume in determining the supply and demand side of the equations.

Range of the price move \( R = H - L \),

Range of the supply side (sell) price move \( S = H - C \),

Range of the demand side (buy) price move \( D = C - L \),

where, “\( H \)” is the highest price, “\( L \)” is the lowest price and “\( C \)” is the closing price of the stock on that day.

Therefore, the supply side volume \( SV = S / R \times V \).

Therefore, the demand side volume \( DV = D / R \times V \) which is equal to \( V - SV \),

where, \( V \) is the volume of the stock traded on that day.

The Supply and Demand indices can be computed as:

Supply index \( SI = S / R \times 100 \) which is equal to \( SV / V \times 100 \).

Demand index \( DI = D / R \times 100 \) which is equal to \( DV / V \times 100 \).
The percentage can be plotted over a plain scale ranging from -100 to +100 using the formulae given below.

**Supply index SI** = \((S / R - 1.0) \times 100\).

**Demand index DI** = \((D / R - 1.0) \times 100\).

In the computation, it is essential to set value above 100 as 100 and below -100 as -100 indicating saturation.

However, combining supply and demand of price and volume in a time-series analysis highlights the point in time when the momentum on the demand side diminishes and the momentum on the supply side picks up to generate the sell signal. Similarly, it is possible to determine the point in time when the momentum on the supply side diminishes and the momentum on the demand side picks up to generate the buy signal.

The price and volume indices can be included in the stock monitoring systems and the indices must be monitored on a constant basis. The transaction is assumed to take place in a reduced speed, when volume index is below 100. When volume index is less than 100 and change in price is around 0, the stock is reaching a pause. This indicates that there not much interest in the stock for both the buyers and sellers. However when the volume index is less than 80 and the price change is positive, then it indicates that all the stock that is sold is being picked up. This along with any other technical studies is a good signal for buying the stock. Similarly, it is possible to notice the negative price change increasing when the volume percent is diminished at the early stages of topping.
3.7.4 Leading, On Time and Lagging Rules

The success in building good trading systems lies in identifying high probability signal generating rules using time-series indicators, oscillators, statistics and other stochastic analytics. These rules should be used very critically according to their types. There are three types of signal generating rules. (1) Leading, (2) On time and (3) Lagging signal generating rules. Each one has its own importance.

- **Leading Signal Generating Rule**: It has good predictive capability.

- **On Time Signal Generating Rule**: These rules give good decision making capability for buying and selling.

- **Lagging Signal Generating Rule**: These rules occur after the time of buying or selling is passed. However, lagging rules provide high degree of confirmation. This indicator is not much used. But this helps in deciding early exit from the already traded positions.

Therefore, the Leading and On Time rules can be used to make buying and selling decisions. Lagging indicators to confirm the leading and on time rules. If the trading is committed on the first two rules and if the lagging indicator does not say good things about the decisions, then it is better to exit from the positions we have already taken. This will reduce the loss.

3.7.5 Back Testing of Rule

Once the appropriate rules are identified, the efficiency of each rule should be evaluated by testing it on the historic data. Each rule has to be evaluated very carefully
and the profit / loss percentages must be generated. This is a way to convert subjective and objective rules into solid mathematical values to help in further decision making. These percentages help the investors to identify which rule should be used as the main rule. Also, the combination of rules that improve the performance further should be looked at. The idea of using combination should be to obtain further confirmation early. Thus, the performance could be improved by the combination of complex decision making process by if/else rules reductions. The performance can further be improved by filtering out the less significant signals.

One of the important aspects in analytics is the early detection of trend changes. Early detection of trend changes has great promise for research and understanding. The stock price changes are usually taking place in waves of up and down movements. Any interval of bar data charting can be taken into consideration and the upward and downward waves of price changes can be seen. Thus, under each interval there are constant wave movements in prices. This indicates that that when bulls finish their process, the bears take charge from there. When bears exhaust their strength, once again bulls take over. Hence, as in any nature's cycles, supply and demand processes are cycling alternatively, exhausting one another. Therefore, in a cyclical system, it is possible to trade all the time on the cycle and as well as on long term trend.

3.7.6 Trend Reversal

A trend reversal takes place after a major move on the upside or downside. In between, little short term up or down of smaller cycles may take place. Thus, trend is the major wave and the cycle is the short term wave. In order to trade on the short term
waves or cycles, one should look at the lower interval of charts such as 1 hour or 5 minutes charts. These are the magnifications of long term waves such as daily or weekly charts. This is the main reason behind looking at charts of various intervals. In these circumstances, the analytics remain the same, but the decision making processes are different.

### 3.8 Types of Trading Systems

Many different kinds of trading systems used by professional practitioners to meet out various application needs are described below.

#### 3.8.1 Chart Trading System

This is the first level of trading system and is based on plotting the data as charts. The data belonging to a single time interval is used in the chart trading systems. There are no comparative analyses between various time intervals. Hence, chart trading systems are very fundamental in nature. However, coming out with the best chart trading system is the first step in the process of building complex trading systems. Therefore, the chart trading systems hold the key for future success. The accuracy of these systems must be very high and the return from them should also be high.

#### 3.8.2 Query Trading System

Query Trading System is designed for comparative study. Comparison is done within a stock across different time intervals of bar data. Comparison is done between different stocks as well. Query gives the facility to compare a stock with any index symbol. For example, one can compare a stock with the index of the industry group to
understand how a stock is performing compared to the index. In other words, gold stocks having symbols “GOLD” - Randgold Resources Ltd, “NEM”- Newmont Mining Corporation, “AU” - AngloGold Ashanti Ltd, and “KGC” - Kinross Gold Corporation can be compared with the gold index “$XAU.X”. Note that each index is generated by combining weighted values of individual stocks within the industry group. The stocks are analyzed according to the index and time intervals. Then the queries facilitate to sort and filter stocks based on the conditions defined within the WHERE clause. Thus, query takes the development of trading systems one level higher.

3.8.3 Monitoring Trading Systems

These systems are built using charts and query trading systems to meet out portfolio management requirements. All the monitoring trading systems are normally deployed as auto programs. These programs generate messages that are watched by pit or admin tool or other trading system programs such as the “Auto Trader”. The monitoring trading systems explore the boundary of available tools and help the analysts to understand the market, the stock or sectors or industry. The monitoring trading systems can further be classified as follows.

3.8.3.1 Stock Monitoring Trading System

All the trading applications are designed to watch a single stock on line. This is the machine replacement for a human being watching the stock. Thus, a stock monitoring trading system is a watch dog. This is very useful to monitor a portfolio of stocks that need to pay critical attention. This could be even watching the broader market or sector index. The sector index is an index that measures the performance of a narrow market
segment, such as biotechnology or small capitalization stocks. The Market Sector Indices page summarizes the performance of stocks grouped by specific market sectors. This allows investors to benchmark the performance of a particular stock market sector or industry.

Stock Monitoring Trading Systems will keep on watching only one symbol. These auto program trading systems can be deployed as a direct single auto program or as a batch of programs. This can be designed to monitor a single or list of stock symbols.

3.8.3.2 Sector Rotation Watching Trading System

When a stock price reaches the traders price objectives, the trader sells the stock and the related stock prices movement can be noticed. This is because huge funds are allocated for a particular industry group of stocks by fund managers. That is the reason behind certain industry groups doing well for some time and then they stagnate or go down in prices. This is referred to as “Market Sector Rotation”. This can be understood well by watching the sector or industry group indices. The industry group indices reflect the money flow from huge fund managers. While moving funds from one industry group to another, fund managers look at the cyclicality of business as well. For example, retail stocks do well during major holiday seasons. Sports stocks do well in the summer. College and school related stocks do well during the starting of fall and winter semesters. How long these groups are going to do well is not known. The trading systems can be designed to watch these groups for trend reversal and try to understand where the money is moving.
3.8.3.3 Market Health Analysis Trading Systems

This is a general trading system that is used to understand the major market trends and following it. There are companies that analyze the major footprint the stock market is indicating. These footprint analysts try to predict major market moves, major trend reversal and wavering market conditions. For this kind of trading system applications, major economic information need to be integrated into the trading systems. For footprint analysis, large quantum of information has to be grabbed from the web. Searching the web sites like [109] will serve the purpose. This site could give some indications about their major footprint analysis. The newsletters from the market analyst, Elaine Garzarelli [108] to her subscribers fund managers are of good use. The automatic informative content retrieval tool [52] makes the job of web surfing simple.

3.8.3.4 Option Trading System

Most of the option analysis is done using Black-Scholes methodology [27]. The fundamental insight of Black-Scholes is that the option is implicitly priced if the stock is traded. Option trading is one of the important trading and it is very risky. Although, carefully traded options could give substantial rewards as well. Options play on the risk premium of the underlying stock worthiness at the distant future. Therefore, options expire on the designated time with reward or risk according to the play the trader has intended.
3.9 Memory Components in stock data

Historic data is the past memory that has hidden predictive future performance. The presence of long-memory components [71] in asset returns has important implications for many of the paradigms used in modern financial economics. For example, optimal consumption / savings and portfolio decisions may become extremely sensitive to the investment horizon if stock returns were long-range dependent. Traditional tests of the capital asset pricing model and the arbitrage pricing theory are no longer valid since the usual forms of statistical inference do not apply to time series exhibiting such persistence. To develop a method for detecting long-term memory, the distinction between long-range and short-range statistical dependence must be made precise. There is ample evidence of changing variances in stock returns over periods longer than five years, but unstable volatilities can be a symptom of time varying conditional moments which can manifest itself in stationary time series. In contrast to the short-term memory of "weakly dependent", the processes of natural phenomena often display long-term memory in the form of non-periodic cycles.

3.10 Arbitrage Pricing

Arbitrage pricing in finance [21], [22], and [26] is a process of asset pricing that has become influential in the pricing of shares. It holds that the expected return of a financial asset can be modeled as a linear function of various macro-economic factors or theoretical market indices, where sensitivity to changes in each factor is represented by a factor-specific beta coefficient. The Beta coefficient, in terms of finance and investing, is a measure of a stock (or portfolio) volatility in relation to the rest of the market. The
model-derived rate of return will then be used to price the asset - the asset price should equal the expected end of period price discounted at the rate implied by model. If the price diverges, arbitrage should bring it back into line. An arbitrage is a transaction that involves no negative cash flow at any probabilistic or temporal state and a positive cash flow in at least one state; in simple terms, a risk-free profit.

Some people believe that the stock price behaves random walk [21], [69]. Technical analysts and many others believe that the past stock price carries the memory for the future stock price that can be predicted [71]. The logic behind the belief is simple that those who bought the stock in the past all collectively thought that the price of the stock was undervalued and therefore will go up. Therefore, they hold the stock even if it goes down as all of them collectively think it will go up. The probability of larger set of people believing that the stock price is going up than those who believe that the stock price is going down is a very powerful indicator to indicate that the stock price will go up.

The people who believe that the stock price is going down and shorting can not do so indefinitely. There will be a point when their short shares will be called by the people who loaned the stock to the short sellers and force the short sellers to cover their positions. When you buy the stock, you own the stock. When you short sell the stock, you borrow it from someone else and sell it in the market. Therefore at some point you will have to buy it back from the market and give it to the people who lend it to you before.

The collective probability is what matters unless such probability is altered by new information. For example, let us consider an IT company. All the people who bought the stock during 2005 believed that the company will make 1 USD per share profit using
all the information they had. However, when the company announced their annual report, they said that they made 1.50 USD as profit, and then the stock price jumps to adjust to the new price. However, if the company would have told that it made only 0.85 USD, and then the stock price would have gone down to adjust to the fall in annual revenue. Given this analysis, it is always good to bet along with the majority of the people either on the upside or on the down side.

While dealing with stock prices and probability, one has to keep in the mind the psychology of the market participants as well. When a majority of the people thinks that the stock price is going to move up, then there is a frenzy to buy the stocks and there is shortage of stock supply. At the same time, the people who have shorted the stock get very much frenzied and enter to cover their stocks. Therefore, there is greater demand than what is warranted and the stock price shoots at rocket speed. Hence, the stock prices over shoots the intrinsic value the stock for all the known information about the stock. When the stock belongs to a company that has low number of float stocks then the demand crunch takes place and the stocks shoot too farther than the intrinsic value and hold the value there for some time.

It is possible that at a particular point in time, the majority of the people may be wrong to think that the stock will go beyond. This is the condition when some good stocks get hammered down beyond the intrinsic value of the stock. Thus, in the market under pricing and over pricing of the stock takes place all the time. However, the market adjusts the price over a period of time to correct the price to the intrinsic price of the stock. Thus, we can say the market is always in a state of flux or dynamic state where the prices of the stock oscillate in and around the intrinsic price of the stock. Therefore, all
our analytical techniques should be directed at playing around the intrinsic value of the stock and benefit from the up and down swings. This is called swing trading. That is the stock prices swing up and down the intrinsic price of the stock and buying at the bottom and selling when it goes beyond the intrinsic value will bring good returns on a continuous basis.

The correlation between price and volume reveals market behavior [79], [86]. Number of technical indicators and time-series analytics used by financial experts are well documented [113], [55]. However, the criterion that is used to combine these analytics to arrive at predictive strategies is not understood well. Hence, a systematic study is performed to individually evaluate the time series analytics for their predictability for profitable stock trades. Also, when multiple non-correlated time series analytics are combined, there is a possibility to improve the predictive power [84], [31]. The combined performances of selective financial indicators are studied and the combinational patterns that maximize profitable trades, as well as results in high return on investment are explored in this thesis.

The outcome of this exploration journey has yielded three unique algorithms, namely, Time Series Quantitative Analytics 3 (TSQA3), Time Series Quantitative Analytics 4 (TSQA4) and Time Series Quantitative Analytics 5 (TSQA5), which are discussed in chapter V of this thesis.