Spring 2012

STOCK MARKET ANALYSIS

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DOI: <https://doi.org/10.31979/etd.w9nk-m4ut>
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STOCK MARKET ANALYSIS

SAN JOSÉ STATE UNIVERSITY

A Project Report

Presented to

The Faculty of the Department of Computer Science

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Masters of Computer Science

by

Sachin Kamath

May 2012

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The Designated Project Committee Approves the Project Titled
STOCK MARKET ANALYSIS BASED ON
TECHNICAL INDICATORS

by
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ABSTRACT

STOCK MARKET ANALYSIS BASED ON TECHNICAL INDICATORS

by Sachin Kamath

Stock market plays a pivotal role in financial aspect of the nation's growth, but stock market is highly volatile and complex in nature. It is affected by significant political issues, analyst calls, news articles, company's future plans of expansions and growth and many more. Hence, any investor would be interested in understanding the stock market overtime and how the factors mentioned above affect the behavior of the stock market.

On Every business day, millions of traders invest in stock market. Most of these investors lose money and others gain. However, considering any trading day, loss or gain is absolutely inconsistent. The demand to predict stock prices are extremely high, hence is the need for stock market analysis. This project is focused on analyzing a stock of any given company based on statistical technical indicators. Some of these indicators are deterministic in nature and the remaining are probabilistic. The objective of this project is to minimize the risk of loss in every trade thereby maximizing the profit.

ACKNOWLEDGEMENT

I would like to thank Dr. Teng Moh for his help through this project. His suggestions are the keys to the successful completion of this project. I also would like to thank Dr. Sami Khuri for helping me understand the basic of analysis and design of algorithms without which is the most important factor behind implementing efficient code.

I also would like to thank my family, especially my brother, Mr. Kiran Kamath for his emotional and financial support throughout my masters.

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1 Introduction

The world is flooded with information and we are only concerned about the information relevant to us. The information available can be classified based on various fields like engineering, arts, science, history, sports, geography, economics. In such situations it becomes important for us to boil down to the information relevant to us.[16] Especially when it comes to the field of finance, the information available is not well organized and they are just information of present state.

The stock market can be viewed as a platform where almost all major economic transactions in the world occur at a dynamic rate called the stock value which is based on the market equilibrium. A correct prediction of this stock trend beforehand can earn huge profits. [14, 21]

In this project, two approaches are implemented to achieve the prediction. One of them is to use various technical indicators. These technical indicators are implemented to anticipate future changes in the stock trends. [21] A technical indicator is based on mathematical calculations that can be applied to a stock's price, volume, or, even, to another technical indicator.[12] The deterministic nature of the technical indicators will provide a strong evidence to foresee the stock market.[21] The technical indicators implemented in this stock market prediction tool will back the predictability strongly.

The second approach is a more probabilistic, which is based on the Hidden Markov Model. This model is more suitable for dynamic systems and has been broadly

used in pattern recognition problems. [22, 23] It is centered on the statistical methods and has the ability to handle new data robustly. In this model, based on the historical datasets that complement with present day's stock price behavior, the two dataset's are interpolated with suitable neighboring price elements.[16, 15] This results in a forecast for tomorrow's stock trend of the variable of interest. [22]

Stock market can be analyzed based on fundamental analysis which is about financial results of the particular company which we are analyzing and also important financial news about the company.[14] This brings us down to news analysis in which we need to parse all the relevant documents and news about the company to extract required information based on which we can make a decision to invest. [12]

Stock market runs on a well-known theory known as “Theory of Demand and Supply” [18, 12]. It states demand is always inversely proportional to supply.[18] Hence, as demand increases buyers take over the stock market and market turns bullish. On the other hand, as soon as supply comes in sellers take over the market and stock prices start falling drastically.

Stock market can also be analyzed based on “Head and Shoulder Theory”[18] according to which, Highest price of any stock is considered the head and the next peak high is considered shoulder.

Most of the indicators which we will see in this report are statistical in nature. Hence, there are a few assumptions which are made in the design phase of every technical indicator. For my analysis I have used data from Indian stock market which

includes Bombay Stock Exchange and National Stock Exchange.

The following sections provide detailed information about the analysis of stock market.

- Section 2 provides information about literature review and calculation of technical indicators.
- Section 3 has information about interpretation of these technical indicators and various approaches which we have followed to obtain results.
- Section 4 contains limitations of this project.
- Section 5 contains conclusion and future work.
- Section 6 contains references which are used for this project.

2 Literature Review

In this section we will review Key Terms, Technical Indicators and probabilistic models in depth.

2.1 Introduction to Literature Review

Stock market prediction is an area of research which walks hand in hand with all the other businesses in the world. Hence, it is known as 'Mother of all Businesses'. [21, 18] Before trying to jump into analysis we need to understand the following terms.

2.1.1 Key Terms

2.1.1.1 Interval

Millions of trades take place every second. Hence, for analysis we need to classify these trades based on the interval at which they took place. We can divide these trades into intra-day and long term intervals. Intra-day can be sub-classified into 1 minute, 2, 5, 10, 15, 30 and 60 minutes. Long term intervals can be classified into daily, weekly, monthly and so on. [4, 19]

2.1.1.2 Tick Prices

At every interval any stock will have 4 types of prices associated with it. High price, Low price, Open Price and Close price. High price is the highest value at which it was traded in that particular interval. Low price is the lowest price which it reached in

that interval. Open price is the first trade which took place at that particular interval and Close price the price at which the stock was last traded at that interval. [12]

2.1.1.3 Trend

At any instance of time, any stock will have either higher demand than supply or lower demand than available supply. Hence we can classify the Trend into two types namely Bearish and Bullish. A stock is said to be in Bullish Trend if it has higher demand than its supply at that instance of time. If the stock has higher available supply when compared with demand, it is said it be in Bearish Trend. [19]

2.1.2 Data Representation

Data need to be represented in some format before we can start analyzing it. In this section we will discuss how can we represent data for better interpretation.

2.1.2.1 Japanese Candle [24]

Figure 1 Japanese Candle

Figure 1 represents two different candle sticks. The green candle represents gain, and red candle represents loss. This candle stick always contains all attributes associated with an interval (Example: tick prices). Since it represents an interval what we are looking at, we will refer to a candle stick as an interval in the rest of this report.

2.1.2.2 Line Graph [25]

Line graph is a graphical way of representing data points in stock market based only on close price or current trading price of the stock. [24]

Figure 2 Line Graph

[25]

2.1.3 Accuracy

Accuracy is defined as the result of number of right decisions made divided by total number of decisions.

2.1.3.1 Accuracy based on Close Price

When we calculated accuracy, if we relied on next interval's close price for decision verification, we have mentioned it as Accuracy based on Close price in the rest of the report. When we make a Buy call, to verify based on close price, we check if next

interval's close price is above current interval's close price. [18] If so, we consider the decision as a right decision. Also, if we make a Short sell, to verify the decision based on close price, we check if next interval's close price is lesser than that of current interval's close price. If so, we consider the decision as right decision.

2.1.3.2 Accuracy based on Low/High Price

When calculating accuracy, if relied on next interval's low/high price for decision verification, we have mentioned it as Accuracy based on high/low price in the rest of the report. When we make a Buy call, to verify the decision based on high price, we check if current interval's close price is lesser than next interval's high price. [4] If so, we consider the decision as a right decision. Similarly, if we make a Short sell, to verify the decision based on low price, we check if next interval's low price is lesser than current interval's close price. If so, we consider this decision as right decision.

2.1.3.3 Short Sell

Short sell is a type of trade where we sell the stock first, before buying it and buy it at a later point of time. Investors perform this trade if they think stock market is going to follow Bearish trend. [15, 12, 20]

2.1.3.4 Buy Call

Buy call is a type of trade where investors invest by buying the stock first and selling it at a later point of time. They perform this trade if they think, the stock in which they are investing will follow Bullish trend and can yield them profit. [15, 12, 20]

2.1.4 Technical Indicators

Technical Indicators are the properties associated with any stock based on its tick prices (2.1.1.2). Calculation of each indicator is mentioned in the following subsections. Interpretation of each of the indicator is explained in detail in section 3.0.

2.1.4.1 Simple Moving Average (SMA)

Simple Moving Average is calculated exclusively based on close price of the stock which we are trying to analyze. For instance if we need to calculate SMA of 'x' intervals we need to get close prices of previous 20 intervals and divide it by 'x'. Hence the first available SMA value will correspond to xth interval. To calculate we add all close prices starting from the current interval looking back for n number of intervals. In this case n stands for number of intervals for which we need to calculate SMA. [21, 4, 5]

2.1.4.2 EXPONENTIAL MOVING AVERAGE (EMA)

Exponential Moving Average is also calculated based on close price of the stock which we are analyzing. If we need to calculate EMA of 'x' intervals, we first need to calculate SMA (2.1.2.1) till xth interval and for every subsequent interval we calculate EMA based on the following formula. [21, 18, 15]

$$EMA = \frac{((Current\ Close - SMA) * 2 * (interval + 1))}{(interval + 1)}$$

Hence, the first available EMA value will be corresponding to xth interval. EMA

moves hand in hand with price of stock. Higher the number of intervals we choose to calculate EMA, higher the stability of EMA. [18] Hence, we chose 2, 5, 10, 20, 50 and 100 intervals for calculating EMA.

2.1.4.3 Relative Strength Index (RSI)

Relative Strength Index is calculated based on SMA and close price of the stock for the given interval. We must get familiar with the following terms to better understand the calculation of RSI: Gain, Loss. If the close price of a stock at a given interval is greater than its open price, the stock resulted in Gain, vice versa it resulted in Loss. [18] Here are the formulae to calculate RS and RSI. [3, 4]

$$RS = \text{Average Gain} / \text{Average Loss}$$

$$RSI = 100 - \frac{100}{1 + RS}$$

RSI indicates the strength of the current trend. Higher the value of interval we choose, we get stable RSI values. We need to find out a threshold value. If RSI falls below its threshold, it is an indication of sellers taking over buyers. If RSI value rises over its threshold, it indicates that buyers are taking over sellers and stock prices will go high. [14]

2.1.4.4 Bollinger Band (BB)

Bollinger Band is calculated based on Standard Deviation (2.1.2.3) and close price of the stock at a given interval. [12] Bollinger Bands are calculated based on the following formulae: [18, 12]

$$Standard\ Deviation = \sqrt{\frac{Close - SMA(interval)^2}{Interval}}$$

$$UpperBand = SMA[20] + (2 * SD[20])$$

$$LowerBand = SMA[20] - (2 * SD[20])$$

Bollinger Band's values provide an insight on how much more the stock can rise if it is in Bullish trend. Or, how much can it fall, if the stock is in Bearish trend. [3, 4]

2.1.4.5 Fast Stochastic (FS)

Fast Stochastic is the technical indicator which involves two values, namely, %k and %d. For a given interval these values are calculated based on current close price of the stock,[18] lowest low price in the look-back period and highest high price of the stock in the look-back period. Lowest low and highest high are the lowest price and highest price at which the stock was traded in the given look-back period with respect to given interval respectively. [4, 19]

Here are the formulae to calculate %k and %d:

$$\%k = \frac{CurrentClose - LowestLow}{HighestHigh - LowestLow}$$

$$\%d = SMA(interval)of\%k$$

At a given interval %k's value falls below %d's value, market takes Bearish trend. Otherwise, if %k's value rises above %d's value it indicates Bullish trend. However, it is

very difficult to identify how long will the trend predicted from FS is valid. [4, 19]

2.1.4.6 Moving Average Convergence Divergence (MACD)

This indicator is calculated based on exponential moving average. To calculate MACD we first need to compute EMA of 9 intervals and EMA of 26 intervals. Now starting from 27th interval till 35th interval subtract EMA (26) from EMA (9) and store the result for further processing.[4] This value represents upper MACD indicator. With these values now calculate EMA of previously stored results starting from 36th interval. This represents lower MACD indicator. Minimum number of intervals needed for MACD is 35 and is its only limitation. [5]

Whenever lower MACD value falls below upper MACD value it shows a trend reversal from Bullish to Bearish. If lower MACD value rises above its upper MACD value it indicates a trend reversal from Bearish to Bullish. [19]

2.1.4.7 Williams Average (WA)

Williams Average is calculated based on current close, highest high and lowest low (2.1.2.5). Here is the formula to calculate Williams Average: In order to calculate this indicator we first subtract current close from highest high and store the result and call it HC. Now we subtract lowest low from highest high, store it and call it HL. With these results we now calculate Williams Average by the following formula. [4, 19, 12]

$$WA = \frac{HC}{HL} * -100$$

WA indicates oversold and overbought conditions. [4] Whenever it reaches close to 0 it shows oversold condition. If WA value is closer to 100 it shows overbought condition. [12] We need to identify the optimal threshold for which this indicator gives accurate results.

2.1.4.8 Fibonacci Series

Fibonacci Series is calculated using the following formula: [4, 5, 16]

$$n^{th} \text{ Fibonacci number} = \frac{\phi^n - (-\phi^n)}{\sqrt{5}}$$

Fibonacci series helps us to identify support level or resistance level of a given stock. Whenever we make a decision based on certain indicator we can use this indicator to identify we made the right decision before making a trade. [5]

2.1.4.9 Rate Of Change (ROC)

To calculate ROC we need to know the current trading price of the current interval and close price of the interval which is look-ahead parameter intervals previous to current interval. Here is the formula to calculate ROC. [4]

$$\text{Rate Of Change} = \frac{\text{Current Price} + \text{Close}(\text{interval})}{\text{Close}(\text{interval})} * 100$$

Rate of change is directly proportional to the trend of the stock market. If ROC is lesser than 20 it is an indication that the market is in bearish trend. If ROC is greater

than 80 it is a strong signal to buy stocks. [18, 12]

2.1.4.10 Artificial Neural Networks (ANN)

This model is a multi-level perceptron model which feeds forward the result of every computation to the next level of computation. The author [7] has modified the approach of feed-forward model by adding pseudo input variables into ANN. First version of ANN propagates back and forth to provide final results. [7] Author in his approach has argued that, by modifying the model he could minimize the back and forth movement of the data to increase optimization of computer's computational power. ANN's are always very less susceptible to noise points in the data. If a model is trained based on noise points accuracy of the prediction would decrease drastically due to increase in false positives. Using this model author is making the decision to hold, sell or buy stocks at given time. He used a Genetic algorithm to select the data from the given data set.[20] This selected data will be given as an input to ANN which would classify the labels based on the weight of computed results. In his results he proves that 2 layer ANN is more feasible than a single layer perceptron. The author [9] has improved the model by embedding pattern matching with basic ANN. Pattern matching algorithms are always highly susceptible to noise.[13] However, for given patterns the algorithm will detect the re-occurrence if any. Hence, by embedding this advantage with ANN author has opened the doors of fortunes. This improved model can now be used for prediction on data that contains extreme noise (stock market often is the case). He has also proved the same with his results in the publication. [9]

2.1.4.11 Hidden Markov Model (HMM)

Hidden Markov Models are statistical models that are used to determine the most likely sequence of occurrence given a sequence of data. This model consists of transition matrix, observation matrix and initial set of observation distribution, denoted as A , B and π respectively [21]. This model is used to uncover hidden information behind any set of sequences that has happened. In stock market ticks of respective intervals are taken into consideration for computing initial set of observations and observation distribution. Based on the computed results we then calculate the transition matrix. It is the transition matrix, which author relied on to calculate the likeliness of the trading sequence. When he trained this model with ticks whose results we already know since they are training records. He then calculated its likeliness. [10] Now he calculates likeliness for a sequence whose results we don't know yet. It is based on this likeliness; we predict the future trend for that particular stock [6]. The author [10] has used tick prices of current interval as 4 of his observations. He also considered close price of next interval, relative to the current interval, as fifth observation for training his model. Based on these data he computes A , B and π as discussed previously. This model now can be used to predict next most likely observation. [10, 22, 23]

3 Approaches to make decision

In this section we will be discussing about the significance of technical indicators mentioned in section 2. We will also see how it benefits us in analyzing current trend and predicting future trend of stock market with respect to the stock which we are analyzing.

Any indicator does not give optimal results for all types of stocks consistently. [4, 12] Hence, for analysis we have chosen stocks from various sectors traded in Indian stock market under the assumption that all stocks in the same sector behave the same and have common patterns. Chosen stock names are the following.

ICICI Bank and Kotak Bank are chosen from Banking sector. Infosys and Wipro are chosen from IT sector. Tata Motors and Maruthi Motors are chosen from Private sector. Ambuja Cement and ACC Cements are chosen from cement sector. We also chose Nifty 50 which is an index of 50 stocks in Indian stock market. The data which we used for analysis contains data starting from year 1994 or the date when the company went IPO, till year 2012.

In the following subsections we discuss various decision making approaches based on technical indicators. We have also experimented with Hidden Markov Model to include it as a technical indicator for making decisions.

3.1 Based on Exponential Moving Average (EMA)

We have discussed calculation of EMA in section 2.1.2.1. In this approach we have chosen 2, 5, 10, 20, 50 and 100 intervals EMA. Whenever a stock's current trading

price is trading above selected EMA it means, there is relatively higher demand for the stock when compared with its supply. Hence the current trend of the stock will be Bullish. [14] In other case, if current trading price is below selected EMA, it means sellers are dominating the market over buyers.[21] Hence current trend will be Bearish. To trigger decisions based on EMA we followed the below mentioned approach.

Whenever the chosen lower EMA crosses over upper EMA we can be sure that there is a trend reversal. [4] If the current trend is Bullish and if there is lower crossover then the future trend, relative to the crossover point, will be Bearish. In current approach whenever there is a lower crossover, we trigger a Short selling decision. [21] If it is an upper crossover, we trigger Buy decision. For this approach we have analyzed the data from Nifty 50. The results are shown in Table 1.

EMA		Type of Interval	Accuracy	
Lower EMA	Higher EMA		Based on Close Price	Based on High/Low
50	100	Daily	0.6086956	0.8695652
20	50	Daily	0.58064514	0.8172043
10	20	Daily	0.56626505	0.74698794
5	10	Daily	0.5415861	0.7446808
20	50	Weekly	0.75	0.8125
50	100	Weekly	0.75	0.875
2	5	Weekly	0.4955357	0.70535713
10	20	Weekly	0.6296296	0.7777778
5	10	Weekly	0.5508475	0.7542373

Table 1 Results from EMA

When we analyzed the results from Table 1 we found that we are unable to achieve high accurate decisions. These errors happened since we were not waiting for a

trend reversal confirmation after we found the crossover point.

Hence we extended the decision model to accommodate three EMA values. For understanding, let's call them lower EMA, middle EMA and higher EMA (Ex: 10 minute : lower :: 20 minute : middle :: 50 minute : higher). In this approach, we first wait for lower EMA to cross over middle EMA. Whenever there is such a crossover, choose that interval as our initial point of entry. [21]

If lower EMA crosses over middle EMA in the lower direction, starting from this point we look ahead until we find a point where middle EMA makes a lower crossover with higher EMA. Whenever we find such a data point, we trigger Short sell. [21]

If lower EMA crosses over middle EMA in the upper direction, starting from this point we look ahead until we find a point where middle EMA crosses over higher EMA in upper direction. When we successfully find such a data point we trigger Buy call. [14]

The results of this approach are shown in Table 2.

EMA			Type of Interval	Accuracy	
Lower EMA	Middle EMA	Higher EMA		Based on Close Price	Based on High/Low
20	50	100	Daily	0.5	0.5
10	20	50	Daily	0.5	0.5
5	10	20	Daily	0.8	0.8
2	5	10	Daily	0.5	0.8
20	50	100	Weekly	0.8	1.0
10	20	50	Weekly	0.6	0.7
5	10	20	Weekly	0.7	0.8
2	5	10	Weekly	0.5	0.7

Table 2 Results from multiple EMA

This extended model showed improved accuracy (table 2) than previous model.

3.2 Based on Fast Stochastic (FS)

We have discussed calculation of FS in section 2.1.2.5. In this approach we have chosen 14 as the interval to calculate FS [4, 15]. As we already know FS consists of two attributes namely, %k and %d. At any given point, if %k's value is greater than %d's value, we can say that there is a higher demand for the stock than the current available supply. In which case, the trend would be Bullish. If %k's value is lesser than %d's value, current trend would be Bearish. [4] Based on these facts we implemented the model to find out its accuracy. [18]

Whenever %k's value crosses over %d's value in lower direction, we triggered a Short sell. If %k's value crosses over %d's value in upper direction, we triggered a Buy call. The results of this approach are shown in Table 3 and Figure 3.

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
ACC	Daily	0.47751322	0.71031743
ACC	Weekly	0.49295774	0.7394366
Ambuja Cements	Daily	0.43636364	0.7163636
Ambuja Cements	Weekly	0.44642857	0.7202381
ICICI Bank	Daily	0.4677686	0.72066116
ICICI Bank	Weekly	0.47887325	0.75352114
Infosys	Daily	0.47034484	0.7186207
Infosys	Weekly	0.44102564	0.71794873
Kotak Bank	Daily	0.4918919	0.74864864
Kotak Bank	Weekly	0.4318182	0.77272725
Maruthi Motors	Daily	0.4680307	0.71867007
Maruthi Motors	Weekly	0.50617284	0.8148148

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
NIFTY	Daily	0.4423338	0.6662144
NIFTY	Weekly	0.46875	0.7
TATA MOTORS	Daily	0.48773006	0.702454
TATA MOTORS	Weekly	0.49726775	0.7704918
WIPRO	Daily	0.45244956	0.6930836
WIPRO	Weekly	0.39664805	0.67597765

Table 3 Results based on FS

Figure 3 Results based on FS

Analyzing the results from Table 3 we found that current model's accuracy to predict the future trend is low. Hence, we extended the model by applying thresholds to %k. Let us consider an example to understand the need for this threshold. Consider a scenario where the stock market is in Bearish trend for a long time. If %k's value is

below lower threshold (even if it is above %d's value) it is not suggested to trigger Buy calls, this crossover may be due to an attempt by buyers to dominate over sellers. This may or may not fail; however, we need a confirmation of trend reversal before we can trigger a decision. [4, 16]

Whenever there is a lower crossover, %k's value must be below upper threshold. If so we trigger Short sell. If there is an upper crossover, %k's value must be greater than lower threshold, in which case we trigger a Buy call. After performing experiment over various threshold values, we found 84 as upper threshold and 26 as lower threshold, which works as optimal threshold value. The results of this approach are mentioned in Table 4 and Figure 4. [4, 19]

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
ACC	Daily	0.43404254	0.65957445
ACC	Weekly	0.5416667	0.7083333
Ambuja Cements	Daily	0.4773519	0.73170733
Ambuja Cements	Weekly	0.54	0.68
ICICI Bank	Daily	0.5215517	0.7241379
ICICI Bank	Weekly	0.46296296	0.7407407
Infosys	Daily	0.491453	0.75213677
Infosys	Weekly	0.48	0.76
Kotak Bank	Daily	0.59821427	0.78571427
Kotak Bank	Weekly	0.5185185	0.7777778
Maruthi Motors	Daily	0.48360655	0.75409836
Maruthi Motors	Weekly	0.61538464	0.84615386
NIFTY	Daily	0.51785713	0.6964286
NIFTY	Weekly	0.516129	0.7741935
TATA MOTORS	Daily	0.48295453	0.6875
TATA MOTORS	Weekly	0.425	0.675
WIPRO	Daily	0.44131455	0.7089202
WIPRO	Weekly	0.5217391	0.73913044

Table 4 Results after applying threshold on FS

Figure 4 Results after applying threshold on FS

Based on Table 4 and Figure 4 we see that there is an improvement in prediction accuracy after applying thresholds. Also, this model works with better accuracy for Maruthi motors.

3.3 Based on Moving Average Convergence Divergence (MACD)

As discussed in section 2.1.2.6, MACD consists of two values. Upper value which is the difference of 26 interval EMA and 12 interval EMA. Let's call this as 'U'. Lower value which is 9 interval EMA of U. Let us call this as 'L'. [4, 17]

Whenever U crosses over L in lower direction, we triggered a Short sell. If the crossover is in upper direction, we triggered a Buy call. The results of this approach are mentioned in Table 5 and Figure 5.

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
ACC	Daily	0.56	0.65957445
ACC	Weekly	1	1
Ambuja Cements	Daily	0.4642857	0.75
Ambuja Cements	Weekly	0.875	0.875
ICICI Bank	Daily	0.44444445	0.7407407
Infosys	Daily	0.31034482	0.5862069
Infosys	Weekly	0.75	1
Kotak Bank	Daily	0.42105263	0.68421054
Kotak Bank	Weekly	0.4	0.6
Maruthi Motors	Daily	0.4375	0.75
Maruthi Motors	Weekly	1	1
NIFTY	Daily	0.53333336	0.8
NIFTY	Weekly	0.4	0.6
TATA MOTORS	Daily	0.65217394	0.73913044
TATA MOTORS	Weekly	0.625	0.625
WIPRO	Daily	0.65384614	0.88461536
WIPRO	Weekly	1	1

Table 5 Results based on MACD

Figure 5 Results based on MACD

Based on results in Table 5 and Figure 5 we see that MACD works relatively better for IT sector and motor sector. However, this may also vary depending on fluctuation of individual stock prices. [4, 9]

3.4 Based on Bollinger Band (BB)

Bollinger band, as discussed in 2.1.2.4 has upper and lower bands. These values at any particular interval act as upper and lower limits for that stock. However, this range is limited only for that interval. Even though this indicator provides bound only till the end of that interval, this is how we can benefit from it. Let us consider an example for better understanding. At any given point of time, if the current trading price (close price) is above upper band it means there is an excessive demand in the market for this stock and the supply will come in a short time. Hence the trend will reverse to Bearish; however this trend reversal may not be valid for long term. [13, 20, 21]

The validity of trade which we performed based on this is valid only till the end of the interval. However, if the interval is not yet complete and the current trading price is already above upper band or below lower band, the close price is more likely to move in the opposite direction before the end of interval. Example: If we are looking at a candle stick at 32nd minute and the type of interval which we have chosen is 60 minutes. We still have 28 minutes for this interval to complete. In this case if the price is above upper band, we can trigger Short sell. [4] If the current trading price is below lower band we can trigger Buy call and exit the market at the end of interval. However, our research has shown this decision making is more accurate if it is a higher crossover and works

relatively less accurate when it is a lower crossover. The results of this approach are shown in Table 6 and Figure 6. [21, 14]

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
ACC	Daily	0.3456352	0.6202981
ACC	Weekly	0.30914825	0.6214511
Ambuja Cements	Daily	0.3565051	0.6447704
Ambuja Cements	Weekly	0.3150289	0.65317917
ICICI Bank	Daily	0.35329342	0.64499575
ICICI Bank	Weekly	0.37906137	0.6967509
Infosys	Daily	0.36666667	0.6333333
Infosys	Weekly	0.35153583	0.6416382
Kotak Bank	Daily	0.34840426	0.63829786
Kotak Bank	Weekly	0.30952382	0.6369048
Maruthi Motors	Daily	0.6369048	0.617268
Maruthi Motors	Weekly	0.38853502	0.6687898
NIFTY	Daily	0.307321	0.541432
NIFTY	Weekly	0.2987013	0.2987013
TATA MOTORS	Daily	0.35476375	0.6103796
TATA MOTORS	Weekly	0.34405145	0.60771704
WIPRO	Daily	0.3599386	0.61857253
WIPRO	Weekly	0.33742332	0.63190186

Table 6 Results based on BB

Figure 6 Results based on BB

We made the following observations based on previous approach. If we triggered a Short sell decision based on BB and if the price did not fall below the upper band even after the interval completed, we can continue holding on to the same decision for another interval(with high risk). The same is not true when it is a lower crossover and we need to exit at the end of current interval. [14]

3.5 Based on Relative Strength Index (RSI)

Calculation of RSI is discussed above in section 2.1.2.3. To trigger decisions based on RSI, we applied threshold to the value of RSI. If RSI goes above the threshold we trigger a Buy decision. If the crossover is lower, we trigger a Short sell decision. Experimenting over various values we found the optimal threshold for RSI as 43.50. Results of this approach can be found in Table 7 and Figure 7. [12, 14]

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
ACC	Daily	0.5140713	0.7692308
ACC	Weekly	0.5765766	0.7927928
Ambuja Cements	Daily	0.5291181	0.78702164
Ambuja Cements	Weekly	0.60747665	0.60747665
ICICI Bank	Daily	0.49115914	0.7563851
ICICI Bank	Weekly	0.48	0.79
Infosys	Daily	0.5246801	0.74223036
Infosys	Weekly	0.4673913	0.73913044
Kotak Bank	Daily	0.48427674	0.7358491
Kotak Bank	Weekly	0.4848485	0.7121212
Maruthi Motors	Daily	0.47972974	0.75
Maruthi Motors	Weekly	0.51111114	0.8
NIFTY	Daily	0.5477273	0.7409091
NIFTY	Weekly	0.54347825	0.73913044
TATA MOTORS	Daily	0.5433884	0.76859504
TATA MOTORS	Weekly	0.5222222	0.7777778
WIPRO	Daily	0.4973913	0.7478261
WIPRO	Weekly	0.47540984	0.6885246

Table 7 Results based on RSI

Figure 7 Results based on RSI

Based on the observations found in previous experiment we found RSI is unable to make an entire decision on its own. Hence we concluded to use this indicator as a secondary indicator to confirm the decision made by some other indicator. [21]

3.6 Based on Williams Average (WA)

Calculation of Williams average is discussed in section 2.1.2.7. To trigger decisions based on WA we applied threshold with various values. After experimenting over various values we found WA calculated for 21 intervals works best with 90 being its upper threshold value and 10 being its lower threshold value. We have used the threshold values for all calculations and decisions in all following models. To make a decision based on WA values we followed the following approach. [4] When WA value falls below lower threshold we triggered a Short sell. [9] If WA crossed upwards through upper threshold we triggered a Buy call. Results of this model can be found in Table 8 and Figure 8.

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
ACC	Daily	0.47212455	0.73480666
ACC	Weekly	0.5045249	0.77375567
Ambuja Cements	Daily	0.48111427	0.75967896
Ambuja Cements	Weekly	0.5205479	0.783105
ICICI Bank	Daily	0.48563218	0.48563218
ICICI Bank	Weekly	0.47058824	0.77030814
Infosys	Daily	0.48086867	0.7399173
Infosys	Weekly	0.503386	0.78555304
Kotak Bank	Daily	0.52165896	0.764977
Kotak Bank	Weekly	0.47297296	0.7747748
Maruthi Motors	Daily	0.46927375	0.7467412

Company	Type of Interval	Accuracy	
		Based on Close Price	Based on High/Low
Maruthi Motors	Weekly	0.50691247	0.78341013
NIFTY	Daily	0.50997007	0.716351
NIFTY	Weekly	0.5248869	0.7556561
TATA MOTORS	Daily	0.4744898	0.7127551
TATA MOTORS	Weekly	0.4675926	0.7453704
WIPRO	Daily	0.47131783	0.70490956
WIPRO	Weekly	0.4536817	0.7434679

Table 8 Results based on WA

Figure 8 Results based on WA

After analyzing results from the previous approach we found that using WA as the primary indicator may lead the investor to end up in loss. Hence, we decided to use this indicator as secondary indicator to validate decisions made from some other indicator.

[4, 18, 21]

3.7 Based on Rate Of Change (ROC)

Calculation of ROC is discussed in section 2.1.2.9. We performed an experiment using ROC as primary indicator to make decisions. We applied threshold over ROC with various values and tried to predict the trend. However, we found that our approach did not lead us good accuracy. Hence we discarded this indicator from our list of indicators for analysis. [4, 7]

3.8 Based on Exponential Moving Average (EMA) and Fast Stochastic (FS)

Calculation and interpretation of values of EMA and FS is already discussed in previous sections namely 2.1.2.2 and 2.1.2.5 respectively.

To make decisions based on this approach, we chose EMA as the primary indicator. We chose two EMA values for one run of the experiment from 2, 5, 10, 20, 50 and 100 intervals EMA values. In this approach whenever we found a lower crossover between lower EMA and higher EMA (ex: 2 lower, 5 higher) we looked forward for a data point where %k crossed over %d in lower direction. On success we triggered Short sell. If we found an upper crossover from lower EMA and higher EMA, we then looked ahead for a data point where %k crosses over %d in upper direction. On success, we triggered Buy call. Results of this approach are mentioned in Table 9 and Figure 9. [4, 10, 21]

We extended the model by applying threshold to %k value. Whenever we found a lower crossover data point from lower EMA and higher EMA, we looked ahead for a data point where %k makes a lower crossover from %d. At this data point we checked if

%k is greater than lower threshold, if so we triggered Short sell. If we found an upper crossover from EMA values, then we looked ahead till we found a data point where we found an upper crossover between %k and %d values. On success we checked if %k value is lesser than upper threshold, if so we triggered Buy call. The results of this approach can be found in Table 9 and Figure 9. [4, 12, 21]

Company	EMA				Stochastic		Accuracy	
	2-5	5-10	10-20	20-50	Without Threshold	With Threshold	Close	High/Low
TATA MOTORS				x	x		0.6666667	0.666667
TATA MOTORS				x		x	1	1
TATA MOTORS			x		x		0.0	0.0
TATA MOTORS			x			x	0.6666667	0.6666667
TATA MOTORS	x				x		0.6	0.6
TATA MOTORS	x					x	0.625	0.625
NIFTY				x	x		1.0	1.0
NIFTY			x		x		0.5	0.5
NIFTY			x			x	0	0.6666667
NIFTY		x			x		0.33333334	0.6666667
NIFTY		x				x	0.5	1.0
NIFTY	x				x		0.5	0.75
NIFTY				x		x	1.0	1.0
Infosys				x	x		1.0	1.0
Infosys				x		x	0.7142857	0.85714287
Infosys			x		x		0	1.0
Infosys		x			x		0.6666667	0.8333333
Infosys		x				x	0.2	0.4
Infosys	x				x		0.625	0.8333333
Infosys	x					x	0.5652174	0.73913044
ICICI				x	x		1.0	1.0

Company	EMA				Stochastic		Accuracy	
	2-5	5-10	10-20	20-50	Without Threshold	With Threshold	Close	High/Low
ICICI BANK			x		x		0.6	0.8
ICICI BANK			x			x	0.5714286	0.85714287
ICICI BANK				x	x		1.0	1.0
ICICI BANK		x				x	0.6666667	0.7777778
ICICI BANK	x				x		0.75	0.75
ICICI BANK	x					x	0.5555556	0.6666667
ACC				x	x		0.75	1.0
ACC			x		x		0.5882353	0.7647059
ACC			x			x	0.75	0.8125
ACC		x			x		0.33333334	0.33333334
ACC		x				x	0.4	0.8
ACC	x				x		0.6363636	1.0
ACC				x		x	1.0	1.0
Kotak Bank				x	x		0.4	1.0
Kotak Bank			x		x		0.5	0.8333333
Kotak Bank	x				x		0.33333334	0.6666667
Kotak Bank				x		x	1	1
Maruthi Motors		x				x	0.5	0.636742
Maruthi Motors	x				x		0.2857143	0.2857143
Maruthi Motors	x					x	0.25	0.25
Wipro				x	x		0.33333334	0.5833333
Wipro			x		x		0.8	1
Wipro			x			x	0.5	0.75
Wipro				x		x	1	1

Company	EMA				Stochastic		Accuracy	
	2-5	5-10	10-20	20-50	Without Threshold	With Threshold	Close	High/Low
Wipro	x				x		0.42857143	0.5714286
Wipro	x					x	0.6	0.7
Ambuja Cements				x	x		0.0	0.666666
Ambuja Cements			x		x		0.5	0.5

Table 9 Results based on EMA and FS

Figure 9 Results based on EMA and FS

Based on the results found in Table 9 and Figure 9 we found this approach gives good results when EMA values are calculated from 20 and 50 intervals for IT stocks.

3.9 Based on Fast Stochastic (FS) and Exponential Moving Average (EMA)

We have already discussed about calculation of FS and EMA in previous sections

namely 2.1.2.5 and 2.1.2.2 respectively. If we consider EMA as first point of entry, we observed we would miss many data points in between the crossovers. Hence, in this approach we chose initial point of entry based on FS and then considered EMA as secondary indicator to trigger decisions. [4, 5, 21]

In this approach we look ahead for a lower crossover between %k and %d values of FS, considering that interval as the primary point of entry we proceeded to check for a lower crossover between lower EMA and higher EMA. Whenever we found such a data point, we triggered a Short sell. If %k made an upper crossover from %d we considered that as primary point of entry. We looked ahead starting from this interval to find out next upper crossover between lower EMA and higher EMA. When we found such a data point, we triggered Buy call. The results of this approach are displayed in Table 10 and Figure 10. [9, 21]

Company	EMA				Accuracy	
	2-5	5-10	10-20	20-50	Close	High/Low
ACC				x	1.0	1.0
ACC			x		-	-
ACC	x				0.56666666	0.83333333
ACC		x			0.72222222	0.88888889
Ambuja Cements				x	1.0	1.0
Ambuja Cements			x		0.5	0.75308645
Ambuja Cements	x				0.49389416	0.77204883
Ambuja Cements		x			0.48087433	0.48087433
ICICI BANK				x	0.75	0.75
ICICI BANK			x		0.5070422	0.79577464
ICICI BANK		x			0.625	0.725
ICICI BANK	x				0.5246423	0.5246423
Infosys				x	1.0	1.0

Company	EMA				Accuracy	
	2-5	5-10	10-20	20-50	Close	High/Low
Infosys			x		0.5555556	0.7619048
Infosys		x			0.7619048	0.71428573
Infosys	x				0.52816904	0.7591549
Kotak Bank				x	1.0	1.0
Kotak Bank			x		0.48387095	0.7263158
Kotak Bank		x			0.6666667	1.0
Kotak Bank	x				0.529563	0.7609255
Maruthi Motors				x	0.48387095	0.7419355
Maruthi Motors		x			0.53333336	0.8666667
Maruthi Motors			x		0.5714286	0.9285714
Maruthi Motors	x				0.5096419	0.7988981
NIFTY				x	1.0	1.0
NIFTY			x		0.58778626	0.7480916
NIFTY		x			0.5226481	0.73519164
NIFTY	x				0.5112782	0.7263158
TATA MOTORS				x	0.45614034	0.7017544
TATA MOTORS		x			0.5882353	0.7777778
TATA MOTORS			x		0.62237763	0.8041958
TATA MOTORS	x				0.5279879	0.74281394
Wipro				x	1.0	1.0
Wipro			x		0.5555556	0.76296294
Wipro	x				0.46164772	0.7130682
Wipro		x			0.48672566	0.7138643

Table 10 Results based on FS and EMA

Figure 10 Results based on FS and EMA

Even though we found good accuracy based on this approach, we observed there is a considerable amount of error rate. Hence we extended this approach by applying threshold to %k value to choose initial point of entry. All other conditions as discussed in previous approach were kept unaltered. Results of this extended approach are mentioned in Table 11 and Figure 11. [12, 14]

Company	EMA					Accuracy	
	2-5	5-10	10-20	50-100	20-50	Close	High/Low
ACC					X	0.5714286	0.8
ACC				X		0.39285713	0.71428573
ACC			X			0.8888889	1
ACC	X					0.5247748	0.7657658
ACC		X				0.6388889	0.8611111
Ambuja Cement					X	0.5510204	0.85714287
Ambuja Cement				X		0.5	0.8636364
Ambuja			X			0.5416667	0.7083333

Company	EMA					Accuracy	
	2-5	5-10	10-20	50-100	20-50	Close	High/Low
Ambuja Cement	X					0.49434572	0.77867526
Ambuja Cement		X				0.537037	0.8518519
ICICI Bank					X	0.55	0.775
ICICI Bank				X		1	1
ICICI Bank			X			0.5081967	0.8032787
ICICI Bank	X					0.5573441	0.78470826
ICICI Bank		X				0.56	0.86
Infosys					X	0.45454547	0.6818182
Infosys				X		0.5	0.6
Infosys			X			0.5167785	0.738255
Infosys	X					0.5714286	0.85714287
Infosys		X				0.530648	0.7618214
Kotak Bank					X	0.14285715	0.42857143
Kotak Bank				X		0.68292683	0.80487806
Kotak Bank			X			0.5	0.61538464
Kotak Bank	X					0.5410448	0.76865673
Kotak Bank		X				0.59090906	0.8181818
Maruthi					X	0.4516129	0.67741936
Maruthi				X		0.35714287	0.64285713
Maruthi			X			0.5714286	0.85714287
Maruthi	X					0.5145631	0.79611653
Maruthi		X				0.6	0.75
Nifty					X	0.6666667	0.8666667
Nifty				X		1	1
Nifty			X			0.6097561	0.75609756
Nifty	X					0.524	0.726
Nifty		X				0.5813953	0.76744187
Tata Motors					X	0.4375	0.625
Tata Motors				X		0.6666667	0.84090906
Tata Motors			X			0.33333334	1
Tata Motors	X					0.5205761	0.7633745
Tata Motors		X				0.627907	0.81395346
Wipro					X	0.41666666	0.6666667
Wipro				X		0.5	1
Wipro			X			0.71428573	0.85714287

Company	EMA					Accuracy	
	2-5	5-10	10-20	50-100	20-50	Close	High/Low
Wipro	X					0.48809522	0.7281746
Wipro		X				0.5254237	0.7457627

Table 11 Results based on FS with threshold and EMA

Figure 11 Results based on FS with threshold and EMA

We then extended the above approaches by modifying the model to fit 3 EMA values (lower, middle, higher). After we found initial point of entry from %k and %d(FS), we then looked ahead for a similar crossover signal from lower EMA and middle EMA. Once we found this data point, we confirmed the decision by looking forward for a similar crossover signal from middle and higher EMA. On success we triggered respective decision (Short sell/Buy). Results of this extended approach are mentioned in Table 12 and Figure 12. [4, 14, 21]

Company	EMA				Stochastic		Accuracy	
	2-5-10	10-20-50	5-10-20	20-50-100	Without Threshold	With Threshold	Close	High/Low
ACC				x	x		0.4	0.76666665
ACC			x		x		1	1
ACC		x			x		0.53521127	0.76760566
ACC	x				x		0.60465115	0.8372093
ACC				x		x	0.75	1
ACC			x			x	0.46774194	0.7580645
ACC		x				x	0.5714286	0.8
ACC	x					x	0.57471263	0.8314176
Ambuja Cements				x	x		0.39130434	0.8695652
Ambuja Cements			x		x		1	1
Ambuja Cements		x			x		0.4969325	0.75460124
Ambuja Cements	x				x		0.48087433	0.74590164
Ambuja Cements				x		x	0.5	0.8636364
Ambuja Cements			x			x	0.5510204	0.85714287
Ambuja Cements		x				x	0.48701298	0.7467533
Ambuja Cements	x					x	0.47634068	0.7318612
ICICI Bank				x	x		0.68421054	0.84210527
ICICI Bank			x		x		0.75	0.75
ICICI Bank		x			x		0.5035461	0.79432625
ICICI Bank	x				x		0.6	0.8
ICICI Bank				x		x	0.6	0.8666667
ICICI Bank			x			x	0.85714287	0.85714287

Company	EMA				Stochastic		Accuracy	
	2-5-10	10-20-50	5-10-20	20-50-100	Without Threshold	With Threshold	Close	High/Low
ICICI Bank		x				x	0.5041322	0.8016529
ICICI Bank	x					x	0.5037037	0.76666665
Infosys		x			x		0.5	0.75
Infosys			x		x		1	1
Infosys				x	x		1	1
Infosys	x				x		0.5233161	0.7512953
Infosys				x		x	0.5	0.8333333
Infosys			x			x	0.45454547	0.6818182
Infosys		x				x	0.55172414	0.76724136
Infosys	x					x	0.5167785	0.738255
Kotak Bank			x		x		0.5	0.75
Kotak Bank				x	x		1	1
Kotak Bank		x			x		1	1
Kotak Bank	x				x		0.5233161	0.7512953
Kotak Bank			x			x	0.5	0.61538464
Kotak Bank		x				x	0.6818182	0.79545456
Kotak Bank	x					x	0.5449102	0.75449103
Maruthi Motors				x	x		0.42857143	0.71428573
Maruthi Motors			x		x		0.5	0.5
Maruthi Motors		x			x		0.47368422	0.81578946
Maruthi Motors	x				x		0.53333336	0.8666667
Maruthi Motors				x		x	0.4	0.6

Company	EMA				Stochastic		Accuracy	
	2-5-10	10-20-50	5-10-20	20-50-100	Without Threshold	With Threshold	Close	High/Low
Maruthi Motors			x			x	0.625	0.625
Maruthi Motors		x				x	0.4848485	0.8484849
Maruthi Motors	x					x	0.45945945	0.7567568
Nifty				x	x		0.64285713	0.85714287
Nifty			x		x		0.5714286	0.8367347
Nifty		x			x		0.58778626	0.7480916
Nifty	x				x		0.5043478	0.75652176
Nifty				x		x	0.6666667	0.8666667
Nifty			x			x	0.71428573	0.85714287
Nifty		x				x	0.60655737	0.75409836
Nifty	x					x	0.5346154	0.74230766
TATA Motors				x	x		0.47368422	0.6315789
TATA Motors			x		x		0.45614034	0.7017544
TATA Motors		x			x		0.6180556	0.7986111
TATA Motors	x				x		0.59210527	0.78289473
TATA Motors				x		x	1	1
TATA Motors			x			x	0.5625	0.6875
TATA Motors		x				x	0.6862745	0.84313726
TATA Motors	x					x	0.56766915	0.7744361
Wipro				x	x		1	1
Wipro			x		x		0.8333333	1
Wipro		x			x		0.5	1
Wipro	x				x		0.48672566	0.7138643
Wipro				x		x	0.41666666	0.6666667
Wipro			x			x	0.53333336	0.8666667

Company	EMA				Stochastic		Accuracy	
	2-5-10	10-20-50	5-10-20	20-50-100	Without Threshold	With Threshold	Close	High/Low
Wipro		x				x	0.5344828	0.7586207
Wipro	x					x	0.5	0.75

Table 12 Results based on FS and multiple EMA

Figure 12 Results based on FS and multiple EMA

Based on the results in Table 12 and Figure 12, we found this model works best when we have calculated EMA values based on higher number of intervals. Example: 20-50-100. However, this model is not stable over all company stocks.

3.10 Based on Fast Stochastic (FS) and Moving Average Convergence Divergence (MACD)

We have already discussed about calculation of FS and MACD in previous sections namely 2.1.2.5 and 2.1.2.6. In this decision model, we chose initial point of entry based on FS and then triggered the decision checking MACD values. Here are the various approaches we followed.

We chose initial point of entry based on %k and %d crossovers. If it was a lower crossover, then we checked if upper value of MACD is below lower value of MACD. If so, we triggered Short sell. If initial point of entry was chosen based on upper crossover, we checked if lower MACD value is smaller than higher MACD value. If so, we triggered Buy call. Results of this approach are mentioned in Table 13 and Figure 13. [4, 14, 18]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.5586854	0.82159626
Ambuja Cements	0.5272727	0.79545456
ICICI Banks	0.49253732	0.78109455
Infosys	0.53424656	0.75342464
Kotak Bank	0.5964912	0.7894737
Maruthi Motor	0.5254237	0.8135593
Nifty	0.50769234	0.774359
TATA MOTOR	0.5645933	0.7894737
Wipro	0.5164319	0.75117373

Table 13 Results based on FS and MACD

Figure 13 Results based on FS and MACD

When we analyzed the results of Table 13 and Figure 13, we found this model gives better prediction for private sector stocks. However, it has higher error rate when compared with all sectors.

We then extended our approach by adding threshold to %k value as an attempt to improve the accuracy. We chose initial point of entry based on a crossover signal from FS. On signal, if it is a lower crossover, we checked if %k's value is lesser than upper threshold. In which case, we made initial decision as Short sell and triggered the decision after confirming the same from MACD. In the other case, we chose initial

decision as Buy after confirming %k's value is greater than lower threshold, which we then confirmed from MACD before triggering a Buy call. Results of this extended approach are shown in Table 14 and Figure 14. [9, 12, 21]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.55	0.82
Ambuja Cements	0.5496183	0.8091603
ICICI Banks	0.42857143	0.71428573
Infosys	0.52459013	0.73770493
Kotak Bank	0.60655737	0.8196721
Maruthi Motor	0.49333334	0.73333335
Nifty	0.51	0.81
TATA MOTOR	0.61111111	0.8240741
Wipro	0.51304346	0.773913

Table 14 Results based on FS with threshold and MACD

Figure 14 Results based on FS with threshold and MACD

When we analyzed the results from Table 14 and Figure 14, we observed that we were able to achieve better accuracy than previous model.

3.11 Based on Exponential Moving Average (EMA), Fast Stochastic and Moving Average Convergence Divergence (MACD)

We have already discussed calculation of EMA, FS and MACD in previous sections 2.1.2.2, 2.1.2.5 and 2.1.2.6 respectively. In This approach we used EMA as primary point of entry and FS and MACD as secondary indicators for triggering decisions. [9, 14]

Initially we chose two EMA values, and detected crossover points and considered that as our primary point of entry. Depending on the type of EMA crossover we looked ahead for a similar FS crossover signal (%k and %d crossover). When we found a successful crossover point from FS we checked if the trend decision (Bull/Bear) is supported by MACD. If so we triggered respective decisions. Results of this approach are mentioned in Table 15 and Figure 15. [4, 9]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.54545456	0.74545455
ACC	10	20	0.5121951	0.76829267
ACC	5	10	0.5145631	0.80582523
ACC	2	5	0.5280899	0.7977528
Ambuja Cements	20	50	0.46938777	0.71428573

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Ambuja Cements	5	10	0.4827586	0.75
Ambuja Cements	2	5	0.495	0.79
ICICI Bank	20	50	0.52380955	0.78571427
ICICI Bank	10	20	0.42666668	0.69333333
ICICI Bank	5	10	0.44339624	0.6886792
ICICI Bank	2	5	0.5411765	0.8
Infosys	20	50	0.5897436	0.82051283
Infosys	10	20	0.57894737	0.7236842
Infosys	5	10	0.4869565	0.67826086
Infosys	2	5	0.49723756	0.71270716
Kotak Bank	20	50	0.8	0.84
Kotak Bank	10	20	0.6041667	0.7291667
Kotak Bank	5	10	0.6507937	0.8095238
Kotak Bank	2	5	0.58	0.76
Maruthi Motors	20	50	0.53846157	0.8076923
Maruthi Motors	10	20	0.5555556	0.8666667
Maruthi Motors	5	10	0.5409836	0.78688526
Maruthi Motors	2	5	0.4489796	0.78571427
NIFTY	20	50	0.52272725	0.79545456
NIFTY	10	20	0.47142857	0.7
NIFTY	5	10	0.47959185	0.68367344
NIFTY	2	5	0.48214287	0.75595236
Tata Motors	20	50	0.5555556	0.8
Tata Motors	10	20	0.5113636	0.75
Tata Motors	5	10	0.5392157	0.8039216
Tata Motors	2	5	0.5352941	0.7823529
Wipro	20	50	0.59090906	0.79545456
Wipro	10	20	0.51898736	0.7721519
Wipro	5	10	0.4909091	0.74545455
Wipro	2	5	0.4494382	0.71910113

Table 15 Results based on EMA, FS and MACD

Figure 15 Results based on EMA, FS and MACD

We then extended our approach by applying threshold to FS crossover. i.e., chose initial point of entry from EMA crossovers. If this crossover was a lower crossover, we looked ahead for a lower crossover between %k and %d. When we found such a data point we checked if %k's value is lower than higher threshold, we then confirmed if MACD also suggests future trend as Bearish. If it did, then we triggered a Short sell.[4] If the initial point of entry chosen from EMA crossover was due to upper crossover between lower and higher EMA values, we looked ahead for a upper crossover signal from FS(%k and %d). When we found the signal, we checked if value of %k value was higher than lower threshold, if so we checked the suggested trend from MACD was Bullish. On success, we triggered Buy call. Results of this extended approach are

mentioned in Table 16 and Figure 16. [4, 14]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	50	100	0.5483871	0.7741935
ACC	20	50	0.4827586	0.79310346
ACC	10	20	0.5375	0.775
ACC	5	10	0.50980395	0.7941176
ACC	2	5	0.5477707	0.5477707
Ambuja Cements	50	100	0.5833333	0.75
Ambuja Cements	20	50	0.46938777	0.71428573
Ambuja Cements	10	20	0.5	0.7380952
Ambuja Cements	5	10	0.50442475	0.7699115
Ambuja Cements	2	5	0.48044693	0.75418997
ICICI Bank	50	100	0.4	0.8
ICICI Bank	20	50	0.56	0.88
ICICI Bank	10	20	0.55172414	0.79310346
ICICI Bank	5	10	0.6	0.9
ICICI Bank	2	5	0.52678573	0.8125
Infosys	50	100	0.8888889	1
Infosys	20	50	0.61538464	0.7692308
Infosys	10	20	0.5675676	0.7027027
Infosys	5	10	0.5106383	0.82978725
Infosys	2	5	0.5041322	0.74380165
Kotak Bank	50	100	0.71428573	0.71428573
Kotak Bank	20	50	0.90909094	0.90909094
Kotak Bank	10	20	0.5531915	0.7234042
Kotak Bank	5	10	0.71428573	0.85714287
Kotak Bank	2	5	0.5595238	0.75
Maruthi Motors	50	100	0.5	0.875
Maruthi Motors	20	50	0.53846157	0.8076923
Maruthi Motors	10	20	0.61904764	0.9047619
Maruthi Motors	5	10	0.5689655	0.7758621
Maruthi Motors	2	5	0.7758621	0.7692308

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
NIFTY	50	100	0.6315789	0.84210527
NIFTY	20	50	0.5	0.77272725
NIFTY	10	20	0.5555556	0.7407407
NIFTY	5	10	0.46391752	0.68041235
NIFTY	2	5	0.4935065	0.77272725
Tata Motors	50	100	0.7	1
Tata Motors	20	50	0.6086956	0.9130435
Tata Motors	10	20	0.5882353	0.7941176
Tata Motors	5	10	0.5744681	0.80851066
Tata Motors	2	5	0.6052632	0.78070176
Wipro	50	100	0.6	0.68
Wipro	20	50	0.6136364	0.79545456
Wipro	10	20	0.61538464	0.7948718
Wipro	5	10	0.54901963	0.7647059
Wipro	2	5	0.4962963	0.76296294

Table 16 Results based on EMA, FS with threshold and MACD

Figure 16 Results based on EMA, FS with threshold and MACD

Based on the results based on Table 16, Figure 16, we see that this approach predicts future trend for banking sector stocks with a relatively better accuracy. However, it yields less accurate results for private sector stocks and indices. We observed that these errors took place due to relatively high fluctuation in respective stocks. Hence, we extended our approach by adding 3 EMA values to choose initial point of entry. Whenever we found a lower crossover between lower EMA and middle EMA, we looked ahead for a lower crossover between middle EMA and higher EMA. When we found such a data point we chose it as initial point of entry. We then looked ahead for a lower crossover between %k and %d, when we found such a data point, we checked at interval, if MACD suggested current trend as Bearish. [9] If it did, we triggered a Short sell.

If initial point of entry was found based on higher crossover between lower EMA and middle EMA followed by a higher crossover between middle EMA and higher EMA, we looked ahead for an upper crossover between %k and %d. If we found such a data point, we checked at that interval if MACD also suggested the current trend as Bullish. If so, we triggered a Buy call. Results of this approach are mentioned in Table 17 and Figure 17. [4, 12, 18]

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	100	0.75	0.75
ACC	10	20	50	0.5294118	0.74509805
ACC	5	10	20	0.51428574	0.8142857
ACC	2	5	10	0.8	0.8

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
Ambuja Cements	20	50	100	1.0	1.0
Ambuja Cements	10	20	50	0.4883721	0.7209302
Ambuja Cements	5	10	20	1.0	1.0
Ambuja Cements	2	5	10	0.51754385	0.81578946
ICICI Bank	20	50	100	0.44444445	0.77777778
ICICI Bank	10	20	50	0.5365854	0.8292683
ICICI Bank	5	10	20	0.4057971	0.6956522
ICICI Bank	2	5	10	0.44230768	0.72115386
Infosys	20	50	100	0.78571427	1.0
Infosys	10	20	50	0.5945946	0.8378378
Infosys	5	10	20	0.75	0.75
Infosys	2	5	10	0.6666667	0.6666667
Kotak Bank	20	50	100	0.6666667	0.8333333
Kotak Bank	10	20	50	0.7826087	0.8695652
Kotak Bank	5	10	20	0.70454544	0.8181818
Kotak Bank	2	5	10	0.84615386	0.9230769
Maruthi Motors	20	50	100	1.0	1.0
Maruthi Motors	10	20	50	0.52	0.8
Maruthi Motors	5	10	20	1.0	1.0
Maruthi Motors	2	5	10	0.5344828	0.79310346
Nifty	20	50	100	0.5882353	0.8235294
Nifty	10	20	50	0.5	1.0
Nifty	5	10	20	0.50793654	0.74603176
Nifty	2	5	10	0.5217391	0.7282609
TATA Motors	20	50	100	1.0	1.0
TATA Motors	10	20	50	0.5714286	0.8095238
TATA Motors	5	10	20	0.53333336	0.7733333
TATA Motors	2	5	10	0.62	0.81
Wipro	20	50	100	0.45454547	0.6363636
Wipro	10	20	50	0.6666667	1.0
Wipro	5	10	20	0.5652174	0.7826087
Wipro	2	5	10	0.6	0.8

Table 17 Results based on multiple EMA, FS and MACD

Figure 17 Results based on multiple EMA, FS and MACD

When we observed the results of Table 17 and Figure 17 we found, if this model predicted the trend with good accuracy, it made too few decisions. For all other companies it gave a higher error rate.

We tried to improve the previous approach by applying threshold to %k value. To choose the initial point of entry we relied on lower, middle and higher EMA values. Whenever we found a lower crossover between lower EMA and middle EMA, we looked ahead for a lower crossover between middle EMA and higher EMA. When we found such a data point, we looked ahead for a data point with a lower crossover of %k and %d values. If we found such a data point, we checked if %k's value was lower than

upper threshold. If it was true then we checked if MACD also suggests Bearish trend. If so we triggered a Short sell. [15]

If the initial point of entry was due to an upper crossover between lower EMA and middle EMA followed by an upper crossover of middle EMA and higher EMA, we looked ahead for a data point where %k makes an upper crossover over %d. When we found such a data point, we checked if %k value was greater than lower threshold. If so, we checked if MACD also suggested trend as Bullish. On success, we triggered a Buy call. Results of this approach are mentioned in Table 18 and Figure 18. [17, 19]

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	100	0.75	1.0
ACC	10	20	50	0.5	0.85714287
ACC	5	10	20	0.625	0.875
ACC	2	5	10	0.6	0.8
Ambuja Cements	20	50	100	1.0	1.0
Ambuja Cements	10	20	50	0.4883721	0.7209302
Ambuja Cements	5	10	20	0.33333334	1.0
Ambuja Cements	2	5	10	0.5607477	0.8317757
ICICI Bank	20	50	100	0.44444445	0.7777778
ICICI Bank	10	20	50	0.55	0.85
ICICI Bank	5	10	20	0.4117647	0.4117647
ICICI Bank	2	5	10	0.5102041	0.7653061
Infosys	20	50	100	1.0	1.0
Infosys	10	20	50	0.5277778	0.8055556
Infosys	5	10	20	0.53731346	0.6567164
Infosys	2	5	10	0.75	0.875
Kotak Bank	20	50	100	0.8333333	0.8333333

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
Kotak Bank	10	20	50	0.8888889	0.8888889
Kotak Bank	5	10	20	0.60465115	0.76744187
Kotak Bank	2	5	10	0.75	1.0
Maruthi	20	50	100	0.41666666	0.8333333
Maruthi Motors	10	20	50	0.52	0.8
Maruthi	5	10	20	1.0	1.0
Maruthi Motors	2	5	10	0.60714287	0.83928573
Nifty	20	50	100	0.64705884	0.88235295
Nifty	10	20	50	0.5	0.7631579
Nifty	5	10	20	1.0	1.0
Nifty	2	5	10	0.53932583	0.74157304
TATA Motors	20	50	100	1.0	1.0
TATA Motors	10	20	50	0.5	1.0
TATA Motors	5	10	20	0.5466667	0.7866667
TATA Motors	2	5	10	0.6041667	0.8229167
Wipro	20	50	100	0.52380955	0.61904764
Wipro	10	20	50	0.61904764	0.8095238
Wipro	5	10	20	0.5970149	0.80597013
Wipro	2	5	10	0.5377358	0.6981132

Table 18 Results based on multiple EMA, FS with threshold and MACD

Figure 18 Results based on multiple EMA, FS with threshold and MACD

When we observed the observations of Table 18 and Figure 18, even though we did improve our model, we still had a higher error rate of prediction.

3.12 Based on Fast Stochastic (FS), Exponential Moving Average (EMA) and Moving Average Convergence Divergence (MACD)

We have discussed calculating FS, EMA and MACD in previous 2.1.2.5, 2.1.2.2 and 2.1.2.6 respectively sections. In this approach we chose initial point of entry based on FS and then confirmed the signal from EMA and MACD before we triggered a decision. [16]

We chose the initial point of entry from FS. Whenever we found a lower crossover between %k and %d, we looked ahead for a lower crossover between lower EMA and higher EMA. We then confirmed if MACD also suggests current trend as Bearish, if it did, we triggered a Short sell. While choosing initial point of entry, if %k had an upper crossover between %d, we looked ahead for a upper crossover between lower EMA and

higher EMA. When we found such a data point, we confirmed if MACD also suggested current trend as Bullish. If it did, we triggered a Buy call. Results of this approach are mentioned in Table 19 and Figure 19. [4, 12, 21]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	50	100	0.56	0.72
ACC	20	50	0.5106383	0.70212764
ACC	10	20	0.5151515	0.8030303
ACC	5	10	0.511811	0.77952754
ACC	2	5	0.5303644	0.77732795
Ambuja Cement	50	100	0.45	0.65
Ambuja Cement	20	50	0.42105263	0.7105263
Ambuja Cement	10	20	0.49315068	0.7123288
Ambuja Cement	5	10	0.4413793	0.7586207
Ambuja Cement	2	5	0.5109489	0.7883212
ICICI Bank	50	100	0.4375	0.625
ICICI Bank	20	50	0.40625	0.8125
ICICI Bank	10	20	0.41538462	0.7076923
ICICI Bank	5	10	0.49668875	0.74834436
ICICI Bank	2	5	0.5037594	0.7781955
Infosys	50	100	0.75	1
Infosys	20	50	0.4375	0.6875
Infosys	10	20	0.5873016	0.74603176
Infosys	5	10	0.4532374	0.7122302
Infosys	2	5	0.5	0.74264705
Kotak Bank	50	100	0.875	0.875
Kotak Bank	20	50	0.85	0.95
Kotak Bank	10	20	0.5555556	0.7111111
Kotak Bank	5	10	0.6075949	0.75949365
Kotak Bank	2	5	0.5686275	0.7647059
Maruthi	50	100	0.61538464	0.7692308

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Maruthi Motors	20	50	0.5263158	0.7368421
Maruthi Motors	10	20	0.51282054	0.7692308
Maruthi	5	10	0.4868421	0.81578946
Maruthi Motors	2	5	0.4722222	0.8055556
Nifty	50	100	0.6666667	0.8666667
Nifty	20	50	0.6	0.9142857
Nifty	10	20	0.5714286	0.7619048
Nifty	5	10	0.48360655	0.76229507
Nifty	2	5	0.4978903	0.75527424
TATA Motors	50	100	0.73333335	0.8666667
TATA Motors	20	50	0.43243244	0.7837838
TATA Motors	10	20	0.5890411	0.7808219
TATA Motors	5	10	0.50735295	0.75735295
TATA Motors	2	5	0.5283019	0.7735849
Wipro	50	100	0.59090906	0.77272725
Wipro	20	50	0.4375	0.6875
Wipro	10	20	0.48333332	0.7
Wipro	5	10	0.47887325	0.6971831
Wipro	2	5	0.51229507	0.7336066

Table 19 Results based on FS, EMA and MACD

Figure 19 Results based on FS, EMA and MACD

We extended the previous approach by applying threshold to %k value of FS. Whenever we found a lower crossover between %k and %d, we checked if its %k value is lower than upper threshold. If it was true, we looked ahead for a lower crossover between lower EMA and higher EMA. If it was true we checked if MACD also suggested Bearish trend, if so we triggered Short sell. [4, 17, 19]

If we found initial point of entry based on an upper crossover between %k and %d values, we checked if %k is higher than its lower threshold. If we found such a data point, we looked ahead for data point where lower EMA crosses over higher EMA. If we found an interval, we checked if MACD also suggested Bullish trend. If it did, we triggered a Buy call. The results of this approach are mentioned in Table 20 and Figure 20.

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	50	100	0.54545456	0.72727275
ACC	20	50	0.33333334	1
ACC	10	20	0.5217391	0.82608694
ACC	5	10	0.48598132	0.7757009
ACC	2	5	0.5480769	0.7980769
Ambuja Cement	50	100	0.4117647	0.5882353
Ambuja Cement	20	50	0.47058824	0.8235294
Ambuja Cement	10	20	0.55813956	0.8372093
Ambuja Cement	5	10	0.65217394	0.82608694
Ambuja Cement	2	5	0.5131579	0.7850877
ICICI Bank	50	100	0.42857143	0.64285713
ICICI Bank	20	50	0.5294118	0.88235295
ICICI Bank	10	20	0.5285714	0.74285716
ICICI Bank	5	10	0.7368421	0.8947368
ICICI Bank	2	5	0.5586207	0.7862069
Infosys	50	100	0.72727275	1
Infosys	20	50	0.44117647	0.7352941
Infosys	10	20	0.546875	0.734375
Infosys	5	10	0.48	0.88
Infosys	2	5	0.5100671	0.7785235
Kotak Bank	50	100	0.85714287	0.85714287
Kotak Bank	20	50	0.7368421	0.84210527
Kotak Bank	10	20	0.6785714	0.8214286
Kotak Bank	5	10	0.6197183	0.7605634
Kotak Bank	2	5	0.5762712	0.779661
Maruthi Motors	50	100	1	1
Maruthi Motors	20	50	0.5	0.8333333
Maruthi Motors	10	20	0.61538464	0.84615386
Maruthi	5	10	0.47887325	0.8028169

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Maruthi Motors	2	5	0.53571427	0.78571427
Nifty	50	100	1	1
Nifty	20	50	0.64285713	0.85714287
Nifty	10	20	0.55555556	0.77777778
Nifty	5	10	0.625	0.875
Nifty	2	5	0.50248754	0.76119405
TATA Motors	50	100	0.71428573	0.85714287
TATA Motors	20	50	0.51428574	0.74285716
TATA Motors	10	20	0.51282054	0.7692308
TATA Motors	5	10	0.5503876	0.78294575
TATA Motors	2	5	0.5619469	0.7876106
Wipro	50	100	0.5	1
Wipro	20	50	0.5294118	0.7058824
Wipro	10	20	0.8	0.8
Wipro	5	10	0.5322581	0.7741935
Wipro	2	5	0.5103448	0.7724138

Table 20 Results based on FS with threshold, EMA and MACD

Figure 20 Results based on FS with threshold, EMA and MACD

Making an attempt to improve this approach whose results are mentioned in Table 20 and Figure 20, we extended the model by adding a total of 3 EMA values to the model. We chose initial point of entry based on FS. Whenever %k crossed over %d in lower direction, choosing that point as initial point of entry, we looked ahead for a lower crossover between lower EMA and middle EMA. When we found such a data point, we looked ahead for a lower crossover between middle EMA and higher EMA. When we found such a data point, we checked the trend suggested by MACD, if it was Bearish, we triggered a Short sell. [4, 14]

If the initial point of entry was chosen on an upper crossover between %k and %d values, we looked ahead for an upper crossover between lower EMA and middle EMA. When such a data point was found we looked ahead for an upper crossover between middle EMA and higher EMA. When we found such a data point, we checked if MACD at that interval suggested current trend as Bullish. If it did, we triggered a Buy call. Results from this approach are mentioned in Table 21 and Figure 21. [9, 21]

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	100	0.53846157	0.7307692
ACC	10	20	50	0.5106383	0.70212764
ACC	5	10	20	0.5074627	0.80597013
ACC	2	5	10	0.511811	0.77952754
Ambuja Cement	20	50	100	0.45	0.65
Ambuja Cement	10	20	50	0.42105263	0.7105263

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
Ambuja Cement	5	10	20	0.49315068	0.7123288
Ambuja Cement	2	5	10	0.4413793	0.7586207
ICICI Bank	20	50	100	0.46666667	0.66666667
ICICI Bank	10	20	50	0.40625	0.8125
ICICI Bank	5	10	20	0.41538462	0.7076932
ICICI Bank	2	5	10	0.49668875	0.74834436
Infosys	20	50	100	0.75	1
Infosys	10	20	50	0.41935483	0.67741936
Infosys	5	10	20	0.5873016	0.74603176
Infosys	2	5	10	0.4532374	0.7122302
Kotak Bank	20	50	100	0.85714287	0.85714287
Kotak Bank	10	20	50	0.85	0.95
Kotak Bank	5	10	20	0.5555556	0.7111111
Kotak Bank	2	5	10	0.6075949	0.75949365
Maruthi Motors	20	50	100	0.61538464	0.7692308
Maruthi Motors	10	20	50	0.5263158	0.7368421
Maruthi	5	10	20	0.51282054	0.7692308
Maruthi Motors	2	5	10	0.4868421	0.81578946
Nifty	20	50	100	0.64285713	0.85714287
Nifty	10	20	50	0.6	0.9142857
Nifty	5	10	20	0.5714286	0.7619048
Nifty	2	5	10	0.48360655	0.76229507
TATA Motors	20	50	100	0.71428573	0.85714287

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
TATA Motors	10	20	50	0.43243244	0.7837838
TATA Motors	5	10	20	0.5890411	0.7808219
TATA Motors	2	5	10	0.50735295	0.75735295
Wipro	20	50	100	0.59090906	0.77272725
Wipro	10	20	50	0.4375	0.6875
Wipro	5	10	20	0.48333332	0.7
Wipro	2	5	10	0.47887325	0.6971831

Table 21 Results based on FS, multiple EMA and MACD

Figure 21 Results based on FS, multiple EMA and MACD

When we analyzed the results from Table and Figure 21, we found some of the stock predictions have a higher error rate. Hence we attempted to reduce the same by extending the model by applying threshold to %k value of FS. In this approach we found

initial point of entry based on FS crossover. If %k made a lower crossover, we checked if %k's value is lower than its upper threshold. If it was true, we then looked ahead for a lower cross over between lower EMA and middle EMA. If we found such a data point, we proceeded to look ahead for a lower crossover between middle EMA and higher EMA. If we found such a data point, we checked if MACD also suggested Bearish trend. If it did, we triggered a Short call. [4, 18, 21]

If the initial point of entry was chosen since there was an upper crossover between %k and %d, we checked if %k's value is greater than its lower threshold. If it was true, we looked ahead till we found an upper crossover between lower EMA and middle EMA. If we found such a data point, we looked ahead till we found an upper crossover between middle EMA and higher EMA. If we found such a data point, we checked if that interval's MACD suggested Bullish trend. If it did, we triggered a Buy call. The results of this approach are mentioned in Table and Figure 22. [4, 9, 13]

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	100	0.6666667	1
ACC	10	20	50	0.4883721	0.6976744
ACC	5	10	20	0.65	0.8
ACC	2	5	10	0.5	0.7941176
Ambuja Cement	20	50	100	0.4117647	0.5882353
Ambuja Cement	10	20	50	0.5	0.7
Ambuja Cement	5	10	20	0.5714286	0.8
Ambuja Cement	2	5	10	0.43703705	0.7407407

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
ICICI Bank	20	50	100	0.42857143	0.64285713
ICICI Bank	10	20	50	0.5	0.9
ICICI Bank	5	10	20	0.4848485	0.7878788
ICICI Bank	2	5	10	0.46616542	0.7744361
Infosys	20	50	100	1	1
Infosys	10	20	50	0.41935483	0.67741936
Infosys	5	10	20	0.546875	0.734375
Infosys	2	5	10	0.5046729	0.7570093
Kotak Bank	20	50	100	0.85714287	0.85714287
Kotak Bank	10	20	50	0.7368421	0.84210527
Kotak Bank	5	10	20	0.6511628	0.7209302
Kotak Bank	2	5	10	0.6	0.73333335
Maruthi Motors	20	50	100	0.61538464	0.84615386
Maruthi Motors	10	20	50	0.5	0.8333333
Maruthi Motors	5	10	20	0.5555556	0.8333333
Maruthi Motors	2	5	10	0.47887325	0.8028169
Nifty	20	50	100	0.64285713	0.85714287
Nifty	10	20	50	0.61764705	0.9117647
Nifty	5	10	20	0.8	0.8
Nifty	2	5	10	0.47826087	0.7478261
TATA Motors	20	50	100	0.6923077	0.84615386
TATA Motors	10	20	50	0.54545456	0.8181818
TATA Motors	5	10	20	0.57575756	0.75757575
TATA Motors	2	5	10	0.5503876	0.78294575
Wipro	20	50	100	0.5294118	0.7058824

Company	EMA			Accuracy	
	Lower EMA	Middle EMA	Higher EMA	Based on Close Price	Based on High/Low
Wipro	10	20	50	0.5625	0.75
Wipro	5	10	20	0.55737704	0.73770493
Wipro	2	5	10	0.5531915	0.78723407

Table 22 Results based on FS with threshold, multiple EMA and MACD

Figure 22 Results based on FS with threshold, multiple EMA and MACD

However, after analyzing results from Table and Figure 22 we could not achieve a significant increase in accuracy. However, it predicts IT and motor sector stocks with good accuracy which can be used to intraday trading.

3.13 Based on Exponential Moving Average (EMA) and Relative Strength Index (RSI)

In this approach we chose initial point of entry based on EMA. Whenever we

found a lower crossover between lower EMA and higher EMA, we chose that interval as point of entry. Now we checked if current interval's RSI value is lower than its threshold. If so we triggered a Short sell. If initial point of entry was chosen based on an upper crossover between lower EMA and higher EMA, we checked if that interval's RSI value is greater than threshold, if so we triggered a Buy call. Results of this approach are mentioned in Table and Figure 23. [5, 18]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.627451	0.8235294
ACC	10	20	0.58992803	0.8345324
ACC	5	10	0.53488374	0.81686044
ACC	2	5	0.49861497	0.7770083
Ambuja Cement	20	50	0.57894737	0.81578946
Ambuja Cement	10	20	0.54605263	0.75
Ambuja Cement	5	10	0.5263158	0.7535885
Ambuja Cement	2	5	0.48751485	0.74791914
ICICI Bank	20	50	0.4864865	0.6486486
ICICI Bank	10	20	0.5	0.75
ICICI Bank	5	10	0.53257793	0.76487255
ICICI Bank	2	5	0.51962113	0.7631935
Infosys	20	50	0.36842105	0.65789473
Infosys	10	20	0.4962963	0.73333335
Infosys	5	10	0.47922438	0.7257618
Infosys	2	5	0.49527666	0.7341431
Kotak Bank	20	50	0.42857143	0.6666667
Kotak Bank	10	20	0.475	0.675
Kotak Bank	5	10	0.49339208	0.74449337
Kotak Bank	2	5	0.52424943	0.7806005
Maruthi	20	50	0.5652174	0.82608694

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Maruthi Motors	10	20	0.49333334	0.8
Maruthi Motors	5	10	0.46875	0.75
Maruthi Motors	2	5	0.47330096	0.76941746
Nifty	20	50	0.51282054	0.7948718
Nifty	10	20	0.5	0.71875
Nifty	5	10	0.49221185	0.7227414
Nifty	2	5	0.517094	0.73646724
TATA Motors	20	50	0.41463414	0.7804878
TATA Motors	10	20	0.5208333	0.7916667
TATA Motors	5	10	0.5371429	0.7657143
TATA Motors	2	5	0.52689654	0.75448275
Wipro	20	50	0.47058824	0.8235294
Wipro	10	20	0.5	0.734375
Wipro	5	10	0.47733334	0.7173333
Wipro	2	5	0.475641	0.71153843

Table 23 Results based on EMA and RSI

Figure 23 Results based on EMA and RSI

Even though the previous model made good predictions on few companies like ACC, on an average it failed to make accurate predictions.

3.14 Based on Fast Stochastic (FS) and Relative Strength Index (RSI)

In this approach we chose initial point of entry based on FS. Whenever we found a lower crossover between %k and %d, we checked if %k is lower than its upper threshold. If so, we checked if that interval's RSI value is lower than its threshold. On success, we triggered a Short sell.

If the initial point of entry was chosen based on an upper crossover between %k and %d, we checked if %k's value is greater than its lower threshold. If so, we checked if that interval's RSI value is higher than its threshold. On success, we triggered a Buy call. Results of this approach are mentioned in Table 24 and Figure 24. [8, 19]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.42857143	0.63809526
Ambuja Cements	0.5413534	0.80451125
ICICI Banks	0.53571427	0.76785713
Infosys	0.48979592	0.79591835
Kotak Bank	0.5714286	0.7619048
Maruthi Motor	0.48076922	0.8269231
Nifty	0.5064935	0.7532467
TATA MOTOR	0.47887325	0.69014084
Wipro	0.4347826	0.7282609

Table 24 Results based on FS with threshold and RSI

Figure 24 Results based on FS with threshold and RSI

When we observed the results in Table 24 and Figure 24 we found this model predicts with better accuracy for stocks like Ambuja Cement. However, on an average this model has higher error rate.

3.15 Based on Exponential Moving Average (EMA), Fast Stochastic (FS) and Relative Strength Index (RSI)

In this approach we chose initial point of entry based on EMA. Whenever we found a lower crossover between lower EMA and higher EMA, we chose that point as initial point of entry. We looked ahead from this interval looking for a lower crossover between %k and %d values, if we found such a data point, we checked if %k is below its

upper threshold, if so then we checked if that interval's RSI value is lower than its threshold.[4] On success, we triggered Short sell.

If the initial point of entry was chosen based on an upper crossover, we looked ahead for an upper crossover between %k and %d. If we found such a data point, we checked if that interval's %k value is greater than its lower threshold, if so then we checked if its RSI value is greater than its threshold. On success we triggered a Buy call. Results from this approach are mentioned in 26. [5, 7]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.54545456	0.77272725
ACC	10	20	0.5263158	0.7105263
ACC	5	10	0.55263156	0.75438595
ACC	2	5	0.5347222	0.7430556
Ambuja Cement	20	50	0.3902439	0.70731705
Ambuja Cement	10	20	0.45	0.7375
Ambuja Cement	5	10	0.4090909	0.68939394
Ambuja Cement	2	5	0.47252747	0.75274724
ICICI Bank	20	50	0.6857143	0.85714287
ICICI Bank	10	20	0.6388889	0.8333333
ICICI Bank	5	10	0.55454546	0.77272725
ICICI Bank	2	5	0.56666666	0.81333333
Infosys	20	50	0.6666667	0.8148148
Infosys	10	20	0.5555556	0.75
Infosys	5	10	0.5169492	0.7372881
Infosys	2	5	0.5224719	0.76404494
Kotak Bank	20	50	0.47058824	0.9411765
Kotak Bank	10	20	0.62222224	0.8
Kotak Bank	5	10	0.5217391	0.79710144
Kotak Bank	2	5	0.5268817	0.7741935

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Maruthi Motors	20	50	0.45	0.85
Maruthi	10	20	0.5714286	0.88095236
Maruthi Motors	5	10	0.5441176	0.7647059
Maruthi Motors	2	5	0.51648355	0.82417583
Nifty	20	50	0.6	0.8
Nifty	10	20	0.484375	0.75
Nifty	5	10	0.4857143	0.6857143
Nifty	2	5	0.5	0.6959459
TATA Motors	20	50	0.5609756	0.8780488
TATA Motors	10	20	0.47297296	0.7567568
TATA Motors	5	10	0.44761905	0.72380954
TATA Motors	2	5	0.51428574	0.7785714
Wipro	20	50	0.3783784	0.7027027
Wipro	10	20	0.47297296	0.7702703
Wipro	5	10	0.4148148	0.6962963
Wipro	2	5	0.47619048	0.73214287

Table 25 Results based on EMA, FS with threshold and RSI

Figure 25 Results based on EMA, FS with threshold and RSI

Based on the prediction accuracy rate we can conclude that this model predicts with a higher error rate. However, this model can be used for intraday trend prediction since its accuracy based on low/high price is good.

3.16 Based on Fast Stochastic (FS), Exponential Moving Average (EMA) and Relative Strength Index (RSI)

In the this approach we chose the initial point of entry based on FS crossovers. Whenever we found a lower crossover between %k and %d's values, we chose that point as initial point of entry. Starting from this interval we looked ahead for a lower crossover between lower EMA and higher EMA. If we found such a data point, we checked if that interval's RSI value is lower than its threshold. On success, we triggered a Short sell. [9]

If initial point of entry was chosen based an upper crossover between %k and %d, we check if %k's value is greater than its lower threshold. If we found such a data point,

we looked ahead till we found a higher crossover between lower EMA and higher EMA. On finding such a point, we checked if that interval's RSI value is greater than its threshold. On success, we triggered a Buy call. Results of this approach are mentioned in 27. [9, 14]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.48333332	0.76666665
ACC	10	20	0.5321101	0.7614679
ACC	5	10	0.57222223	0.8388889
ACC	2	5	0.4957627	0.7542373
Ambuja Cement	20	50	0.5652174	0.84782606
Ambuja Cement	10	20	0.518797	0.7593985
Ambuja Cement	5	10	0.49748743	0.7035176
Ambuja Cement	2	5	0.47766322	0.75601375
ICICI Bank	20	50	0.51428574	0.7714286
ICICI Bank	10	20	0.4848485	0.7878788
ICICI Bank	5	10	0.5114943	0.7816092
ICICI Bank	2	5	0.5884774	0.80246913
Infosys	20	50	0.4871795	0.71794873
Infosys	10	20	0.55445546	0.75247526
Infosys	5	10	0.52261305	0.7236181
Infosys	2	5	0.5335689	0.7809187
Kotak Bank	20	50	0.52	0.64
Kotak Bank	10	20	0.5967742	0.7258065
Kotak Bank	5	10	0.56565654	0.74747473
Kotak Bank	2	5	0.5588235	0.8014706
Maruthi Motors	20	50	0.44827586	0.6551724
Maruthi Motors	10	20	0.45614034	0.7894737
Maruthi	5	10	0.45454547	0.7373737

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Maruthi Motors	2	5	0.4642857	0.76428574
Nifty	20	50	0.5777778	0.7777778
Nifty	10	20	0.59090906	0.75454545
Nifty	5	10	0.55191255	0.75956285
Nifty	2	5	0.5319149	0.73617023
TATA Motors	20	50	0.4375	0.7083333
TATA Motors	10	20	0.6454545	0.8545455
TATA Motors	5	10	0.57714283	0.7714286
TATA Motors	2	5	0.55364805	0.7467811
Wipro	20	50	0.5	0.82
Wipro	10	20	0.52577317	0.7525773
Wipro	5	10	0.4611399	0.7202073
Wipro	2	5	0.47692308	0.75769234

Table 26 Results based on FS with threshold, EMA and RSI

Figure 26 Results based on FS with threshold, EMA and RSI

Based on the results in Table 26 and Figure 26, we see that this model predicts trend with a good accuracy when we compute accuracy based on low/high price of next interval. Hence, it is the decision of the investor to exit from the market before the next interval completes.

3.17 Based on Fast Stochastic (FS), Moving Average Convergence Divergence (MACD) and Relative Strength Index (RSI)

In this approach we chose FS crossover as initial point of entry. When we found a lower crossover between %k and %d, we checked %k's value is lower than its upper threshold. On success, we checked if MACD is also suggesting Bearish trend by its lower value lower than its higher value. If so we triggered Short sell. If the initial point of entry was decided based on an upper crossover between %k and %d, we checked if %k is greater than its lower threshold, if so we checked suggested current trend from MACD. If it suggested Bullish, we triggered a Buy call. [7, 9] Results of this approach are mentioned in Table 27 and Figure 27.

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.53846157	0.78846157
Ambuja Cements	0.47976878	0.7398844
ICICI Banks	0.4875	0.79375
Infosys	0.50955415	0.75159234
Kotak Bank	0.59183675	0.79591835
Maruthi Motor	0.505618	0.8202247
Nifty	0.58389264	0.82550335
TATA MOTOR	0.5714286	0.78881985
Wipro	0.5212121	0.75757575

Table 27 Results based on FS with threshold, MACD and RSI

Figure 27 Results based on FS with threshold, MACD and RSI

Based on the results of this model, we can conclude, it does predict future trend with good accuracy for private sector stocks. However, range of profit will not be optimal based on this approach since, it is investors decision to quit the market.

3.18 Based on Exponential Moving Average (EMA) and Williams Average (WA)

In this approach we chose initial point of entry based on EMA. Whenever we encountered a lower crossover between lower EMA and higher EMA, we chose that interval as initial point of entry. We then checked if WA value is lower than its upper threshold. [1] On success, we triggered a Short sell. If initial point of entry was chosen since there was an upper crossover between lower EMA and higher EMA, we checked if WA value is higher than its lower threshold. On success, we triggered a Buy call. Results of this approach are mentioned in Table 28 and Figure 28. [6, 9]

Company	EMA				Accuracy	
	2-5	5-10	10-20	20-50	Close	High/Low
ACC				X	0.5888889	0.8111111
ACC			X		0.5491803	0.84016395
ACC		X			0.52272725	0.81439394
ACC	X				0.49731663	0.7808587
Ambuja Cement				X	0.5294118	0.7647059
Ambuja Cement			X		0.49011856	0.7312253
Ambuja Cement		X			0.5016892	0.7483108
Ambuja Cement	X				0.4862013	0.7540584
ICICI Bank				X	0.5	0.71875
ICICI Bank			X		0.50230414	0.7511521
ICICI Bank		X			0.52662724	0.75936884
ICICI Bank	X				0.5184843	0.7560074
Infosys				X	0.37704918	0.6393443
Infosys			X		0.48803827	0.71770334
Infosys		X			0.47582206	0.72147
Infosys	X				0.48938054	0.7292035
Kotak Bank				X	0.43589744	0.6666667
Kotak Bank			X		0.43650794	0.6666667
Kotak Bank		X			0.46945336	0.7299035
Kotak Bank	X				0.501548	0.75541794
Maruthi				X	0.5813953	0.7209302
Maruthi			X		0.515625	0.7734375

Company	EMA				Accuracy	
	2-5	5-10	10-20	20-50	Close	High/Low
Maruthi		X			0.4948097	0.7543253
Maruthi	X				0.49029127	0.7669903
Nifty				X	0.44285715	0.7285714
Nifty			X		0.47345132	0.6858407
Nifty		X			0.4663951	0.69450104
Nifty	X				0.50185186	0.7185185
Tata Motors				X	0.44444445	0.7916667
Tata Motors			X		0.5	0.7838983
Tata Motors		X			0.50671786	0.7581574
Tata Motors	X				0.4888691	0.7408727
Wipro				X	0.4477612	0.7761194
Wipro			X		0.4753363	0.7219731
Wipro		X			0.48087433	0.715847
Wipro	X				0.48367697	0.7182131

Table 28 Results based on EMA and WA

Figure 28 Results based on EMA and WA

Based on the results we can conclude this model's prediction is not stable since

accuracy based on close price is very low.

3.19 Based on Fast Stochastic (FS) and Williams Average (WA)

In this approach we chose FS crossover as initial point of entry. When we found a lower crossover between %k and %d's values, we checked if %k is lower than its upper threshold. On success we checked if WA value is lesser than its upper threshold. If so we triggered a Short sell. [3] If initial point of entry was chosen since there was an upper crossover between %k and %d's values, we then check %k's value is greater than its lower threshold. If so, then we check if that interval's WA value is greater than its lower threshold. On success, we triggered a Buy call. Results from this approach are mentioned in Table 29 and Figure 29. [3, 4]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.38135594	0.5762712
Ambuja Cements	0.43537414	0.67346936
ICICI Banks	0.5462185	0.7478992
Infosys	0.47457626	0.7627119
Kotak Bank	0.4915254	0.7457627
Maruthi Motor	0.41509435	0.754717
Nifty	0.5151515	0.7373737
TATA MOTOR	0.44705883	0.67058825
Wipro	0.47115386	0.74038464

Table 29 Results based on FS with threshold and WA

Figure 29 Results based on FS with threshold and WA

Based on the results of this model, we can conclude it fails to predict future trends with good accuracy.

3.20 Based on Exponential Moving Average (EMA), Fast Stochastic (FS) and Williams Average (WA)

In this approach we relied on EMA for choosing the initial point of entry. When we found a lower crossover between lower EMA and higher EMA we chose that interval as initial point of entry. Now we looked ahead for a lower crossover between %k and %d, when we found such a data point, we checked if %k is lower than its lower threshold. [5] If so we checked that interval's WA's value is lesser than its upper threshold. On success, we triggered a Short sell. [3] If initial point of entry was chosen due to a upper crossover between lower EMA and higher EMA, we look ahead for upper

crossover between %k and %d. When we found such a data point, we checked if %k's value is greater than its lower threshold. If so, then we check if that interval's WA's value is greater than its lower threshold. On success, we trigger a Buy call. Results from this approach are mentioned in Table 30 and Figure 30. [5, 11]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.4	0.71428573
ACC	10	20	0.46666667	0.65
ACC	5	10	0.505618	0.74157304
ACC	2	5	0.5225806	0.7225807
Ambuja Cement	20	50	0.3448276	0.6551724
Ambuja	10	20	0.40677965	0.6779661
Ambuja Cement	5	10	0.4	0.6695652
Ambuja Cement	2	5	0.45454547	0.7326203
ICICI Bank	20	50	0.6296296	0.8518519
ICICI Bank	10	20	0.60714287	0.8035714
ICICI Bank	5	10	0.5063291	0.7721519
ICICI Bank	2	5	0.51428574	0.7785714
Infosys	20	50	0.5217391	0.73913044
Infosys	10	20	0.5272727	0.72727275
Infosys	5	10	0.5102041	0.71428573
Infosys	2	5	0.46994534	0.72677594
Kotak Bank	20	50	0.42857143	0.9285714
Kotak Bank	10	20	0.6	0.7714286
Kotak Bank	5	10	0.48214287	0.75
Kotak Bank	2	5	0.5	0.7
Maruthi Motors	20	50	0.5294118	0.88235295
Maruthi Motors	10	20	0.5151515	0.8787879
Maruthi Motors	5	10	0.49019608	0.7254902

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Maruthi	2	5	0.47674417	0.74418604
Nifty	20	50	0.6363636	0.6969697
Nifty	10	20	0.5614035	0.7894737
Nifty	5	10	0.5116279	0.7093023
Nifty	2	5	0.5	0.69135803
TATA Motors	20	50	0.625	0.90625
TATA Motors	10	20	0.50793654	0.7936508
TATA Motors	5	10	0.46153846	0.7582418
TATA Motors	2	5	0.48630136	0.7876712
Wipro	20	50	0.4516129	0.8064516
Wipro	10	20	0.4920635	0.7936508
Wipro	5	10	0.42718446	0.6796116
Wipro	2	5	0.49375	0.7

Table 30 Results based on EMA, FS with threshold and WA

Figure 30 Results based on EMA, FS with threshold and WA

Based on the results of this model, we can conclude, this model's prediction is unstable for next interval. However, we can still consider this model for risky intra-day traders who will exit the market within few intervals from their entry.

3.21 Based on Fast Stochastic (FS), Exponential Moving Average (EMA) and Williams Average (WA)

In this approach, we relied on FS crossovers for initial point of entry. When we found a lower crossover between %k and %d's values, we checked if %k is lower than its upper threshold, we chose that interval as initial point of entry. Now we look ahead for a lower crossover between lower EMA and higher EMA. If found then we checked if that interval's WA's value is greater than its upper threshold. On success, we triggered a Short sell.[10] If initial point of entry was chosen because of an upper crossover between %k and %d's values, we check if %k's value is greater than its lower threshold. On success we confirm it as initial point of entry. We now look ahead for an upper crossover between lower EMA and higher EMA, on success, we check if that interval's WA's value is greater than its lower threshold. If so, we trigger a Buy call. Results of this approach are mentioned in Table 31 and Figure 31. [2, 13]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.53571427	0.78571427
ACC	10	20	0.5090909	0.8181818
ACC	5	10	0.5793651	0.8730159
ACC	2	5	0.49805447	0.7626459
Ambuja Cement	20	50	0.6086956	0.9130435
Ambuja Cement	10	20	0.44117647	0.7058824
Ambuja Cement	5	10	0.49668875	0.70198673
Ambuja Cement	2	5	0.46178344	0.74840766
ICICI Bank	20	50	0.45454547	0.6363636
ICICI Bank	10	20	0.5294118	0.84313726
ICICI Bank	5	10	0.5403226	0.83870965
ICICI Bank	2	5	0.5720165	0.80658436
Infosys	20	50	0.36363637	0.6818182
Infosys	10	20	0.5762712	0.7627119
Infosys	5	10	0.5174825	0.74825174
Infosys	2	5	0.54035085	0.7719298
Kotak Bank	20	50	0.42857143	0.5714286
Kotak Bank	10	20	0.5263158	0.6315789
Kotak Bank	5	10	0.55421686	0.74698794
Kotak Bank	2	5	0.5466667	0.7733333
Maruthi Motors	20	50	0.54545456	0.6363636
Maruthi Motors	10	20	0.43333334	0.8333333
Maruthi Motors	5	10	0.42465752	0.6849315
Maruthi Motors	2	5	0.50625	0.7875
Nifty	20	50	0.5185185	0.8148148

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Nifty	10	20	0.60655737	0.78688526
Nifty	5	10	0.515625	0.7421875
Nifty	2	5	0.5498155	0.7490775
TATA Motors	20	50	0.42307693	0.7692308
TATA Motors	10	20	0.66101694	0.91525424
TATA Motors	5	10	0.5625	0.78125
TATA Motors	2	5	0.5037879	0.7613636
Wipro	20	50	0.42857143	0.9047619
Wipro	10	20	0.50980395	0.78431374
Wipro	5	10	0.4814815	0.7407407
Wipro	2	5	0.44814816	0.7185185

Table 31 Results based on FS with threshold, EMA and WA

Figure 31 Results based on FS with threshold, EMA and WA

Based on the results from Table 31 and Figure 31, we see that this model predicts with accuracy lesser than 50% for few companies. However, it does predict good accurate results for few companies like TATA and Nifty. Hence, we can use it specifically for those companies.

3.22 Based on Fast Stochastic (FS), Moving Average Convergence Divergence (MACD), Relative Strength Index (RSI) and Williams Average (WA)

In this approach we chose FS crossover for choosing initial point of entry. When we found a lower crossover between %k and %d's values, we checked if %k's value is lower than its upper threshold. If so we chose that interval as initial point of entry. [5] Now we checked if that interval's MACD's lower value is lower than its MACD's higher value. If so then we checked if that interval's RSI's value is lesser than its threshold. If so we checked if that interval's WA's value is lesser than its upper threshold. On success, we triggered a Short sell. [8, 20]

If we detected an upper crossover between %k and %d's values, we checked if %k's value is greater than its lower threshold. If so, we chose that interval as initial point of entry. Now we checked if that interval's MACD lower value is greater than higher MACD value. [10] If so, we checked if that interval's RSI's value is greater than its threshold. If so, then we checked if that interval's WA's value is greater than its lower threshold. On success, we triggered a Buy call. Results of this approach are mentioned in Table 32 and Figure 32.

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.53333336	0.82222223
Ambuja Cements	0.48453608	0.72164947
ICICI Banks	0.43956044	0.73626375
Infosys	0.48192772	0.73493975
Kotak Bank	0.54545456	0.7818182
Maruthi Motor	0.4716981	0.754717
Nifty	0.53571427	0.8214286
TATA MOTOR	0.5940594	0.77227724
Wipro	0.43956044	0.7582418

Table 32 Results based on FS with threshold, MACD, RSI and WA

Figure 32 Results based on FS with threshold, MACD, RSI and WA

When we analyzed these results we found applying all these indicators at the same time reduces prediction accuracy.

3.23 Based on Fast Stochastic (FS), Moving Average Convergence Divergence (MACD) and Williams Average (WA)

In this approach we chose FS crossover to choose initial point of entry. When we found a lower crossover between %k and %d's values, we checked if %k's value is lower than its upper threshold. If so we chose that interval as initial point of entry. Now we checked if that interval's MACD's lower value is lower than its MACD's higher value. If so we checked if that interval's WA's value is lesser than its upper threshold. On success, we triggered a Short sell. [5, 17]

If we detected an upper crossover between %k and %d's values, we checked if %k's value is greater than its lower threshold. If so, we chose that interval as initial point of entry. Now we checked if that interval's MACD lower value is greater than higher MACD value. If so we checked if that interval's WA's value is greater than its lower threshold. On success, we triggered a Buy call. Results from this approach are mentioned in Table 33 and Figure 33. [2, 19]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.5	0.8145161
Ambuja Cements	0.488	0.752
ICICI Banks	0.4224138	0.7155172
Infosys	0.49612403	0.751938
Kotak Bank	0.53246754	0.76623374
Maruthi Motor	0.47887325	0.7605634
Nifty	0.51282054	0.7777778
TATA MOTOR	0.5378788	0.75757575
Wipro	0.42982456	0.7631579

Table 33 Results based on FS with threshold, MACD and WA

Figure 33 Results based on FS with threshold, MACD and WA

Based on the results found in Table 33 and Figure 33, we see that this model is more suitable to intraday prediction for risk taking traders.

3.24 Based on Exponential Moving Average (EMA) and Bollinger Band (BB)

In this approach we chose EMA for choosing initial point of entry. When we found a lower crossover between lower EMA and higher EMA, we choose that interval as initial point of entry. Now we check if that interval's BB's upper band's value is lower than current interval's close price. If so we trigger a Short sell. [7, 21]

When we detect an upper crossover between lower EMA and higher EMA, we choose that interval as initial point of entry. Now we check if that interval's BB's lower band's value is greater than interval's close price. If so, we trigger Buy call. Results from this approach are mentioned in Table 34 and Figure 34. [4]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.5974026	0.8051948
ACC	10	20	0.5418719	0.8522167
ACC	5	10	0.5144628	0.8161157
ACC	2	5	0.4939535	0.7804651
Ambuja Cement	20	50	0.53571427	0.75
Ambuja Cement	10	20	0.48598132	0.7429907
Ambuja Cement	5	10	0.49723756	0.7550644
Ambuja Cement	2	5	0.48438817	0.75864977
ICICI Bank	20	50	0.5185185	0.7592593
ICICI Bank	10	20	0.507772	0.7564767
ICICI Bank	5	10	0.5300207	0.76397514
ICICI Bank	2	5	0.5207547	0.75754714

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Infosys	20	50	0.35714287	0.625
Infosys	10	20	0.46842104	0.70526314
Infosys	5	10	0.47082496	0.72032195
Infosys	2	5	0.48830935	0.72751796
Kotak Bank	20	50	0.38235295	0.61764705
Kotak Bank	10	20	0.40186915	0.635514
Kotak Bank	5	10	0.4567474	0.716263
Kotak Bank	2	5	0.4952381	0.75079364
Maruthi Motors	20	50	0.6052632	0.7368421
Maruthi Motors	10	20	0.52136755	0.7863248
Maruthi Motors	5	10	0.50537634	0.75985664
Maruthi Motors	2	5	0.49673203	0.76960784
Nifty	20	50	0.43939394	0.72727275
Nifty	10	20	0.45320198	0.6699507
Nifty	5	10	0.45628998	0.68869936
Nifty	2	5	0.49764818	0.7158984
TATA Motors	20	50	0.43103448	0.7758621
TATA Motors	10	20	0.7758621	0.7794118
TATA Motors	5	10	0.50511247	0.7566462
TATA Motors	2	5	0.4853211	0.7385321
Wipro	20	50	0.48076922	0.8076923
Wipro	10	20	0.46276596	0.7180851
Wipro	5	10	0.48242188	0.7207031
Wipro	2	5	0.4822695	0.7189716

Table 34 Results based on EMA and BB

Figure 34 Results based on EMA and BB

Based on the results from Table 34 and Figure 34 we see that this model can be used for intraday trading of private and IT sector stocks.

3.25 Based on Fast Stochastic (FS) and Bollinger Band (BB)

In this approach we chose FS for identifying initial point of entry. When we detect a lower crossover between %k and %d's values, we check if %k's value is lesser than its upper threshold. If so, we choose that interval as initial point of entry. Now we check if that interval's BB's lower band's value is greater than current interval's close price, if so, we trigger a Short sell. [6, 17]

When we detect an upper crossover between %k and %d's values, we check if %k's value is greater than its lower threshold. If so, we choose that interval as initial point of entry. Now we check if that interval's BB's upper band's value is lower than

current interval's close price. On success, we trigger a Buy call. Results of this approach are mentioned in Table 35 and Figure 35. [4, 12]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.4279476	0.65938866
Ambuja Cements	0.46953404	0.7311828
ICICI Banks	0.5263158	0.71929824
Infosys	0.48908296	0.7510917
Kotak Bank	0.5945946	0.7837838
Maruthi Motor	0.48739496	0.75630254
Nifty	0.5120482	0.6927711
TATA MOTOR	0.47953215	0.68421054
Wipro	0.43961352	0.71497583

Table 35 Results based on FS with threshold and BB

Figure 35 Results based on FS with threshold and BB

Based on Table 35 and Figure 35 we can conclude that this model has higher error rate.

3.26 Based on Exponential Moving Average (EMA), Fast Stochastic (FS) and Bollinger Band (BB)

In this approach we rely on EMA for choosing initial point of entry. When we detect a lower crossover between lower EMA and higher EMA, we choose that interval as initial point of entry. Now we look ahead for a lower crossover between %k and %d's values. If such a data point is found, we then check if %k's value is lesser than its higher threshold.[4] If so, we check if that interval's BB's lower band is greater than current interval's close price. If so, we trigger a Short sell. [9, 16]

If the initial point of entry is chosen based on an upper crossover between lower EMA and higher EMA, we look ahead for an upper crossover between %k and %d's values. If we find such a data point, we check if that interval's %k's value is greater than its lower threshold. If so, we then check if that interval's BB's upper band is lesser than current interval's close price. If so, we trigger a Buy call. Results of this approach are mentioned in Table 36 and Figure 36. [4, 12]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.5138889	0.7777778
ACC	10	20	0.52136755	0.72649574
ACC	5	10	0.5	0.7580645
ACC	2	5	0.50872093	0.7383721
Ambuja	20	50	0.44827586	0.7413793

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Ambuja Cement	10	20	0.45901638	0.74590164
Ambuja Cement	5	10	0.42222223	0.72
Ambuja Cement	2	5	0.46097562	0.76585364
ICICI Bank	20	50	0.5849057	0.8113208
ICICI Bank	10	20	0.5555556	0.7592593
ICICI Bank	5	10	0.5284974	0.7202073
ICICI Bank	2	5	0.52681386	0.7570978
Infosys	20	50	0.5	0.6956522
Infosys	10	20	0.5555556	0.7222222
Infosys	5	10	0.52403843	0.71153843
Infosys	2	5	0.5104712	0.7408377
Kotak Bank	20	50	0.5769231	0.96153843
Kotak Bank	10	20	0.57377046	0.7704918
Kotak Bank	5	10	0.5090909	0.7818182
Kotak Bank	2	5	0.4888889	0.7222222
Maruthi	20	50	0.4375	0.65625
Maruthi Motors	10	20	0.516129	0.7741935
Maruthi Motors	5	10	0.5233645	0.7009346
Maruthi Motors	2	5	0.510101	0.74747473
Nifty	20	50	0.55	0.73333335
Nifty	10	20	0.5090909	0.76363635
Nifty	5	10	0.48618785	0.67403316
Nifty	2	5	0.47492626	0.6637168
TATA Motors	20	50	0.55172414	0.8103448
TATA Motors	10	20	0.49565217	0.76521736

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
TATA Motors	5	10	0.4787234	0.7234042
TATA Motors	2	5	0.5141066	0.7711599
Wipro	20	50	0.39655173	0.6551724
Wipro	10	20	0.46086955	0.75652176
Wipro	5	10	0.42723006	0.68075114
Wipro	2	5	0.47965115	0.7209302

Table 36 Results based on EMA, FS with threshold and BB

Figure 36 Results based on EMA, FS with threshold and BB

Based on the results in Table 36 and Figure 36, we see that this model works best for private sector, banking sector and indices.

3.27 Based on Fast Stochastic (FS), Exponential Moving Average (EMA) and Bollinger Band (BB)

In this approach we rely on FS to detect initial crossover point. When we found a lower crossover between %k and %d's values, we check if %k's value is lower than its upper threshold. If so we chose that interval as initial point of entry. Now we check if that interval's BB's lower band's value is greater than current interval's close price. If so, we trigger Short sell. [8, 19]

If we detected an upper crossover between %k and %d's values, we checked if %k's value is greater than its lower threshold. If so, we chose that interval as initial point of entry. Now we check if that interval's BB's higher band's value is lesser than current interval's close price. If so, we trigger Buy call. Results of this approach are mentioned on Table 37 and Figure 37. [8, 19]

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	20	50	0.46938777	0.7755102
ACC	10	20	0.53409094	0.77272725
ACC	5	10	0.5674603	0.82539684
ACC	2	5	0.522	0.77
Ambuja Cement	20	50	0.5405405	0.8648649
Ambuja Cement	10	20	0.47107437	0.75206614
Ambuja	5	10	0.46979865	0.7315436
Ambuja Cement	2	5	0.49251246	0.78036606
ICICI Bank	20	50	0.46875	0.75

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ICICI Bank	10	20	0.53763443	0.86021507
ICICI Bank	5	10	0.50384617	0.77307695
ICICI Bank	2	5	0.5582822	0.78527606
Infosys	20	50	0.375	0.625
Infosys	10	20	0.53125	0.7604167
Infosys	5	10	0.5226481	0.7456446
Infosys	2	5	0.5302491	0.7597865
Kotak Bank	20	50	0.3529412	0.47058824
Kotak Bank	10	20	0.6363636	0.74545455
Kotak Bank	5	10	0.5448718	0.76282054
Kotak Bank	2	5	0.53264606	0.7697595
Maruthi Motors	20	50	0.55	0.75
Maruthi Motors	10	20	0.46153846	0.86538464
Maruthi Motors	5	10	0.4652778	0.7638889
Maruthi Motors	2	5	0.51960784	0.79738563
Nifty	20	50	0.5897436	0.84615386
Nifty	10	20	0.5869565	0.75
Nifty	5	10	0.53174603	0.7380952
Nifty	2	5	0.5168539	0.72284645
TATA Motors	20	50	0.3846154	0.61538464
TATA Motors	10	20	0.6666667	0.8229167
TATA Motors	5	10	0.55598456	0.76447874
TATA	2	5	0.51785713	0.75793654
Wipro	20	50	0.5	0.8125
Wipro	10	20	0.48314607	0.74157304
Wipro	5	10	0.48188406	0.73188406
Wipro	2	5	0.4786642	0.7235622

Table 37 Results based on FS with threshold, EMA and BB

Figure 37 Results based on FS with threshold, EMA and BB

Based on the results in Table 37 and Figure 37 we see that this model works optimally for IT, banking and private sector.

3.28 Based on Fast Stochastic (FS), Moving Average Convergence Divergence (MACD), Relative Strength Index (RSI) and Bollinger Band (BB)

In this approach we rely on FS to detect initial crossover point. When we find a lower crossover between %k and %d's values, we check if %k's value is lower than its upper threshold. If so we choose that interval as initial point of entry. Now we check if that interval's MACD's lower value is lesser than higher value. If so, we check if that interval's RSI value is lesser than its threshold. If so, then we check if current interval's BB's lower band's value is lesser than current interval's close price, if so, we trigger Short sell. [1, 13]

If we detect an upper crossover between %k and %d's values, we check if %k's value is higher than its lower threshold. If so, then we choose current interval as initial point of entry. Now we check if that interval's MACD's lower value is greater than higher value. If so, we check if current interval's RSI's value is greater than its threshold. If so then we check if current interval's BB's higher band's value is greater than current interval's close price. On success, we trigger Buy call. Results of this approach are mentioned in Table 38 and Figure 38. [1, 13]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.5074627	0.76865673
Ambuja Cements	0.48507464	0.73134327
ICICI Banks	0.47727272	0.7878788
Infosys	0.50793654	0.75396824
Kotak Bank	0.5810811	0.8243243
Maruthi Motor	0.47297296	0.8243243
Nifty	0.5967742	0.8467742
TATA MOTOR	0.5642857	0.7785714
Wipro	0.5413534	0.7969925

Table 38 Results based on FS with threshold, MACD, RSI and BB

Figure 38 Results based on FS with threshold, MACD, RSI and BB

Based on the results in Table 38 and Figure 38 we see that, this model works optimally for intraday trading. We should not use this indicator for long term trading.

3.29 Based on Fast Stochastic (FS), Moving Average Convergence Divergence (MACD) and Bollinger Band (BB)

In this approach we rely on FS for choosing initial point of entry. When we find a lower crossover between %k and %d's values, we check if %k's value is lower than its upper threshold. If so we choose that interval as initial point of entry. Now we check if that interval's MACD's lower value is lesser than higher value. If so, then we check if current interval's BB's lower band's value is lesser than current interval's close price, if so, we trigger Short sell. [8, 15]

If we detect an upper crossover between %k and %d's values, we check if %k's

value is higher than its lower threshold. If so, then we choose current interval as initial point of entry. Now we check if that interval's MACD's lower value is greater than higher value. If so, then we check if current interval's BB's higher band's value is greater than current interval's close price. On success, we trigger Buy call. Results of this approach are mentioned in Table 39 and Figure 39 [8, 15]

COMPANY	ACCURACY	
	Based on Close	Based on High/Low
ACC	0.5043478	0.7826087
Ambuja Cements	0.5064935	0.77922076
ICICI Banks	0.49115044	0.7654867
Infosys	0.526087	0.76086956
Kotak Bank	0.54198474	0.79389316
Maruthi Motor	0.46456692	0.78740156
Nifty	0.52403843	0.77403843
TATA MOTOR	0.5185185	0.7572017
Wipro	0.5186916	0.7757009

Table 39 Results based on FS with threshold, MACD and BB

Figure 39 Results based on FS with threshold, MACD and BB

When we analyzed all above approaches, we found we are still unable to identify the right point of entry to trigger a decision with a good accuracy. Hence we extended our approach by co-relating multiple intervals. In this approach we started analyzing data from daily interval, whenever we triggered a Buy or Short sell signal from one or combination of indicators, we moved our algorithm to one lower level in terms of interval. Starting from the next open time of next daily interval we started analyzing intraday data, traversed till end of day and returned the decision for that week, so that we are able to make a more stable decision in daily interval based on intra-day data. We went two lower levels in this approach (starting from daily then to 60 minute then to 30 minute in intra-day data). This approach simulated intra-day trading performed in stock market.

In this analysis we found whenever an indicator chooses an initial point of entry, suggesting trend reversal, for example if the model suggested a trend reversal from Bearish trend to Bullish trend, we need to wait for a signal where buyers will make an attempt to get control of the market. They may fail or may successfully reverse the trend. However, we need to identify that point to trigger our decision. Hence, we implemented a new indicator which identifies the point where comes a temporary demand if trend changed from Bullish to Bearish. Temporary supply if trend changed from Bearish to Bullish. [21]

To identify this, we need to understand head and shoulder pattern in stock market.

We named these points as next lower shoulder and next higher shoulder. Whenever the trend changes from Bullish to Bearish, we need to look for next lower shoulder. In other case if trend changes from Bullish to Bearish, we need to look for next higher shoulder. We have discussed the calculation of these shoulders in next sub-section 3.28. [4]

3.30 Temporary Demand and Supply Indicator

In this approach we choose initial point of entry based on FS or EMA crossover and starting from that interval we decided if are looking for temporary demand or temporary supply. If the signal from initial indicator is Short sell then we look for next lower shoulder. When we find next lower shoulder that represents the interval at which there is a temporary rise in demand, we trigger Short sell. [10, 18]

Here is the approach to identify lower shoulder. Initial entry point's high price will act as upper limit (stop loss) when we are looking for a shoulder. Now starting from the next interval, we check if there is an interval with gain, if so, it is the shoulder which we are looking for. If there is no interval with gain then we look for an interval whose high price is greater than its previous interval's high price also its high price must be smaller than its next interval's high price. Whenever we find such an interval, we identify the last interval which we already have reached (traversed) as lower shoulder. However, actual lower shoulder is the relatively the one previous to the interval which we just chose. After experimenting with various look ahead thresholds we found 15 as the best look-ahead threshold for finding next lower shoulder. [4, 14]

If the initial point of entry suggests Buy signal, then we need to look for next

higher shoulder. Here is the approach to find the next higher shoulder. We start from the next interval relative to the initial entry point. If an interval with loss is found then that is the higher shoulder. If an interval with loss is not found then we continued the search till we found an interval with, low price lower than its previous interval's low price and its low price is also lower than its next interval's low price. If so, we identify the last touched interval as next higher shoulder. However, the interval relatively previous to the found interval is the actual higher shoulder. For higher shoulder we found 15 as the look-ahead threshold which gives optimal result.

This experiment was approached by choosing initial point of entry based on EMA crossover. Results of this approach are mentioned in Table 40 and Figure 40.

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
ACC	50	100	0.85714287	0.97619045
ACC	20	50	0.97619045	0.98571426
ACC	10	20	0.8321678	0.8321678
ACC	5	10	0.84879726	0.9656357
Ambuja Cements	50	100	0.8918919	0.972973
Ambuja Cements	20	50	0.86904764	0.97619045
Ambuja Cements	10	20	0.852071	0.9585799
Ambuja Cements	5	10	0.8304598	0.9511494
ICICI Bank	50	100	0.84375	0.96875
ICICI Bank	20	50	0.8055556	0.9444444
ICICI Bank	10	20	0.8413793	0.9655172
ICICI Bank	5	10	0.8349835	0.9537954

Company	EMA		Accuracy	
	Lower EMA	Higher EMA	Based on Close Price	Based on High/Low
Infosys	50	100	0.95238096	1
Infosys	20	50	0.8181818	0.8939394
Infosys	10	20	0.8525641	0.96794873
Infosys	5	10	0.83282673	0.9574468
Kotak Bank	50	100	0.88235295	0.9411765
Kotak Bank	20	50	0.8627451	0.9607843
Kotak Bank	10	20	0.8666667	0.9777778
Kotak Bank	5	10	0.7932961	0.9385475
Maruthi Motors	50	100	0.9375	1
Maruthi Motors	20	50	0.8863636	0.97727275
Maruthi	10	20	0.835443	0.9746835
Maruthi Motors	5	10	0.82954544	0.95454544
NIFTY	50	100	0.9354839	0.9677419
NIFTY	20	50	0.9358974	0.96153843
NIFTY	10	20	0.96899223	0.99224806
NIFTY	5	10	0.93290734	0.9744409
Tata Motors	50	100	0.9310345	1
Tata Motors	20	50	0.81578946	0.94736844
Tata Motors	10	20	0.86092716	0.95364237
Tata Motors	5	10	0.8664596	0.94720495
Wipro	50	100	0.8064516	0.9354839
Wipro	20	50	0.8076923	0.9230769
Wipro	10	20	0.82530123	0.9096386
Wipro	5	10	0.8208955	0.9283582

Table 40 Results based on EMA and Head and Shoulder

Figure 40 Results based on EMA and Head and Shoulder

We then approached to solve the problem based on choosing initial entry point based on FS. When we encounter a lower crossover between %k and %d's values, we check if %k's value is lower than higher threshold's value, we choose this point as initial point of entry. We then proceed to identify next lower shoulder, and when we find the same, we trigger a Short sell since suggested trend is Bearish. [17]

If we find out an upper crossover between %k and %d's values, we check if %k's value is greater than its lower threshold. If so we choose that data point as our initial point of entry. We now make an attempt to identify next higher shoulder, if we find such a data point, we trigger a Buy call. Results of this approach are mentioned in Table 41 and Figure 41.

Company	Accuracy	
	Based on Close Price	Based on High/Low
ACC	0.86904764	0.96190476
Ambuja Cements	0.7945493	0.9371069
ICICI Bank	0.87531805	0.9669211
Infosys	0.8385542	0.97108436
Kotak Bank	0.82300884	0.94690263
Maruthi Motors	0.83950615	0.962963
NIFTY	0.93782383	0.9766839
Tata Motors	0.8622449	0.96683675
Wipro	0.8456057	0.9501188

Table 41 Results based on FS with threshold and Head and Shoulder

Figure 41 Results based on FS with threshold and Head and Shoulder

Analyzing the results of Table 40 and Figure 40 and Table 41 and Figure 41 we see that we have improved accuracy by a great extent comparing with any previous

approach. However, given any interval we still may not be able to identify the pattern or predict the next trend based on these indicators. Hence we performed an experiment using Hidden Markov Model which is discussed in the next sub section. [22]

3.31 Hidden Markov Model

We train the HMM as discussed in 2.1.2.11. We used 4 observation symbols and 3 hidden states. We chose observation symbols as 0, 1, 2, and 3. We marked the interval as 0 if it was a gain, 1 if it was a gain followed by gain. We marked interval as 2 if it was a loss and marked the interval as 3 if it was loss followed by loss. After training the model based on test data (1/3 of entire data), to find out next most likely observation we followed the following approach. We find the most likely sequence of hidden states for the training sequence used using problem 2 [22]. Now we chose next observation symbol such that, it has the highest probability of occurrence. Results of this approach are mentioned in Table 42 and Figure 42. [22, 23]

Company	Accuracy	
	Based on Close Price	Based on High/Low
ACC	0.45923011	0.57102938
Ambuja Cements	0.46012758	0.63012567
ICICI Bank	0.52013648	0.64908493
Infosys	0.54102386	0.59283920
Kotak Bank	0.53201298	0.61234319
Maruthi Motors	0.55	0.60192749
NIFTY	0.51020012	0.59012342
Tata Motors	0.47023891	0.64012353
Wipro	0.47193678	0.56102389

Table 42 Results based on HMM

Figure 42 Results based on HMM

After analyzing the results based on Table 42 and Figure 42, we see that we are unable to predict future trend based on HMM with relatively good accuracy.

3.32 Co-relating Multiple Intervals

In this approach we relied on EMA and FS for choosing initial point of entry. If we found a lower crossover based on primary indicator we then looked ahead for next lower shoulder. When we found this interval we triggered Short sell and we moved one level lower in terms of intervals and started analyzing the data. i.e., if we were currently in daily data, we moved to 60 minute interval. On encountering a new data point we checked if that point is next higher shoulder or if its price has crossed above the high price of interval where we made the decision (stop loss).[21] If so, we triggered an exit signal to exit the market. If not then we moved one more level in terms of interval and repeated the same process. Whenever we found a next higher shoulder (section 3.29) we triggered an exit signal. [9]

If we had found the initial point of entry based on higher crossover, we then looked ahead for a next higher shoulder to enter the market. When we found such a data point, we triggered a Buy call and starting from next data point, we moved lower by one interval level. After encountering every new data point we checked if that is the next lower shoulder or if its price has made a lower crossover with low price of the interval at which we entered the market (stop loss). If so, we triggered an exit signal to exit from the market. If not we went one more level in terms of interval and repeated the same process. [9]

Based on this approach we were not only able to provide an entry point to the market but also we were able to provide a data point where the investor must exit from

the market with good profit. The accuracy of this model matched the accuracy of the model discussed in section 3.29 since the decisions which were made by this model were the exact same decisions as approach in section 3.29.

In this model we are also able to identify a wrong decision made by the model with use of stop loss. For optimal profit, we should update stop loss with current interval's high price if it is a Short sell (low price if it was a Buy call) as we move further to look if there is a crossover. Based on these observations, we theoretically believe that this model best suits to predict the trend in real time market.

4 Limitations

1. In all the approaches which we discussed in this report, we assumed, whenever we want to make a trade, we are able to find someone who is willing to make that trade with us and we get the shares which we are looking for. This is not true in real time trading. To understand in more detail about the behavior of our approaches, we need to test these models against real time data.

2. For comparison we have chosen stocks from various sectors. However, the behavior of these indicators may vary with other members of the sectors from which we chose the stocks.

3. We have considered data only from Indian stock market. The behavior of these models may differ if we consider stocks from other countries. The reason behind this limitation is due to the emotions associated behind the investors.

4. These indicators may fail to predict any trend if there is not considerable amount of fluctuation in stock market. This situation happens if all investors are waiting for some type of results from that particular company, to invest.

5. In this project we have analyzed static data. In real time stock market the prices change every millisecond. Hence, the decision made at current instant may not be valid at next instant since the trend has changed due to previous trade. This problem can be solved only after analyzing the algorithm with real time data.

6. We have relied on data from year 1994 to 2012 for all stocks which we analyzed. When new data is fed in to the model its accuracy may vary.

5 Conclusion and Future Work

We considered models from [4, 6] as our benchmarks. Other models which are described under sections 3.13 and 3.14 give optimal results for Cement sector. Models discussed under 3.10, 3.19 and 3.24 suit best for Private sector. Models discussed under 3.12, 3.21, 3.26 and 3.27 works optimally for Motor sector. Models discussed under 3.11 and 3.26 are suitable for Banking sector. Models discussed under 3.9, 3.12 and 3.24 are suitable for IT sector. Models discussed under sections 3.26 and 3.27 works optimally for indices. Models discussed under 3.15, 3.23 and 3.28 are theoretically suitable for intraday trading (since we have not implemented real time intraday).

Our models, which are discussed under subsection 3.30 and 3.32 works optimally for all sectors of stocks. Based on these model's results we have found an average accuracy of 81%. Based on the model described in 3.32 we can also ensure we can detect wrong decisions and get the investor out of stock market by providing a stop loss at the time of triggering decision. These models show improved results over all previous models discussed in this report. Prediction accuracies based on these models are relatively consistent across all sectors and stocks which we chose. Based on our model we can also hold on to the same decision until we detect a trend reversal.

A stock can be traded in multiple ways namely, options, futures, equities and commodities. There is a lot of co-relation between these trades. For example; put (a type of option) falls with raise in equities. On the other hand, call (another type of option) is directly proportional to equity prices. A decision made on equity is more stable than a decision made on options. We need to co-relate between these different trade types.

It is very important to note the co-relation between various intervals at any single type of trading alone. For example: If daily interval indicates a fall, intra-day will indicate a bullish trend for a short period of time. However, the converse is not true.

HMM is the best model to capture patterns. However, in our case it did not give us optimal results. We need to include more observation symbols with specific meaning and repeat HMM exercise.

We can also co-relate between stock markets of different countries. As an example, we can co-relate between IT stocks of India with currency exchange rates. Whenever Rupee price falls with respect to Dollar price, IT stocks of India are more likely to show a Bearish trend. The reason being, whenever an IT company makes a deal with a US company, they would have discussed the cost in Dollars. Now since Rupee price fell, they would get paid much lesser than what they were actually expecting.

The same logic is also true with co-relating European currency and US currency with IT stocks in US. As an example, whenever Euro price falls, stock prices of US IT companies fall. Also, we can co-relate between oil prices and power sector, construction sector of stock market. Oil prices are inversely proportional to stock market movements. Also, we need to perform textual mining based on news to find out future trend.

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