

Validating Algorithmic Trading Strategies to Predict Trends in Indian Index Option

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Abstract. Algorithmic Trading is a process in which computers are programmed to take trading decisions using a defined set of rules without any human intervention to make profitable trades. Trading Strategy is pivotal to any automated trading system. Researches performed in past to develop profitable trading strategies using technical analysis has focused only on Stock trading, but not Options. This work proposes intraday trading techniques on Index options. The trading algorithms are based on technical analysis of option prices using different technical indicators. The algorithms designed maximizes the profit by trading on call and put options with minimum risk of losing money. It gives optimal parameters for time period for trading signals and period of historical data to be considered for each technical indicator to generate trade entry signal used in the algorithm. Algorithm will also generate optimal exit signals using stoploss, target profits and trailing stop techniques.

Keywords: Trading, Options, Algorithm, Trading Strategy

1. Introduction

Today investment analysts and traders require efficient tools in financial market. Technical Analysis of stock proves useful for day traders to predict long term and short term trends in stock prices. In case of Index it is difficult to predict trends using technical analysis as an Index is composite of multiple stocks. Idea here is to create an algorithm based Option trading system to predict trends in Index price from price movement in near the money Index Options. Advantage of trading on options is that it limits the risk but does not limits the profit. Technical analysis is a method to forecast movements in price using past price. There are set of trading rules in a technical trading algorithms. These trading rules need to be parametrized. According to the parameter values, trading signals are generated by each trading rule. Combination of different trading rules can be used to provide trading signals. Some of the popular trading rules are RSI, Moving Averages, RMI, etc. Limited research work related to stock trading algorithms are published and shared to keep the strategies secret. Nifty is an Index, options of which are most traded in Indian stock market. As of today, most of the

volume is in out of the money call and put options of these Index.

1.1. Automated Trading

Price of any security being traded in the stock exchange is based on the human decisions and perceptions about the future. The primary direction of any security depends on the number of buyers or sellers willing to buy or sell at the given point of time. Automated trading helps to avoid decision making based on human exceptions and emotions to make trading decisions. As the humans are involved in trading, many of the investment decisions are based on irrelevant reasons. Automated trading systems takes trading decisions based movements in prices of security which helps to capture the behavior of maximum participants in the market and not based on any individuals expectation.

1.2. Options

A derivative contract between two party (option holder and seller of option). It gives right to holder of

option to perform a specified transaction in the contract but not obligation. There are two types of options: Calls and Puts

Call Option: Call option gives right to holder of option to buy said asset at specified price in the contract.

Put Option: Put option gives right to option holder to sell the underlying asset at the specified price in the contract.

When the strike price of an option is equal or near to the price of the security, it is said to be **AT THE MONEY** option. Similarly, Options having strike price more than that of its underlying security, it is called out of money contracts for calls and in the money contracts for put options. Vice-versa, lower strike price options than the underlying security are out of money put option and in the money call option. Option contracts have an expiry. All out of the money contracts become worthless and void after expiration of contract. Option pricing is very complex and depends on various factors.

1.3. Option pricing and Sensitivity

Primary factors which drives the price of options are current price of underlying security, intrinsic value of the option, time remained for expiration and volatility. Movement of stock price in up or down direction directly affects the price of the option. Volatility of option depends on the average rate of change of price of underlying stock.

Two components of price of an options are:

Intrinsic Value: Intrinsic value of any option contract is the price the difference between the strike price of option and underlying security if the option were to be exercised today. All the call options with the strike price less than the current price of the underlying stock price are exercised on the day of expiry and remaining options become null and void. Similarly, in the case of put options the options with strike price greater than the underlying stock price at the time of expiry are exercised and other puts become null and void.

Time Value: Time Value of any option difference between the premium and intrinsic value of the option. Time value of any option depends on the time remained for it to be exercised. More the time for expiry, greater is the time value of the option premium. Time value reduces with as the time to expiry approaches. At the time of expiry, the time value of an option contract become zero. It is called time decay.

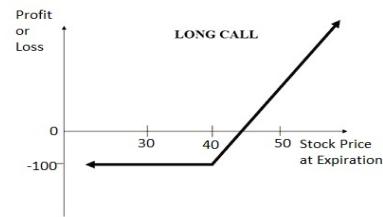


Fig. 1. Payoff chart for call option

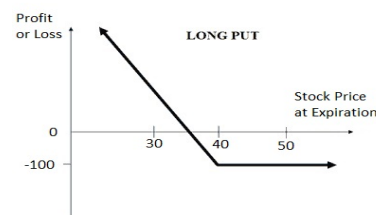


Fig. 2. Payoff chart for put option

1.4. Price Fields

Technical analysis is based on the analysis of prices and volume of traded security. Security's price and volume are defined by the fields explained below.

- **Open** - The first trading price of a security for any period is called open price for that period of that security.
- **High** - The highest trading price of a security in a given period becomes the High price for that period.
- **Low** - The lowest price trading price of a security is low of that period. It is the lowest price offer made in the period.
- **Close** - Close is the last traded price in a period. The most used price for analysis is close price as it is the latest available price of the security.
- **Volume** - Number of contracts traded during the period is called volume for that period.

J. Welles Wilder [26] explains Technical indicators as, a mathematical calculation which can be performed on the price fields of securities which can be used to predict changes in future prices of the security, commodity or any tradable financial entity. The data on which this calculation is made are price fields of securities in recent past. Technical analysis have been proved usable in predicting price movements by many researchers since eighteenth century. Use of technical analysis has increased for short term price prediction

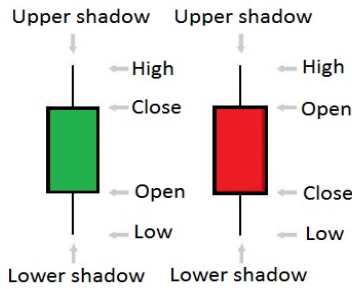


Fig. 3. Candlestick representation of pricefields

in last few decades.

Stephanos Papadamoua [1], in his research paper discussed about how genetic algorithms can be used for improving technical trading system. It shows how machine learning techniques and its optimization can be done to find the best algorithm to find trading rules for a trading system. The problem with this model to be used for option trading is not feasible as the option contracts expires and there is no continuity of relevant data points of more than a month.

Cheol-Ho Park and Scott H. Irwin [9] discuss various types of exits on the trades. It shows how Stoploss, target profits and trailing exits can be used in trading systems and its purpose. In any trading system, exit point is equally important as entry point of a trade. Holding of a false trade for long may increase the losses in system while exiting a trade early may reduce the profitability of the trading strategy. It is found that these exits can improve the performance of trading system.

Mrityunjay Sharma [8], has discussed how the performance of the trading strategy can be evaluated. Trading strategy is a combination of entry and exit signals in a trading system and its effect on the equity or portfolio of the trader. It is necessary to consider practical challenges in trading financial markets. A strategy which seems to be profitable but not executable in the real market would be a useless strategy. It is very important to consider volume, time of signals, market trading hours, spreads in the bid/ask prices. Backtesting a trading strategy is a simulation of how the strategy would have worked on the historical data. This gives insight on the performance of the trading strategy. To evaluate actual performance of the trading system, one must consider the brokerage and slippage in the system. Slippage is a critical part of a trading system. It

may have chaotic effect on the systems profitability.

Taylor, S. J [21], shows how channels around moving average can be used to stop taking trades in noisy movement in the market. Idea is to form an envelope above and below moving average of stock price and take long position only if price moves above upper channel. Vice versa, take short position if the rise of stock is below lower band. This trading strategy helps to reduce number of false trades in the system.

In the next section, we have discussed details about major components of a trading system.

2. Trading System

A trading system, on a broader view is a group of specific parameters or rules which gives entry/exit points. In this section, we have discussed few primary components and performance measures of trading systems.

2.1. Technical Indicators

Data points which can be derived with application of a mathematical formula on securities price fields describes a technical Indicator. It uses one or combination of one or more price fields of a period of time. Most of the indicators uses the close price as it is the last traded value available for that period. Some indicators also considers volume and open interest for calculation.

Relative Strength Index (RSI)

Ugur Sahin and A. Murat Ozbayoglu [4] discussed about RSI indicator. It is a very common Volatility indicator used by the traders. 14-day period and 30-70 thresholds are widely used parameters as RSI rules for stock trend prediction. These parameters are preferred for strategies on daily basis. Parameters like period and threshold should be optimized for option trading on intraday. As the performance of RSI indicator is good for uptrend prediction, it could be more useful for trading on options as there will be only long trades. So the downward trend in underlying index can be predicted by its uptrending put option price.

[24] Formula for RSI calculation for n period can be given as

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

RS = Average gain/Average loss

The very first calculations for average gain and average loss are simple n period averages.

- First Average Gain = Sum of Gains over the past n periods / n .
- Average Loss = Sum of Losses over the past n periods / n

The second, and subsequent, calculations are based on the prior averages and the current gain loss:

- Average Gain = [(previous Average Gain) \times ($n-1$) + current Gain] / n .
- Average Loss = [(previous Average Loss) \times ($n-1$) + current Loss] / n .

It is a smoothing technique to use previous values and current values to increase the accuracy in results.

2.1.1. Exponential Moving Averages

Moving Averages are used for smoothing the price data of a security. It is used to form or derivation of various trend indicators. Moving averages does not find price direction but direction of price currently is defined by it with a lag. Reason for lag in moving average is it uses past prices for calculation.

two popular MA Simple Moving Average(SMA) and Exponential Moving Average(EMA) are used in System trading. the difference between both is that EMA gives more weightage to recent prices. Exponential moving average has less lag compared to SMA.

Length of moving average plays an important role in trading system. It depends on the analytical objective. Short term period is preferred for short term trend prediction and long term periods for long term trend prediction. Moving average of 5-20 period is preferred for short term trading or day trading.

Short term EMA can be used to create an envelop/Channel around the price of stock. This helps to reduce noise for trend prediction system.

cross-over of EMA of different time period is also a popular technique used for trend in System trading prediction.

Many of the technical analysis indicators are derived on the basis of moving averages.

Exponential Moving Averages (EMA) for n periods is calculated as follows:

Multiplier = $2/(n+1)$

Current EMA = Current Close - EMA[$n-1$] \times multiplier + EMA[$n-1$].

multiplier in the above equation is called a smoothing constant.

2.1.2. Average True Range (ATR)

ATR indicates volatility in security price movement which uses Open, High, Low and Close values of stocks for calculations. Volatility measure gives a fair idea about market direction. ATR can be used to spot significant point of breakout. It is a useful indicator to identify trend reversal. Whenever ATR goes high above a certain value there is higher possibility of change in direction.

ATR can be used to find entry signal at bottom price levels.

Wilder[26] has given formula to calculate Average True Range for n period as:

The True Range(TR) is the maximum value of

- current high - current low
- Absolute(current high - previous close)
- Absolute(current low - previous close)

Current ATR = [(Prior ATR \times ($n-1$)) + Current TR] / n

2.1.3. Standard Deviation

Standard Deviation is also a volatility indicator. It can be used to determine the trendless market and reduce trades in noisy movements. When stock price follows a trend, the standard deviation increases. It does not tell the direction of movement. Whether the price increase or decrease, standard deviation increases. It need to combined with some other technical indicator to determine the direction of predicted trend.

2.2. Exit Types

Exit timing from a trade is as important as entry timing for a trade. [2] explains different types of exits in a trading system.

2.2.1. Profit

Target profit could be a percentage value or points value. It is an exit point from a trade when it is often difficult to find what should be the target profit for trades in a trading system. If the value is too small then the system will be less profitable. Again if the target profit values are kept too high, it may happen that many of the trends reverse before hitting target profit resulting in profit less than what could have been

achieved. It needs to be optimized to a fair value on which it can give best results.

2.2.2. Stop Loss

Stop loss is an important exit point used to exit from the trades which does not continue in the direction of trend found by the trading system. Stop loss value also needs an optimization. A large stop loss value may incur huge losses in trading system. Too small value of Stop loss may give false exit signal which in turn may result in less profit. Stop loss is usually given in percentage of price of traded entity. But Price of the option keeps changing every day as the time value of options decreases as it approaches to expiry. So, a stop loss point in option trading system should be some value calculated from underlying entity.

2.2.3. Trailing Stops

Trailing Stops are the special exit points in trading systems. It is activated once a trade becomes profitable after its entry. Idea behind using trailing stops is to exit with some profits if the predicted trend reverses before hitting the target profit price. It works as, once a trade is entered, if the price of the stock increases, trailing stop price also increases. Trade is exited by the trading system if stock price hits the trailing stop value.

2.3. Performance Evaluation of Trading System

Performance of a trading system is measured by various ways. It is a matter of personal preference. Some trader may give more importance to return on capital while other may look for risk parameters or some may look for higher accuracy. Drawdown is the most important factor of measuring the performance and considered by most traders as a factor which may lead to make decision whether a strategy for trading is practically executable or not. According to many professional traders the true measures for a trading strategy are return on capital, maximum drawdown and distribution of profit in different phases of the market. There should be an acceptable balance among these parameters to perform trading on actual money.

2.4. Drawdown

When a strategy loses money, trading system suffers through drawdown. Drawdowns are biggest barrier for any trader or trading system. Drawdown is the difference between a peak to following bottom before another peak is formed in the equity curve. The global maxima of all the drawdowns in the strategy for a pe-

riod is called maximum Drawdown. If the backtest period is large enough to cover all phases of markets and strategy is logically correct, one can take the maximum drawdown as the stopping point of the strategy. If the trading strategy exceeds the max Drawdown, it means that trading strategy is over-fitted for backtested data and not suitable for practical trading. Maximum drawdown duration is the period between a peak and its following peak is global maxima of distance between two peaks in given equity curve.

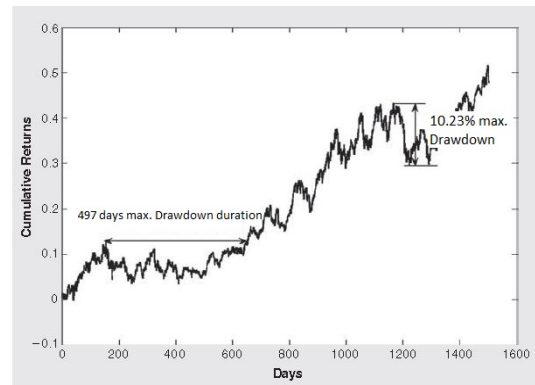


Fig. 4. Max. Drawdown and Max. Drawdown duration

3. Experimental Work and Design

In this section, we have discussed about our experimental setup to develop trading strategies for index option trading.

3.1. Experimental Model

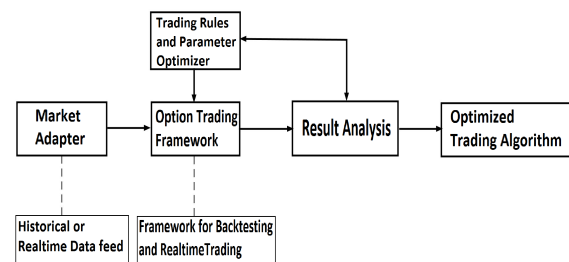


Fig. 5. Architecture Diagram

The developed intraday option trading algorithms for Nifty Index options are based on technical indicators. The system takes only long position in call or put options. The framework allows to define trading rules

to generate entry and exit trading signals based on defined trading rules with given parameters.

- Market Adapter: Input data is the price fields of different series of option symbols. Market adapter will provide the historical/real-time data to the trading system.
- Option trading framework: It is designed to select index option of same month of the trading month. Option symbol with strike price closest to the price of underlying Index for trading. It squares up all trades if positions are open till the end of expiry date of option (last Thursday of month in case of Indian stock market). It is designed to handle different exits (Stop-loss, Target profit and trailing stops).
- Trading Rules: Trading rule is a combination of technical indicators with specific parameters (Period, Threshold Values, Variables, etc.) to make calculations on price fields to generate trading signals.
- Parameter Optimizer: This component in the system would find the most optimal parameters for defined trading rules for profit maximization.

Using this framework, three different trading algorithms has been developed and optimized using Exponential Moving average and Average true range indicators to study the profitability of option trading system.

Three different trading strategies are designed using two technical indicators for making trade decisions. Exponential moving average and Average true range are two indicators used. following are the ideas used for making decisions in each strategy. 15 minute price bars are used for taking trade decisions in every strategy.

An additional component is designed to analyze results of these strategies as a combination of two or more strategies. It gives the effective result if total traded quantity is split between different strategies to learn the effect of distribution of quantity.

4. Experimental Results

Tables below shows the results of backtest of all the three trading strategies. Combined row in the table is the result generated by combiner component. The combined result is generated by splitting the total traded quantity in each trade of different strategies in equal parts.

- All results are based on trading of 1000 quantity of Call/Put Options of Nifty Index
- Average Buy price of call/put option considered for trading is Rs.100 i.e. Profits/Risk levels shown below are on a capital of Rs.1,00,000/- approximately.
- Annual Return is calculated as $(\text{Profit}/(\text{Capital} + \text{Max. Drawdown}) * 100)$
- Results shown are without incorporating profit as capital for further trades.

Data for year 2012 and 2013 was used as training data set for optimizing the trading strategies. And data for year 2014 and 2015 was used as test data set to test the consistency of trading strategies.

All the results above are without considering the brokerages. Brokerage for a trade vary from broker to broker.

Average number of trades in a year for combined strategy is 1300. Considering the least brokerage available in India today, expenses would be Rs.100/trade. So, average yearly expenses would be approximately one lakh fifty thousand rupees.

Equity curve gives a graphical representation of performance of trading System. Figures below shows the equity curve of individual and combined trading strategies on training and test data set. It can be seen that the profit curve is gradually increasing and system gives consistent profit over time.

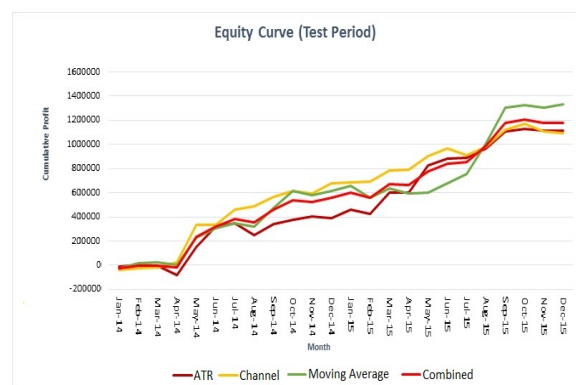


Fig. 6. Equity Curve for test period

All three trading strategies are profitable on yearly basis with minimum profit to risk ratio 1:1.7 and maximum 1:11.7.

Year	Trading Strategy	Profit	Max. Drawdown	Annual Return %	Profit/Risk Ratio	Winning Trade %
2012	Moving Average	6,15,350	1,47,900	248%	4.16	37.92%
	Channel	2,82,500	1,46,150	115%	1.93	37.40%
	ATR	5,88,650	1,23,250	264%	4.78	48.05%
	Combined	4,95,500	1,14,167	231%	4.34	41.12%
2013	Moving Average	9,09,150	2,24,850	280%	4.04	40.29%
	Channel	9,01,750	2,28,500	275%	3.95	42.55%
	ATR	11,16,900	94,800	573%	11.78	44.48%
	Combined	9,75,933	1,03,917	479%	9.39	42.44%
Training Period						

Table 1

Year-wise performance of each trading strategy in Training period

Year	Trading Strategy	Profit	Max. Drawdown	Annual Return %	Profit/Risk Ratio	Winning Trade %
2014	Moving Average	6,15,500	1,41,500	255%	4.35	39.82%
	Channel	6,78,450	97,500	344%	6.96	41.10%
	ATR	3,87,400	2,99,700	118%	1.69	41.06%
	Combined	5,60,450	1,25,550	248%	4.46	40.66%
2015	Moving Average	7,15,900	2,56,050	201%	2.80	40.11%
	Channel	4,14,750	2,04,400	136%	2.03	38.76%
	ATR	7,23,600	2,16,000	229%	3.35	44.41%
	Combined	6,18,083	1,68,750	230%	3.66	41.09%
Test Period						

Table 2

Year-wise performance of each trading strategy in Test period

4.1. Conclusion

Technical indicators like Moving Averages and Average True Range can be effectively used to predict trends in Index options. In this study, we have validated that profitable trading strategies using technical analysis are possible on option price data. It is concluded from the results and charts that Various trading strategies performed better on different time period. But the combination of different trading strategies generate consistent profits. Combining different trading strategies improves average profit to risk ratio of the system significantly without compromising much profits.

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