A COMPARATIVE STUDY OF INTRADAY TRADING SYSTEMS DEVELOPED BASED ON MOVING AVERAGE: SIMPLE, EXPONENTIAL AND HULL

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Abstract- Moving averages are amongst the most widely used technical tools by participants in the financial markets. Moving averages smooth the time series to form a trend following indicator. The strength of a moving average is its ability to filter out price noise reducing what can be extremely volatile price series into more discernible trends, thereby allowing researchers to ascertain the strength and direction of the trend. In this paper, three intra-day trading systems are designed using three different moving averages, namely simple moving average, exponential moving average and smoothed moving average. The systems are tested using the one minute data of CSI 300 Index Future of China. Some special constraints of this emerging markets are considered to fully adjust to this specified markets. The performance of the systems are compared with each other to find out the optimal moving average indicator.

Index Terms— Moving average, simple moving average, exponential moving average, smoothed moving average, intra-day trading, CSI 300

I. INTRODUCTION

The ability of simple rules such as technical analysis, to forecast asset price movements was a controversial subject especially during the late 90s. Technical analysts were generally held in disdain by the academic community during that time, however, with the utilization of technical trading rules in high frequency trading systems, more and more researchers are trying to find out the rational motivation behind technical analysis.

Moving averages may be the most universal of all technical analysis indicators. They do not predict time series' direction, but rather define the current direction with a lag. The lag exists because moving averages are based on past time series. Despite this lag, moving averages are the simplest and powerful tools to smooth time series and filter out most of the noise.

However, according to Fama's [1] Efficient Market Hypothesis (EMH), it is impossible to make profits by exploiting all currently available information because assets prices have fully digested and reflected all private and public information in an efficient market. In 1978, three broad categories of hypotheses were developed by Jensen [2], namely

(1) The Weak-form of the EMH, in which asset prices reflect all market information and that the rates of return on the market should be independent, past rates of return have no effect on future rates.
(2) The Semi-strong form of EMH, in which asset prices reflect all publicly available information. The Semi-strong EMH incorporates the weak form EMH, and investors cannot benefit over and above the market by trading on new information
(3) The Strong-Form of the EMH, in which the asset prices reflect all information both public and private. No investor would be able to profit above the average investor even if he was given private information of the target asset.

In this paper, intra-day trading systems are built based on moving averages, which are computed using historical information. The trading systems will be tested using the intraday data of the emerging China Index Future market. If any of the systems showed consistent over market return, a conclusion can be made that the weak-form EMH won't hold in the future market.

II. LITERATURE REVIEW

The related literature will be divided into three parts in this section. The first part is on technical analysis, the second part is on moving average, and the third part is on intraday trading and trading systems design.

There is a huge amount of literature on the profitability of technical analysis. Many researchers and investors have applied various kinds of technical indicators or technical tools into different markets either to test for the market efficiency or to explore the profitability of certain technical trading rules. F. Ferna´ndez-Rodr´ıguez et al., R.Gencay and T. Chavarnakul, D. Enke, [3]-[5] presented extensive reviews on the relevance of technical analysis in financial markets and the profitability of technical pattern. Technical trading rules were proved by a considerable amount of work to be capable of producing valuable economic signals in both stock markets and foreign exchange markets. F.

Ferna´ndez-Rodr´ıguez et al. [3] tested the ANN forecast based trading strategy on Madrid stock market, significant profit was gained without the consideration of transaction cost. Menkhoff and Taylor indicate that [6]:

(1) the evidence that a considerable number of market participants use technical analysis cannot be simply merged with the circle of irrationality,

(2) the profitability of technical analysis is likely to co-exist with government interventions

(3) technical analysis could be associated with the information reflected by order flows

(4) technical analysis aids to find non-fundamental price factors, especially in the short run. Park and Irwin [7] provided another extensive review on technical trading literature and found out that more research on the profitability of technical analysis were conducted using stock markets rather than those of foreign exchange markets. A recent study by M. Metghalchi et al. [8] tested the profitability of moving average trading rules using the European stock markets and found that technical trading rules can outperform the buy and hold strategy after accounting for transaction costs.

The benchmark literature on moving average trading is Brock el al. who test applied moving average trading rules to the Dow Jones Industrial Average (DJIA) from 1897 to 1986 and found out the results is inconsistent with the EMH as fully reflecting all available information [9]. Bessembinder and Chan, Hudson et al. [10]-[11], conducted some similar study to Brock et al in the following few years.

Blake LeBaron tested the stability of moving average technical trading rules and found out that the differences between conditional means during buy and sell periods has changed dramatically over the testing period of data, however, the differences in conditional variances have not changed much over the entire sample [12]. Marcus, C. T. improved the moving average trading rules by reducing the number of losing trades. Compared the price crossover rule, the trading rules used in Marcus, C.T.'s study are better able to extract meaning from or are better able to understand the same price infromaiton [13]. Milionis, A.E. and Papanagiotou, E. tested the significance of the predictive power of the moving average trading rules using the NYSE, the Athens Stock Exchange and the Vienna Stock Exchange and found out [14] that weak-from market efficiency is clearly accepted for the NYSE, is rejected for the ASE except for the last sub-period 2001 to 2005), while for VSE, it is rejected for the first sub-period (1993 to 1997) and accepted for the other two sub-periods.

Intraday trading is part of the High frequency trading, most of which are algorithm trading and programmed trading. High frequency trading has been popular in recent years for its immense profitability. Compared with traditional low frequency trading, the key innovation of high frequency trading is the high turnover of capital in rapid computer-driven response to fast changing market conditions. Instead of holding their trading positions for days or weeks as traditional money managers do, High frequency traders execute multiple trades each day or even each minutes, gaining very little percent of return per trade. Intraday trading can be divided into several categories by holding period, as shown in the following table.

Table 1 Intraday trading categories

Holding period	Description	Strategies utilized
Less than 1 min	Quantitative algorithms for optimal pricing and execution of market-making positions	Automated liquidity provision
1 min-10 min	Identifying trading party order flow through reverse engineering of observed quotes	Market microstructure trading
10 min- 1 hour	Short-term trading on macro events	Event trading
1 hour- 1 day	Statistical arbitrage of deviations from equilibrium: triangle trades, basis trades, etc.	Deviations arbitrage

Taylor [15] introduced five univariate exponentially weighted methods in the forecasting of intraday time series that contain both intraweek and intraday seasonal cycles. Several applications of these methods like the prediction of call center arrivals, email traffic and electricity loads were mentioned in this paper, it would be interesting to test these models with high frequency financial series. Robert and Magdalena [16] decomposed the volatility of high frequency asset returns into multiplicative easily interpreted and estimated components and applied their volatility forecasting model to a comprehensive sample consisting of 10 minutes returns on more than 2500 US equities. This novel intraday volatility forecasting model could of great help to computerized high frequency trading which depends on volatility forecasts. A much more comprehensive review on high frequency trading is conducted by the FIA in 2013 and the download link is listed in the reference [17].

The main point to take from the above literature review is that a tremendous amount of work has been done on the profitability of technical trading rules such as moving average, however, most of the studies focusing on the long term profitability and most the data sets utilized were past daily, weekly monthly or even yearly data, in this paper, intraday day systems are built to fully exploit the short term prediction advantage of technical analysis.

III. DATA AND METHODOLOGY

3.1 Data set used in this paper

Of all the financial time series, Index Future is one of the most active trading targets that enjoy high trading volumes in both developed and emerging market. For our empirical analysis, we use intraday 1 minute data of the CSI 300 Index Future. The CSI 300 Index Futures is electronically traded at the China Financial Futures Exchange. The underlying asset of this futures contract is CSI 300 index; and the contract multiplier is Y300 per index point. As an emerging index future markets, many arbitrage opportunities may exist since the contract was not introduced until 2010. The 1 minute data of IFLX0 from 20150901 to 20151030 will be used in this paper to test the moving average trading rules. The first month of the data (20150910 to 20150930) will be used to train the model to find out the optimal lag value for each kind of moving average. The second month of the data (20151001 to 20151030) will be used to conduct the out of sample test. The out of sample performance of each kind of moving average will be compared with each to find out the best available moving average. The daily candle stick figure of the data set with moving average line is shown in the following picture.

Fiture 1 candle stick fiture of the data set

3.2 Three kinds of moving average

Basically, three kinds of moving average will be used in this paper, namely the simple moving average, the exponential moving average and the smoothed moving average.

A Simple moving average, also known as an arithmetic average is formed by computing the average price of an asset over a specific number of periods. Each price in the data series is equally weighted, no weighting factors are considered. As most moving averages are based on closing prices (some more representatives of the prices from a certain trading period will be considered in further study), a simple moving average is calculated by adding the closing price of the security for a number of time periods and then dividing this total by the number of time periods. Short-term averages respond quickly to changes in the price of the underlying, while long-term averages are slow to react [18].

Exponential moving average, known as EMA, is a type of moving average that is similar to a simple moving average, except that more weight is given to the latest data. EMA is a member of weighted moving average, EMA reduce the lag of SMA by applying more weight to recent prices. The weighting applied to the most recent price depends on the number of periods in the moving average. The three steps to calculate the EMA is shown below.

(1), Calculate the SMA

SMA= Sum(N periods of prices)/N (1)

Sum() is a function to calculate the sum of the values.
N is the number of lag periods to be considered.
SMA is used as the previous period's EMA in the first calculation. (2), Calculate the weighting multiplier

Multiplier: 2/(N+1) (2)

(3), Calculate the EMA

EMA=(close-EMA(previous period))*Multiplier + EMA(previous period) (3)

Close is the close price for each period, Multiplier is calculated in the second step The last moving average used in this paper is the Hull moving average. The Hull Moving Average makes a moving average more responsive while maintaining a curve smoothness. The formula for calculating this average is as follows:

HMA(i)=SMA((2*SMA(CLOSE,N/2)-SMA(CLOSE,N), SQRT(N)) (4)

Where

HMA(i) is the hull moving average;
SMA() is the function to calculate simple moving average, the first parameter is the data series, the second parameter is the lag value;
N is the number of lag;
CLOSE is the data series.

3.3 Moving average trading

Moving average trading is a practice of systematically or programmed trading of buying and selling whenever the price crosses its average. The trading logic is that at each point in time, the price is either in an uptrend or in a downtrend. An uptrend is a period when prices are rising and a downtrend is a period when prices are dropping. There are various kinds of moving average trading strategies in consideration of the number of the moving average line used. The most simple one is the one in which only one moving average is used, the current price is compared with the moving average value, if the price cut down through its average from above, a sell signal occurs, if the price cuts up through its average from below, a buy signal occurs.

Another commonly used trading strategy is the double crossover, in this strategy, two moving average is used, namely the long-lag moving average and the short-lag moving average. For double crossover strategy, when the short-lag moving average cut up

through the long-lag moving average, a buy signal is indicated, similarly, when the short-lag moving average cut down through the long-lag moving average, a sell signal is indicated. Triple crossover strategy can be built by adding another moving average into the trading decision making process, which is much more process. To simplify this study, only the one moving average method will be used in this paper.

IV. EMPIRICAL EXPERIMENT

To simplify the study, trading volume and bid-ask spread are not considered in this paper. For all of the three kinds of moving average, the first month's data will be used to find out optima lag value for each moving average. In terms of the intraday trading strategy, no position is held overnight. The trading process is illustrated in the following figure.

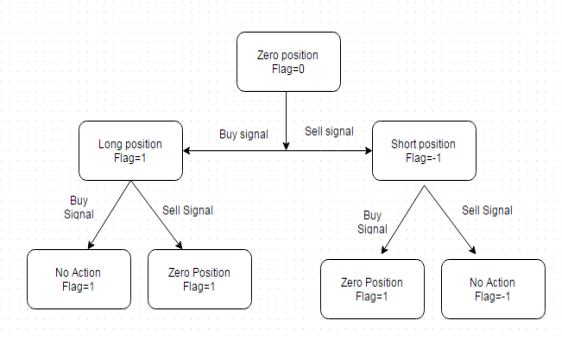


Figure 2 Trading process

At the end of each trading day, all positions will be closed.

The lag value for each moving average will be selected using the enumeration method from 3 to 30. The objective function of selecting lag value is to maximize the cumulative profit using the first month's data.

The value selected and the cumulative profit for each moving average is shown in the following tables.

Top 5 Net Profit of simple moving average is listed in table 2.

Table 2 Top 5 Net Profit of in sample test of SMA

Net Profit	Gross Profit	Gross Loss	Total Trades	% Profitable	Winning Trades	Losing Trades	Max Intraday Drawdown	lag (SMA)
591420.00	1826580.00	-1235160.00	1850.00	43.46	804.00	1008.00	-57180.00	3.00
520140.00	1589040.00	-1068900.00	1544.00	42.55	657.00	862.00	-65040.00	4.00
387600.00	1143900.00	-756300.00	802.00	39.03	313.00	475.00	-95100.00	10.00
340080.00	1180020.00	-839940.00	922.00	37.09	342.00	559.00	-80520.00	9.00
291720.00	1375860.00	-1084140.00	1383.00	38.54	533.00	823.00	-85500.00	5.00

Top 5 Net Profit of exponential moving average is listed in table 3.

Table 3 Top 5 Net Profit of in sample test of EMA

Net Profit	Gross Profit	Gross Loss	Total Trades	% Profitable	Winning Trades	Losing Trades	Max Intraday Drawdown	lag (EMA)
496020.00	1675680.00	-1179660.00	1753.00	41.07	720.00	997.00	-53040.00	3.00
342300.00	1430460.00	-1088160.00	1543.00	38.17	589.00	921.00	-78960.00	4.00
327120.00	1252500.00	-925380.00	1158.00	36.61	424.00	709.00	-87180.00	7.00
294780.00	1356780.00	-1062000.00	1425.00	37.33	532.00	860.00	-76260.00	5.00
293520.00	1291020.00	-997500.00	1288.00	35.87	462.00	796.00	-88020.00	6.00

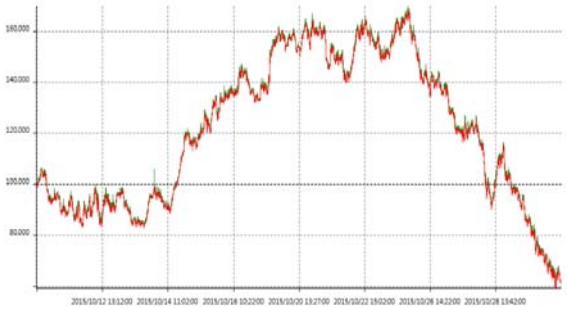
Top 5 Net Profit of hull moving average is listed in table 4.

Table 4 Top 5 Net Profit of in sample test of HMA

Net Profit	Gross Profit	Gross Loss	Total Trades	% Profitable	Winning Trades	Losing Trades	Max Intraday Drawdown	lag (HMA)
291180.00	1408860.00	-1117680.00	1149.00	41.86	481.00	647.00	-52980.00	16.00
102540.00	753720.00	-651180.00	359.00	42.34	152.00	206.00	-83700.00	26.00
69540.00	185880.00	-116340.00	20.00	55.00	11.00	9.00	-101520.00	5.00
69540.00	185880.00	-116340.00	20.00	55.00	11.00	9.00	-101520.00	6.00
69540.00	185880.00	-116340.00	20.00	55.00	11.00	9.00	-101520.00	7.00

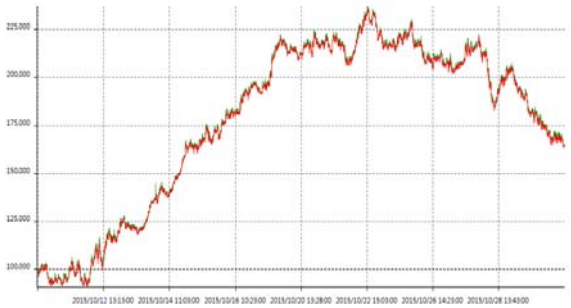
In the one month out of sample trading test, the lag value with the highest net profit in the training period is selected.

The detailed equity curve for out of sample simple moving average with lag value of 3

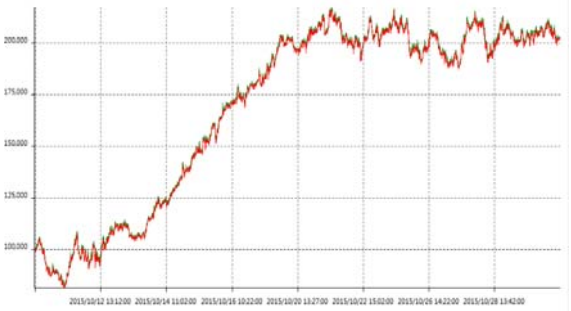


Figre 3 out of sample equity curve of the SMA strategy

The detailed equity curve for out of exponential moving average with lag value of 3



Figre 4 out of sample equity curve of the EMA strategy



Figre 5 out of sample equity curve of the HMA strategy

As shown in Figure 3-5, the out of sample perfomance of SMA strategy suffered a great loss in the last few trading days, which resulting to a total of loss in the out of sample period. The drawdown of the EMA strategy is samller than the SMA strategy, and is able to matain a ganing position in the out of sample period. Compared with the other two moving averge strategy,

the HMA strategy has a much more stable perfomance during the out of sample period.

The out of sample performance of EMA and HMA strategies are inconsistent with weak-from market efficiency hyphtesis as the trading decisions are simply made with historical data.

CONCLUSION

The advantages of using moving averages need to be weighed against the disadvantages. Moving averages are trend following, or lagging, indicators that will always be a step behind. As with most technical analysis tools, moving averages should not be used on their own, but in conjunction with other complementary tools.

The out of sample performance of EMA and HMA trading strategy indicate that the China CSI index future market is not weak-form efficient. With the simple EMA and HMA trading strategies, cumulative profit can be gained from the market. However, much more experiments must be done before these trading systems are deployed into real trading environment. This is because that the experiment results may suffer from over fitting problem and that emerging market assets are heavily influenced by the government policy, past trading environment may be different with the current one.

This paper is just part of my research, some more complicated trading systems are being tested.

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