

RISK CONTROL IN ALGORITHMIC TRADING USING FIBONACCI SERIES

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ABSTRACT

Algorithmic trading has attracted a great deal of attention in stock market especially after 2000. It offers numerous advantages over traditional trading such as less transaction cost, higher speed, and higher accuracy. One of the important building blocks of each trading strategy in algorithmic trading is the risk control part. It protects a strategy from losing the obtained benefits. In this article, a new algorithm using Fibonacci summation series is proposed to better control the amount of loss in trading. The research results show that the proposed algorithm leads to a higher benefit compared to traditional algorithms such as Simple Moving Average with Average True Range Stop-Loss and Exponential Moving Average with Average True Range Stop-Loss.

Keywords: Algorithmic Trading; Risk Control; Fibonacci Summation Series; Trading Strategy

1. INTRODUCTION

Algorithmic trading or Black Box trading has become the main focus of financial institutions such as mutual funds, hedge funds and investment banks. It constitutes approximately 50 to 60 percent of all stocks traded in the United States and European Union (Hendershott, 2011). Rapid cost reduction, higher probability of successful trade execution, anonymity, secrecy, and globalization are only a small set of algorithmic trading advantages (Leshik, 2011). Yet, these factors alone could not guarantee the profitability of a trade which is the ultimate goal of each trading order. Algorithmic trading is also of major concern to market stakeholders because, for example, Dow Jones Industrial Average dropped 600 points in a very short period of time in 2010 Flash crash (Narang, 2009) resulted in loss of \$600 billion in the value of US corporate stocks (Nuti, 2011). Exit and stop-loss strategies are of critical importance because they are used

to determine when to take profit and when to leave the market at loss. Different types of entry strategies such as moving average and volatility break out and also exit strategies such as Average True Range Stop-Loss (ATR-SL), and price target have been proposed and used so far. In this article, a new algorithm which uses the Fibonacci Summation Series is proposed as an exit strategy to set a dynamic limit for downward trends. The goal is to achieve a better control of the loss in trading.

The rest of the paper is organized as follows. In section 2, a literature review about two types of algorithmic trading including High Frequency Trading (HFT) and Quantitative Trading (QT), different parts of a trading strategy, and a number of the most widely used entry strategies such as simple, exponential and weighted moving average is provided. Section 3 will cover the idea of using Fibonacci summation series in stock market trading. In section 4, the proposed method used to limit the losses of a trade as well as data collection and data analysis of the achieved results is discussed. Finally, in section 5, the conclusion and future research pathway are discussed.

2. LITERATURE REVIEW

A. Algorithmic Trading

Human traders are always affected by emotional factors which may result in making incorrect decisions in trading. Algorithmic trading can execute complex math in real time and make decision without human intervention and send the trade orders automatically to the exchange. Furthermore, computers can handle hundreds of issues simultaneously using algorithms. Developments in the computer technology that facilitated real-time analysis of price movements along with the need to reduce the emotional effects of human traders in such a competitive market have made the algorithmic trading an absolute necessity for survival.

There are two types of algorithmic trading that are different in some senses. The first is called High Frequency Trading (HFT). The main goal of High Frequency trading is to earn a lot of small returns in a very short period of time like a few seconds or even milliseconds. HFT technological costs are enormous, and there is a close competition amongst firms. In order to extract small returns, the algorithm must be executed very quickly, which requires high CPU performance and memory handling. Since these algorithms are so effective at moving capital, they have become quite controversial because retail investors are not able to compete. These algorithms can simultaneously process large volumes of information at a rate no human can process, giving investment firms a huge advantage. Despite the mentioned advantages, these algorithms add an extra element of volatility and have been at least partially responsible for market crashes in the past. In a crisis, these HFT algorithms liquidate positions in seconds

causing huge price swings. Several European countries and Canada are banning HFT due to concerns about volatility and fairness of its performance. The system is not “smart” and does not provide real insight for investors because it blindly follows short-term trends. The second form of algorithmic trading is called quantitative trading (QT). This form provides valuable market insight to retail and professional traders. These algorithms analyze the structure and the trends in the market and then find predictable patterns. Investors can trade upon these machine-derived forecasts. The algorithm has a built-in general mathematical framework that generates and verifies statistical hypotheses about stock price developments. Machine learning tools such as artificial neural networks make this prediction system self-learning, and consistently determined to become more precise. QT follows price patterns in the market and then tests the trading strategy on historical data that is called back testing. If the result of back testing shows that the strategy could be profitable, trading orders will be generated and sent to the exchange. The last phase of QT is the post trade analysis which helps to improve the strategy (Leshik, 2011).

B. Trading strategies

Each trading strategy has three building blocks: entries, exits, and filters. Entries are the signals that indicate buy or sell orders are allowed to be placed. Exits indicate that the value of a trade has dropped to the point that the trade should be closed. Filters define a time interval within which the trades are expected to be profitable.

C. Trading strategy entries

Among many entry strategies used today there are some methods that make a foundation for other complex algorithms. Moving average, channel breakout, momentum, volatility breakout, and price oscillators are the important basic ones. In this paper Simple Moving Average and Exponential Moving Average are used.

Moving average

Moving averages whether simple, exponential, or weighted have been used for a long time by traders. It is a mean of a time series and recalculated each trading day. The simplest form, which is the simple moving average (SMA), is an average of close prices of a period recalculated every day.

$$\text{Simple N-day moving average} = \frac{1}{N} \sum \text{Close price } x$$

The next version of the moving average is the exponential moving average (EMA). It is calculated using today’s price value and yesterday’s moving average value. The smoothing factor, α , determines how quickly the exponential moving average responds to current market prices. Large values of α will track prices more closely than smaller values of α (Leshik, 2011).

$$EMA = X_t = (\alpha) Close_t + (1 - \alpha)CloseX_{t-1}$$

$$\alpha = \frac{1}{2 + days}$$

The third version of the moving average is called weighted moving average (WMA). Unlike simple moving average that weights each price equally, weighted moving average gives higher weight to more recent data points. The new forecast is equal to the previous forecast plus an adjustment which is calculated by multiplying the smoothing factor with the most recent forecast error. If the time series contains substantial random variability, a small value of the smoothing factor is preferred (Kestner, 2003) because if the fluctuation is the result of random variability, there is no need to react quickly.

$$WMA = \frac{1}{1+2+3+4} \sum 4 * Close_t + 3 * Close_{t-1} + 2 * Close_{t-2} + 1 * Close_{t-3}$$

In all versions of the moving average strategy, signals are triggered when prices cross above or below moving average. If prices cross above the moving average, prices rise more and it is a signal to buy. When prices cross below the moving average, lower prices is predicted and it is time to sell. Moving average of 20 to 100 days are usually used in practice because shorter time period will respond more quickly to the price changes. It is a simple and efficient algorithm for trading entries that follows trends. However, market prices are not completely predictable. Sometimes after an upward trend, prices quickly reverse and fall below moving average. This is the main drawback of the moving average that it cannot react to sudden movements of the price (Kestner, 2003).

The true range is the largest of the following values:

Today's high – today's low, Today's high- yesterday's close, yesterday's close- today's low.

The ATR is calculated taking the average of the highest true range over the number of days.

D . Trading strategy exits

Trading exits are signals to determine when to exit trades. Signals used to close profitable trades are called exits, and signals to close unprofitable trades are called stop-loss. A few popular exits include profit targets, trailing stops, and fixed value stop-losses (Kestner, 2003). In profit targets, if the profit reaches a certain point, the stock is going to be sold. The trailing and fixed stop-loss both protect the capital when the market starts moving downward. The trailing stop has an advantage over fixed value stop-loss because it is more flexible. Fixed value stop-loss, as its

name defines, sets a fixed value that if the price drops below it, a stop signal is triggered. Trailing stop-loss tracks the price and readjusts itself with the new prices.

E. Trading strategy filters

Trading entries and exits are signals to get in and out of the market, but trading filters are the time intervals when trading will end in higher profits. Trading filters in fact filter the entry signals. The two most widely used filters are the Vertical Horizontal Filter (VHF), and the Average Directional Movement Index (ADX). Filters allow only the trade signals that are greater than some thresholds to get in (Kestner, 2003).

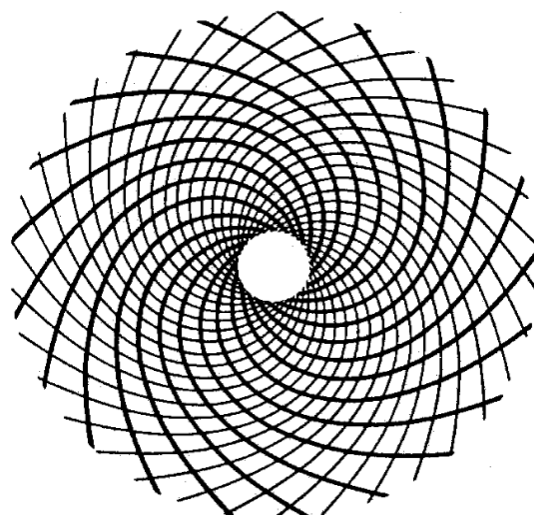
Fibonacci Summation Series

Leonardo Fibonacci is an Italian mathematician who developed the Fibonacci Summation Series (FSS) which runs as follows:

0, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ...

In FSS, each number is the result of summation of the previous pairs of numbers. This is also considered one of the most important mathematical representation of natural phenomena. The number of axils on the stems of many plants follow the FSS rule. The curving lines of sunflower which is shown in Figure1 has two sets of equiangular spirals: superimposed that turns clockwise and intertwined that turns counter clockwise. There are 21 clockwise and 34 counter clockwise that are both part of the FSS (Fischer, 2003).

Figure1. Rule of alternation in sunflower (Fischer, 2003)



FSS has some important characteristics that can be used in developing trading strategies. First, if numbers in the series after the first few numbers are divided by their immediate previous value, the result will oscillates around the ratio 1.618 which was named “divine proportion” by Luca Pacioli. Second, if numbers in the series, except for the first few numbers, are divided by their exact following number, the resulting proportion fluctuates around 0.618. Third, if the ratio between alternate numbers are measured, the result is 0.382. The 0.23 is the result of dividing a number in the series by the number that is three places to the right. Fibonacci ratios are divided into two groups of retracement and extension. Fibonacci retracement ratios are those that are lower than the 100% of a price swing, while extensions are those that are above 100% (Razaqazda, 2008). Fibonacci extension levels are used in trading as profit taking levels. Also Fibonacci retracements are typically used for controlling the loss. Important Fibonacci retracement levels are as follows:

$$0.236, 0.382, 0.618, 0.786, \dots$$

The following series is the important Fibonacci extension levels:

$$1, 1.272, 1.618, 2.618, \dots$$

Fibonacci retracement is created by taking the vertical distance between high and low in a trend and dividing the vertical distance by the Fibonacci key ratios of 0.236, 0.382, 0.618, and 0.786. Once these levels are identified, horizontal lines are drawn to define levels of support and resistance. These points are very important in stock market because they can be used to determine the points at which the price drops. It is assumed that the direction of the previous trend is likely to continue once the price has retraced one of the retracement ratios.

Fibonacci numbers f_n are obtained based on the following formulas:

$$f_0 = 0, f_1 = 1, f_{n+1} = f_{n-1} + f_n, \quad n \geq 1$$

$$\text{If } x^2 = x + 1, \text{ then we have: } x^n = f_{nx} + f_{n-1}, n \geq 2$$

$$\text{For } n > 2 \text{ we have } x^{n-1} = f_{n-1} + f_{n-2}.$$

Therefore

$$x^n = x_{n-1} \cdot x = f_{n-1}(x + 1) + f_{n-2}$$

$$x = (f_{n-1} + f_{n-2})x + f_{n-1} = f_{nx} + f_{n-1}$$

The n^{th} term of the Fibonacci series is given below:

$$F_n = \frac{1}{\sqrt{5}} \left(\frac{1 + \sqrt{5}}{2} \right)^n - \left(\frac{1 + \sqrt{5}}{2} \right)^n, n \geq 0$$

$$X^2 = x + 1,$$

$$\varphi = \left(\frac{1 + \sqrt{5}}{2}\right)^n,$$

$$(1 - \varphi) = \left(\frac{1 + \sqrt{5}}{2}\right)^n,$$

$$\varphi^n = \varphi f_n + f_{n-1},$$

$$(1 - \varphi^n) = (1 - \varphi)f_n + f_{n-1},$$

$$\varphi^n - (1 - \varphi^n) = \sqrt{5}f_n$$

Fibonacci ratios

Fibonacci ratios that are derived from Fibonacci series are calculated as follows:

$$F100\% = \left(\frac{1 + \sqrt{5}}{2}\right)^0 = 1,$$

$$F(n) = 1.000F(n),$$

$$F61.8\% = \left(\frac{1 + \sqrt{5}}{2}\right)^{-1} \approx 0.6181,$$

$$F(n - 1) = 0.618F(n),$$

$$F38.2\% = \left(\frac{1 + \sqrt{5}}{2}\right)^{-2} \approx 0.382,$$

$$F(n - 2) = 0.382F(n),$$

$$F23.6\% = \left(\frac{1 + \sqrt{5}}{2}\right)^{-3} \approx 0.236,$$

$$F(n - 3) = 0.236F(n),$$

$$F0\% = \left(\frac{1 + \sqrt{5}}{2}\right)^{-\infty} \approx 0,$$

$$F50\% = \frac{1}{2} \approx 0.5,$$

$$F(n + 1) = 1.618F(n),$$

$$F(n + 2) = 2.618F(n),$$

$$F(n + 3) = 4.236F(n).$$

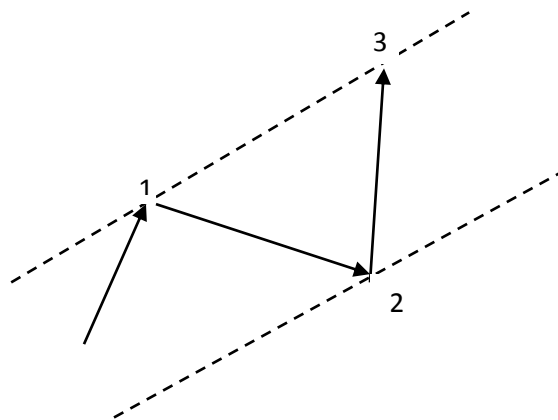
The 1.618 is called the Fibonacci Golden ratio.

4. PROPOSED ALGORITHM

There is an important theory in the field of technical analysis called Elliot Wave theory (Elliot, 1935). The Elliot Wave theory defines that price movements are the result of people's reaction to events (Allahyari, 2012). As a result, prices do not act randomly but follow a certain pattern. In other words, for each upward or downward movement there should be a movement in the opposite direction or there has to be a stimulus for that movement. That driver can be market rumors or other psychological factors. It has been shown by Hurst (Hurst, 1973) that the amount of movement can be interpreted using Fibonacci series characteristics such as retracement.

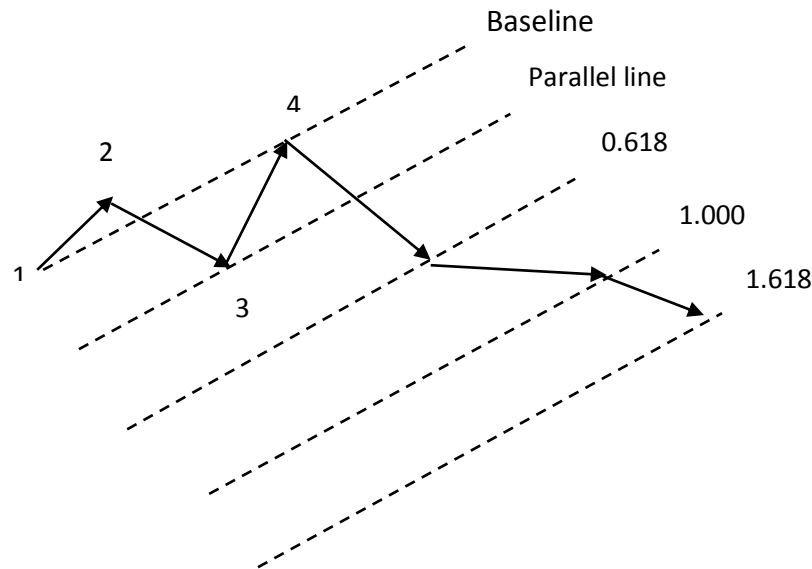
The main waves are called trend waves, and the waves of reaction that go in the opposite direction are called corrective waves. Trends that are also called impulses show the main direction of price whereas the correction waves go in opposite direction. Figure 2 shows an upward wave with two impulse and one corrections.

Figure 2. Upward trend with two impulses and one correction



Points 1 and 3 are in line with the trend and point 2 is the end of a corrective wave which is against the main trend. According to Elliot's theory, price movements in stock market or peaks and valleys in the trend follow Fibonacci retracement pattern. Additionally, every peak or valley is an indicator of what the majority of investors are thinking at any moment. When either of upper or lower channel line is broken, a new trend line can be drawn if the market price moves higher or lower. An alternative to trend channels is the Fibonacci channels that are shown in Figure 3.

Figure 3. Fibonacci channels



Fibonacci channels can better interpret the movements of the price in the market. In trend channels, outside points called peaks and valleys are isolated inside lines to come up with trend lines. However, in Fibonacci channels, lines are based on peak-to-valley and valley-to-peak connections. In figure 3, the parallel line is drawn in point 3 to determine the lowest limit of the trend. The vertical distance between the baseline and parallel line is called the Fibonacci channel width. The Fibonacci channel width can be used to calculate other lines based on Fibonacci retracement and extension ratios. The Fibonacci channel lines are used to generate buy and sell signals.

It is always hard to predict the trend of a price after a peak or valley whether to expect a higher or lower price. It may go in line with the previous trend or it may start a corrective wave in a trend and in the worst case, price may break the trend's border lines. If any of the mentioned cases happens to the price, Fibonacci channels are able to limit the amount of risk and generate appropriate buy or sell signals especially when the market starts downward swings. If drops in the price are not controlled, it might result in losing the most of the benefits achieved by the trading strategy. Each line of the Fibonacci channel can be used to trace the trend of the price. If the price suddenly drops two steps below, for instance, from parallel line to the 1.000 line, it can be a sign of reverse trend which may cause a lot of losses. These kinds of sudden drops are usually results of dissemination of news or other psychological factors in the market. Tracking all of the rumors and news in the market is not easy. Therefore, apart from the cause of the

direction of the trend, big movements indicate that market might not act as it used to be. Keeping the achieved benefits and preventing from big losses are critical in changing markets. In addition to entry signals that can help track changing market, reliable stop-loss rules can help control the risk of trading. It is never possible to know in advance whether a new break out is a start of an upward or downward trend.

The conservative approach to control the loss is to set two stop loss levels. The first level is when the price crosses down the 0.618 level, and the second stop-loss is set when the price touches the lowest line of the Fibonacci level, the golden ratio 1.618. The lowest line stop-loss is used for the worst situation such as Big Crash took place in 2010. In this Fibonacci based algorithm, three levels of Fibonacci channels, one retracement level, 0.618, and two extension levels, 1.000 and 1.618 are considered.

The proposed algorithm works as follows:

- 1- Calculate the downward swing size for each pairs of prices
- 2- Calculate the minimum swing size in the last 20 transactions and set it as the difference price
- 3- The minimum downward swing size is multiplied by 0.618 and then added to the current price to determine the first stop-loss point
- 4- The minimum downward swing size is multiplied by 1.168 and then added to the current price to determine the lowest stop-loss point

If the calculated price is bigger than the first stop- loss and crosses above the entry signal (based on the used algorithm each of the SMA and EMA can be used), then buy at the current price. Otherwise if the price is lower than the first stop-loss then sell, and if the price is equal or lower than the lowest stop-loss then stop trading.

A. Efficiency Factors

According to Karl popper's theory, achieving to the absolute truth is very difficult. He believed that theories could never be proved but they can be falsified through experiments. As a result of Popper's theory, this algorithm does not disprove any other algorithms, but it proposes a strategy that has shown acceptable results relative to the similar algorithms. It should also be considered that back testing a strategy does not mean that the strategy will necessarily do the same in the future. But it is predicted to have the same trend.

Considering above, we will be comparing and evaluating the proposed strategy with SMA and EMA with ATR-SL. In order to evaluate the efficiency and performance of a trading strategy, some of the efficiency factors should be defined. The performance measure used in this paper are number of winning and losing trades, profit factor, gross profit and loss, and net profit. Net profit, one of the famous performance measures, is the amount earned or lost in the process of the back-test. Although it is an important measure of earned money in back testing, it does not take the risk of trading into account. Another important performance measure is the profit factor. It is the proportion of total profit earned on winning trades to the total loss on losing trades. Profitable strategies have profit factors of greater than one, and unprofitable strategies produce profit factors of less than one.

$$\text{Profit Factor} = \frac{\text{Gross Profit}}{\text{Gross Loss}}$$

B. Data collection

In order to implement and test the proposed idea, market data regarding AAPL symbol are used. The data is for the transactions made on AAPL between the years 1950 and 2015 on a weekly basis. The two algorithms of SMA with ATR-SL and EMA with STR-SL are compared to the proposed algorithm which is based on Fibonacci ratios and then different efficiency parameters of the algorithms are calculated. The goal is to compare the effect of using Fibonacci exit algorithm with SMA and EMA that use ATR-SL.

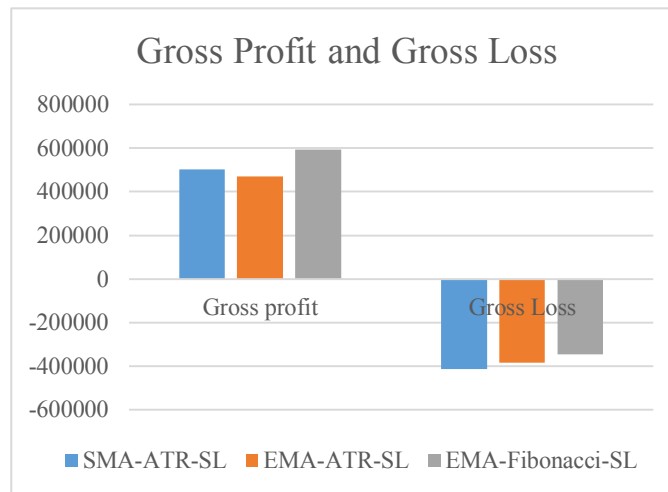
5. RESULTS AND DISCUSSION

Table1 compares three of the efficiency factors- number of winning trades, number of losing trades, and profit factor- are considered to compare the Fibonacci based algorithm with the others. Although the Fibonacci based algorithm does not have a considerable improvement over SMA and EMA, the number of losing trades has a considerable decrease. It shows that the algorithm can better trace the movement of the market in falling market and help the trading algorithm to stop the trading at correct times.

Table 1. Number of winning and losing trades and profit factor

	Number of Winning trades	Number of Losing Trades	Profit Factor
SMA-ATR-SL	1348	968	1.21
EMA-ATR-SL	1329	987	1.22
EMA-Fibonacci-SL	1378	678	1.32

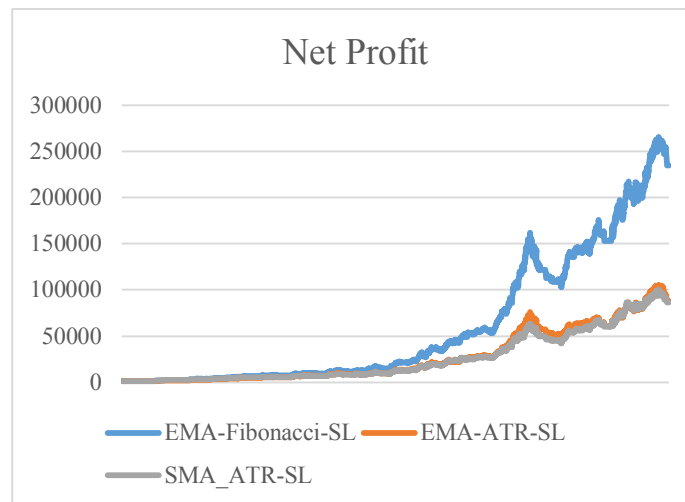
Figure 4. Gross Profit and Gross Loss



In order to measure the amount of profit, \$1000 is spent on the first day of the trade in 1950 and the achieved profit in 2015 is shown in Figure 4. This figure shows that in terms of profit and loss the proposed algorithm beats the others because it tries to trace the trends and then acts accordingly. Since the algorithm tries to prevent going into risky trades, its results can lead to a much better profit.

Figure 5 shows the trend of Net Profit between the years 1950 and 2015. The vertical axis shows the amount of earned net profit. Between the years 1950 and 2005, market had a relatively constant trend. After the year 2000, market prices rose considerably. Figure 5 shows this rise and the big difference between the proposed method and others. It indicates that when the market experiences movements, the proposed algorithm makes more net profits compared to the other ones because of the control channels of the Fibonacci ratios. This figure proves that leaving the market at certain point is a profitable strategy. Investors can use the stop-loss strategy to keep their earned profit and invest it in a time interval when the buying strategy signals to be profitable.

Figure 5. Net profit



6. CONCLUSION

In this paper Fibonacci ratios are used to create a channel of movements to control the downward movements of the price. The proposed algorithm can help traders to get more profit from their trades by controlling the amount of loss. In fact two limits are defined to get the required alert in case of big falls in market prices. Using these two limits shows that even in falling markets traders can make profit. Furthermore, a lowest limit help traders to get out of the market in worst cases such as 2010 market crisis. Another important point of this research is that the market prices whether upward or downward follow the Fibonacci retracement and extension levels. One possible research work for the future would be to set upper limits in upward trends to define a box of four sides which can control the upward and downward movements of the price. The upper side could be the maximum price a stock can achievement, and the low limits are the ones

that have been touched in this paper. Right and left limits are the time intervals when trends are formed in the market.

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