Appendix 1

Project Title	Support Resistance Relative Strength Trading Strategy in China's Financial Markets
Name	Zhou Shuai
Student ID	A0151236N
Itemized workload	
- Data collection	3 hours
- Literature review	12 hours
- Programming	22 hours (including 10 hours learning about how to use the trading system and 4 hours of code refactoring)
- Model testing	8 hours
- Model modification	9 hours
- Model Comparison	7 hours
- Output analysis	23 hours
- Report writing	30 hours
- Report formatting	5 hours
Total workload Sum of above	119 hours
Original contribution	This project has the following original contributions: - Design the parameters of the strategy - Programing strategy in matlab - Implement strategy via Quantrader - Analysing the back-testing results - Make improvement to the original strategy - Back-testing the strategy in different markets - Analysing outlooks for the strategy

FE5110 - Financial Engineering Project

Support Resistance Relative Strength

Trading Strategy in China's Financial Markets

Zhou Shuai (A0151236N)

Abstract

This project studies support resistance relative strength trading strategy by quantifying the support and resistance with daily high and daily low of the stock price in China stock and future markets and using the slope of the linear model as the indicator. The strategy produces annual excess yield of 5.96% in main board market but with maximum drawdown rate over 30%. By making further improvements with MACD, the strategy significantly lifts the sharpe ratio by 20.82% as well as decreases maximum drawdown rate by 80.75% without losing much profit. And the strategy also preforms better than the benchmark index in small and medium enterprise board market, second board market and future market by 2.61%, 3.16% and 15.19% annually. However, the strategy is not very efficient in the future market with negative profit and sharpe ratio. Therefore, the strategy should make further modification.

Contents

1 Description of the Trading Methodologies

Cognition of stock market fluctuation logic and law is a very challenging problem. There are two types of stock investment analysis methods: fundamental analysis and technical analysis [1].

(1) Fundamental Analysis

The main research object of fundamental analysis is the intrinsic value of the enterprise. It carries on the detailed analysis from the macroeconomic situation, industry development prospects, operating performance and other aspects to measure the long-term investment value and margin of safety of listed companies. At the same time, it compares the investment value with the current stock price to form a corresponding investment advice. The fundamental analysis suggests that stock price movements cannot be accurately predicted. However, the stock can only be bought and held in the long term with sufficient margin of safety, and sold after the margin of safety has disappeared.

(2) Technical Analysis

The main research object of technical analysis is intuitive behavior of the stock price and volume with their rise and fall. Unlike the fundamental analysis measuring the intrinsic value of a stock, the technical analysis uses charts, indicators and other tools of the past data to identify patterns and trend as a prediction for price movement. There are three controversial assumptions about technical analysis, 1) market behavior discounts everything, 2) prices fluctuate in a trend manner and 3) history repeats itself.

1.1 Support and Resistance

In technical analysis, support and resistance is a pair of very important concept. Basically, it says that when the price is close to a pre-level of support or resistance, the movement tends to stop and reverse.

A support level is a level where the price will stop decrease when the price falls near. In this situation, the price is more likely to bounce back than to continue to fall because investors tend to buy near this level. However, once this level is broken through over a certain amount, the fall will continue until it reaches another support level.

A resistance level is the opposite of a support level where the price will stop increase when the price rises near. In this situation, the price is more likely to bounce back than to continue to rise because investors tend to sell near this level. However, once this level is broken through over a certain amount, the rise will continue until it reaches another resistance level.

In fact, the most common support and resistance strategy is moving average. When the price is below the average line, the average line is the resistance level. When the price is above the average line, the line is the support level. For example, one simple strategy would be that when the price breaks through 20-day moving average line, buy the stock. Until the price drops below 20-day moving average line, sell the position. The moving average strategy perform well especially in a trend market. However, the trading cost can be tremendous which significant impairs the net value of the position.

Having evolved from the simple moving average, bollinger bands uses a bandwidth to measure the support and resistance. The strategy is not as sensitive to trading cost as moving average. However, sustained losses occurs during the oscillation because of the lagging indicator.

1.2 Relative Support and Resistance

From the analysis above, the moving average strategy and bollinger bands strategy both consider support and resistance level as a threshold of the price range. In order to improve the strategy, it is better not to consider the support and resistance level as a fixed value, but rather as a variable, in other words, focus more on the relative strength between the support level and resistance level.

If the strength of the support level is weaker than the resistance level, it indicates that the market participants are more divided on the support level than the resistance level, and the market is inclined to shift towards the bear market. And if the support strength is stronger than the resistance, the market participants recognize more on support level, the market tends to be a bull market.

1.3 Quantify Support Resistance Relative Strength

As mentioned earlier, in the technical analysis, there are many definitions of support and resistance level. The goal is to find a proxy variable that can reflect its variable nature better. The daily highest price and lowest price can satisfy this demand since they can quickly reflect the recent market's attitude towards resistance and support. From the formation mechanism of the highest and the lowest price, daily highest and lowest price is a kind of resistance and support level that recognized by the trading behavior of market participants.

I use the degree of the relative position, that is, similar to the $\frac{\Delta high_t}{\Delta low_t}$ (when lowest price change one unit, the change of the highest price) to describe the relative strength of the support and resistance level. In fact, delta $\frac{\Delta high_t}{\Delta low_t}$ is the slope of the two points (low_0, $high_0$) and (low_1, $high_1$). Because of the noise of the market price, the slope of the two points also contains too

much noise. Thus, I consider the most recent N data points of (low_t, $high_t$) to get the efficient relative strength and use linear regression.

I set up the following linear model,

$$high_t = \alpha + \beta \cdot low_t + \varepsilon_t \tag{1-1}$$

β is the slope needed. When β is very large, the support strength is stronger than the resistance strength. The highest price increases faster than the lowest price.

In order to eliminate the influence of dimension and make every model regressed comparable if I modify the original model later, it is better to normalize the linear model above. Standard deviation normalization is to take the observed value of a variable minus the average of that variable, and then divide it by the standard deviation of the variable. That is,

$$Y_i^* = \frac{Y_i - \bar{Y}}{S_Y}$$

After standard deviation normalization, one half of the observation values of the variable will be less than 0, the other half of the observation values are greater than 0. The mean value of the variable is 0, and the standard deviation is 1.The standardized data is pure quantity without unit. Standard deviation standardization of variables can eliminate the influence of dimension and their own variation [2]. Therefore, I set up the new normalized linear model as follow,

$$high_t^* = \frac{high_t - \overline{high}}{S_{high}}$$

$$low_t^* = \frac{low_t - \overline{low}}{S_{low}}$$

$$high_t^* = \beta \cdot high_t^* + \varepsilon_t \tag{1-2}$$

In the rising bull market and in the fall bear market, large β is likely reflecting the two kinds of trends in the following figure 1-1 and 1-2. In the bull market, the resistance is getting

smaller and the upward space is getting larger. In bear market, the support is getting stronger, the decline momentum is about to stop.

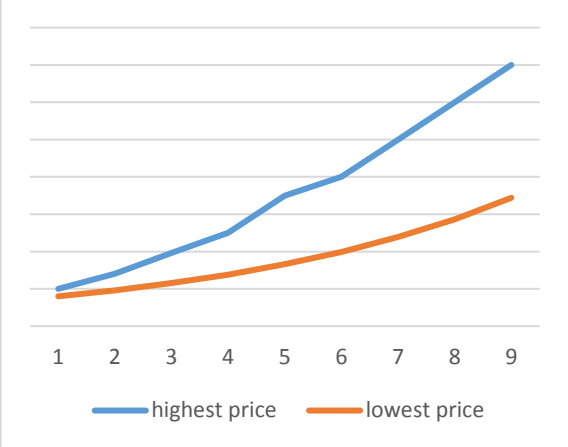

Figure 1-1 Large β in Bull Market

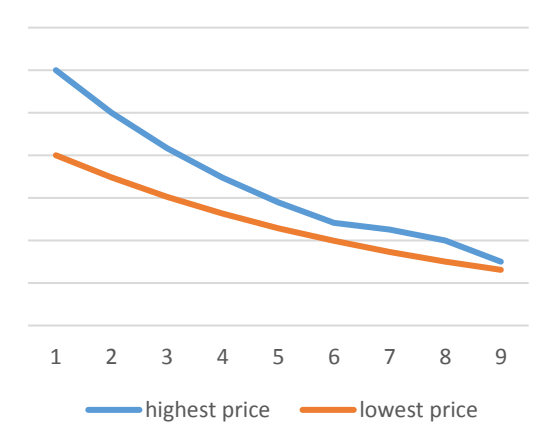

Figure 1-2 Large β in Bear Market

When β is very small, the resistance strength is stronger than the support strength. The highest price changes slower than the lowest price. In the rising bull market and in the fall bear market, it is likely reflecting the two kinds of trends in the following figure 1-3 and 1-4. In the bull market, the resistance is stronger and the upward momentum is gradually ending. In bear market, support is gradually becoming weaker and the down space is growing.

Figure 1-3 Small β in Bull Market

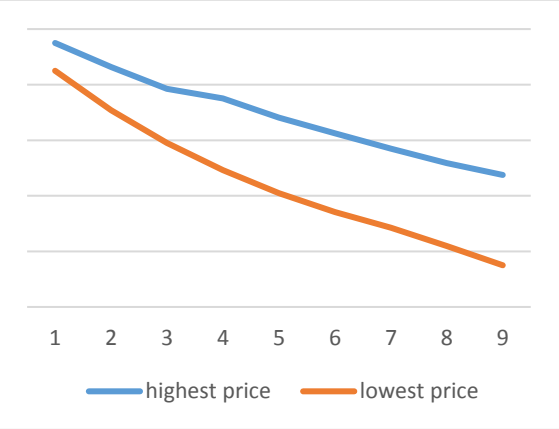

Figure 1-4 Small β in Bear Market

1.4 Trading Logic

1）Variable Assignment

Export the N days of the daily highest price and the daily lowest price as variable *hip* and *lop*.

2）Initialization

The initial position is 0 or it will be assigned to the last day's position.

3）Trading rule

First, fit the model 1-2 with variable *hip* and *lop* to get β. If β is larger than Level 2, open a position with 80% amount of the account balance. If β is lower than Level 1, close all the position. In the next chapter, I will study the statistical characteristics to decide the parameters Level 1 and Level 2.

The trading logic is showing in the flow figure 1-5.

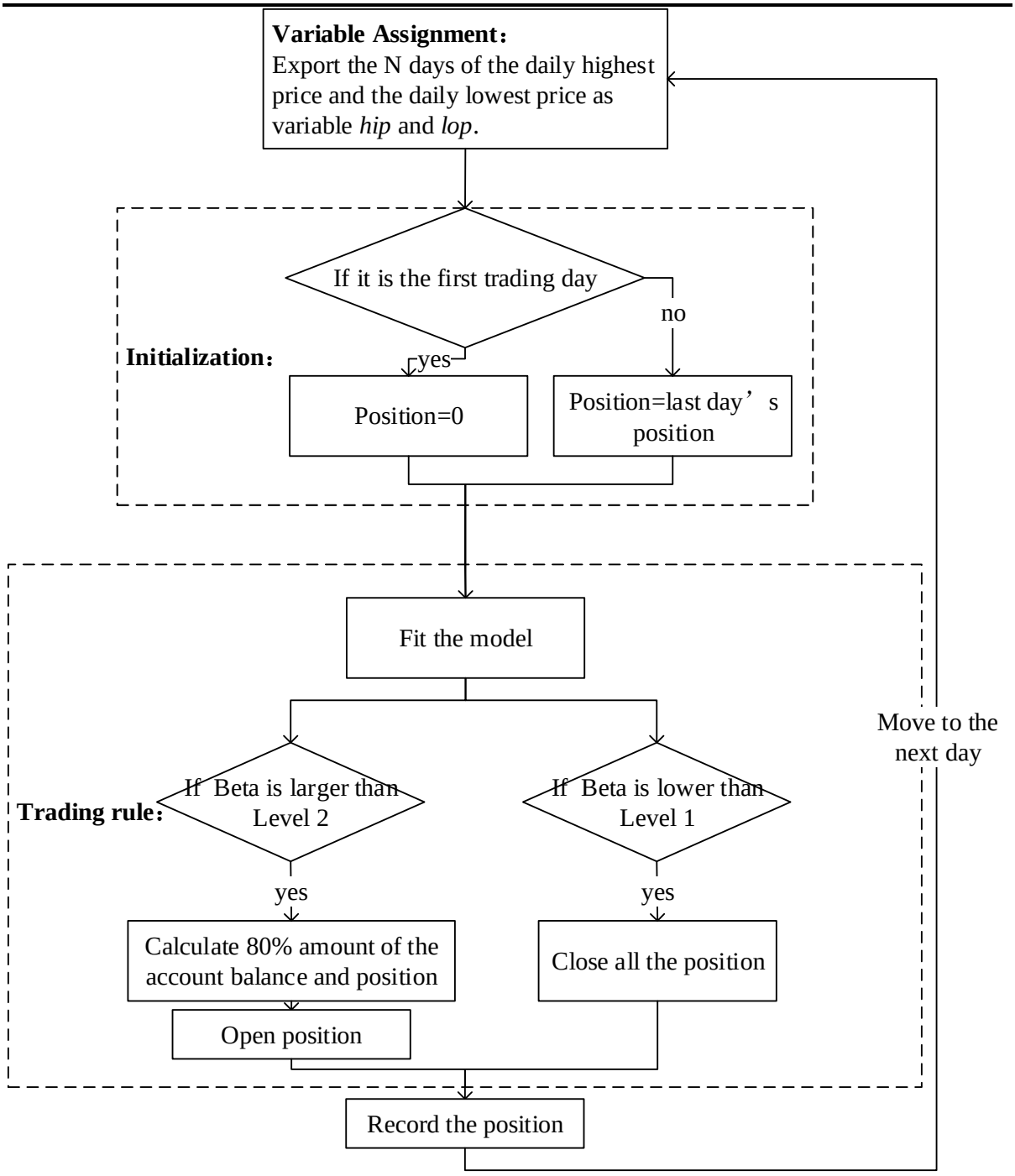

Figure 1-5 Trading Logic

2 Strategy Implementation

2.1 Data Selection

Considering the availability of the data, I choose CSI 300 as the trading object and 04/01/2006 to 03/07/2017 as the trading period. The CSI 300 is a capitalization-weighted stock market index that compiled by the China Securities Index Company. It is designed to replicate the performance of 300 stocks traded in the Shanghai and Shenzhen stock exchanges in China. The CSI 300 sample covers the market value of about 60% of the Shanghai and Shenzhen market and has a good market representation for main board market in China.

2.1.1 Determination of N

In the strategy, I use previous N days of daily high and low to fit model 1-2 and get β to compare with Level 1 and Level 2.

First, the selection of N cannot be too small, or it cannot filter out enough noise. At the same time, it cannot be too big since what I want to get is the relative strength of the support resistance that reflects the current market. If the value is too big, then the lag will be too much. As a result, I set N=15 as the initial value to filter out the noise and avoid lagging too much.

2.1.2 Determination of Level 1 and Level 2

In order to find a reasonable threshold, it is necessary to observe the historical data distribution of β.

The following figure and table are based on the results of program *beta.m* and *main.m*.

beta.m

```
1
2       %function for calculating beta and its statistical characteristics
3
4       function [mea, med,sd,ske,kur,l1,l2] = beta(data,qt1,qt2)
5
6       %set window length=15
7         n=15;
8
9       %find the size of the object data
10        siz=size(data);
11
12      %calculate beta each day
13        for i=(siz-n):-1:1
14            hip=data(i:i+n,2);
15            lop=data(i:i+n,3);
16            hip=(hip-mean(hip))/var(hip);
17            lop=(lop-mean(lop))/var(lop);
18            c=polyfit(hip,lop,1);
19            ratio(i)=c(1);
20        end
21
22      %plot the histogram of beta
23        histfit(ratio);
24
25      %calculate the statistical characteristics of ratio
26        mea=mean(ratio);
27        med=median(ratio);
28        sd=std(ratio);
29        ske=skewness(ratio);
30        kur=kurtosis(ratio);
31
32      %calculate level 1 and level 2
33        l1=quantile(ratio,qt1)-ske*0.1;
34        l2=quantile(ratio,qt2)-ske*0.1;
35      end
```

main.m

```
1       %load data
2       load('HS.mat');
3       %calculate beta
4       [mea1,med1,sd1,ske1,kur1,l11,l21]=beta(data,0.25,0.75);
```

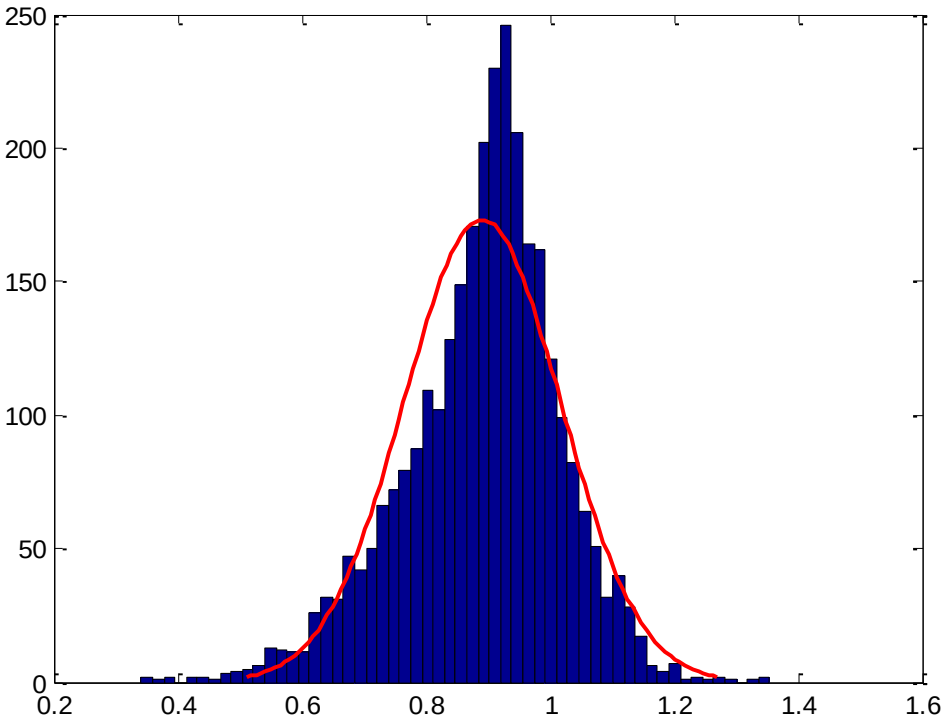

Figure 2-1 Distribution of β

Table 2-1 Statistic of β

Statistic	Value
Mean	0.8908
Median	0.9069
Standard Deviation	0.1266
Skewness	-0.5130
Kurtosis	3.8895

From the statistics, a sensible threshold would be 25% quantile and 75% quantile of the distribution of β. However, after considering the skewness, left shift the threshold by 10% of skewness to get the threshold. That is to say, Level1=25% quantile -10%*skewness=0.8707, Level 2=75% quantile-10%*skewness=1.0227.

2.2 Back-testing

I use quantitative trading system Quantrader to write and back test the strategy. Quantrader supports writing and back-testing trading strategy in Matlab. The program files are in folder *srrs*. The main function is showing below.

```
function [ newStateMatrix ] = srrs( decisionData, stateMatrix )

% set Level 1 and Level 2
    l1=0.8707;
    l2=1.0227;

% get exchange number, stock code of the trading object
  exchange=decisionData.tickerMap{1,2};
  symbol=decisionData.tickerMap{1,3};

% get acount serial
  AccountSerialID=1;

% get 15 days data of daily high and daily low price of the trading object,
  hip=decisionData.HIP_DAY01.data;
  lop=decisionData.LOP_DAY01.data;

% standardize the original hip and lop
  hip=(hip-mean(hip))/var(hip);
  lop=(lop-mean(lop))/var(lop);

% fit the model and get beta
  beta=polyfit(lop,hip,1);
  beta=beta(1);


% the statematrix is empty for the first day, so the innitial position will be set to 0.
  if isempty(stateMatrix)
     stateMatrix.volume=0;
  end

% open a position with 80% amount of the account balance when beta is larger than l2
  if beta>l2
    vol=floor(AccountBalance(AccountSerialID)/hip(length(hip))*0.8);
    PlaceOrder (exchange, symbol,1,vol, 0, 1, AccountSerialID);
  end
```

```
37
38      % get positionid now, close all the position when beta is lower than l1
39 -      positionid = SelectPsnBySymbol(symbol, exchange, AccountSerialID,1 );
40
41 -      if (beta<l1)
42 -        ClosePosition( positionid, stateMatrix.volume, 0);
43 -      end
44
45      % record the position now and assign it to the new state matrix
46 -     if positionid>0
47 -        volume= PositionVolume( );
48 -     else
49 -        volume=0;
50 -     end
51
52 -     newStateMatrix.volume = volume;
53
54 -   end
```

2.2.1 Parameter Setting

1）Trading cost: 0.05‰ of the transaction amount.

2）Trading delay: one day after the trading rule is satisfied.

3）Trading price: volume weighted average price of the next day.

4）Initial equity: RMB 100,000

2.2.2 Back-testing results

During the back testing period, the support resistance relative strength strategy trades 40 times in total. The cumulative yield is 585.17%. In contract, the cumulative yield for CSI 300 is 287.80%. The annualized yield is 18.97% and the annualized yield for CSI 300 is 13.01%. The annual excess yield is 5.96%. The maximum drawdown rate is 36.62%.

Table 2-2 Back-testing Results

Item	Value	Calculation
Initial equity	100000.00	Initial equity

Final equity	685171.02	The final equity includes profit and loss and trading cost when the back testing ends.
Cumulative profit	585171.02	Cumulative profit= Final equity- Initial equity
Cumulative yield (%)	585.17	$(1+r_1)\ (1+r_2)\ \cdots(1+r_{n-1})\ (1+r_n)$, r is daily yield.
Annualized yield (%)	18.97	Annualized yield=Cumulative yield $\times \frac{252}{\text{Tradind days}}$
Annual excess yield (%)	5.96	Annual excess yield =Annualized yield-Benchmark Annualized yield
Trading cost	1223.32	Sum of all the cost for trading.
Maximum drawdown start time	2008/1/14	The time for wave crest of this drawdown.
Maximum drawdown end time	2008/11/4	The time for wave trough of this drawdown.
Sharpe ratio	1.08	Sharpe ratio = (Annualized yield − Risk-free rate)/Standard deviation of yield
Profit factor	5.00	Profit factor =gross profits / gross losses
Sotino ratio	1.57	Sotino ratio = (Annualized yield – Benchmark yield) / square root of benchmark semi-variance
Omega ratio	21.19	The probability weighted ratio of gains versus losses for benchmark yield
Information ratio	0.10	Information ratio = (Annualized yield – Benchmark yield)/ Standard deviation of (Annualized yield – Benchmark yield)
Total number of transactions	40	The total number of opening positions
Average profit	14390.29	Average profit=Total profit/ Number of winning transactions
Number of consecutive winning transactions	8	Number of consecutive winning transactions
Number of consecutive losing transactions	2	Number of consecutive losing transactions
Maximum drawdown	104982.59	Maximum reversal in the direction of a stock's price that goes against the prevailing trend.
Maximum drawdown rate (%)	36.62	Maximum drawdown rate= Maximum drawdown / Total loss
Number of winning transactions	30	Number of winning transactions
Winning percentage (%)	75.00	Winning percentage =Number of winning transactions / Total number of transactions
Total profit	719388.71	Total profit
Average profit	23979.62	Average profit= Total profit / Number of winning transactions
Number of losing transactions	10	Number of losing transactions
Losing percentage (%)	25.00	Losing percentage =Number of losing transactions / Total number of transactions
Total loss	-143776.97	Total loss
Average loss	-14377.70	Average loss= Total loss / Number of losing transactions

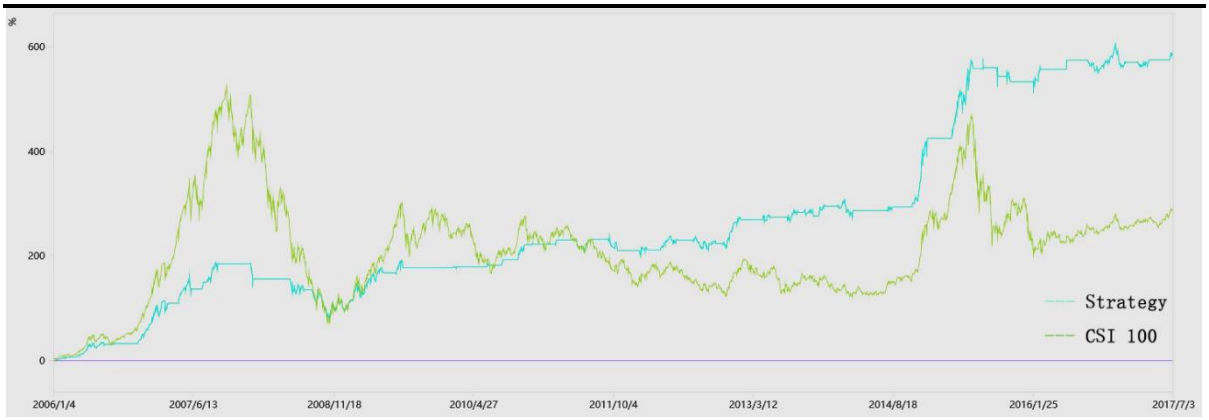

Figure 2-2 Cumulative Yields Compare between Strategy and CSI 100

From figure 2-2, it is clear to observe that this strategy keeps getting profit during the oscillation between 2009 and 2014. In addition, from table 2-2, the total number of transactions is not big. Thus, the trading cost does not have a big effect on the final yield. Further study on the sensibility of yield to trading cost also proves this. From table 2-3, when trading cost doubles from 0.05‰ to 0.1‰, the Cumulative yield only decreases by $\frac{585.17-583.42}{585.17} = 2.99‰$, the sensitivity is as low as 1.50‰.

Table 2-3 Cumulative Yield under Different Trading Cost

Trading cost (‰)	0.04	0.05	0.06	0.1	0.15	0.2
Cumulative yield (%)	585.3	585.17	584.9	583.42	580.91	578.19

In conclusion, the support resistance relative strength strategy overcomes the problem in traditional support resistance strategies mentioned in chapter 1.

3 Strategy Improvement

It is known that there is a big bear market from 16/10/2007 to 28/10/2008 of Chinese equity market. During this period, the market decreased for 73%. In this project, it can be called the bear market of 2008. In the original strategy, the maximum drawdown took place in the bear market of 2008 with a very large maximum drawdown rate of 36.62%. The strategy tries to buy when the market is still going down and when it finds the signal to sell the position, the loss is already significant. So it is vital to modify the original strategy to get rid of this weakness.

3.1 Strategy with R^2

3.1.1 Trading Logic

The original strategy uses linear fitting and the slope to quantify the relative strength of the support and resistance. Under this strategy, the efficiency of whether the slope could be an effective representative of the relative strength of the support and resistance is greatly affected by whether the linear model is fitted well or not. In linear regression, the R^2 (R-squared or coefficient of determination) is an indicator of how well observed outcomes are fitted by the setting model, based on the proportion of total variation of observed outcomes explained by the setting model. The value is in the range of [0, 1] and the larger R^2 is, the model fits better.

In order to weaken the effect of the fitting effect on the strategy, the modified strategy opens position when β is larger than level 1 as well as R^2 is larger than level 3. Under the modified strategy, it will not buy when the original β is big whereas the R^2 is small to

overcome the flaw of buying in the bear market.

The trading logic is showing in the flow figure 3-1.

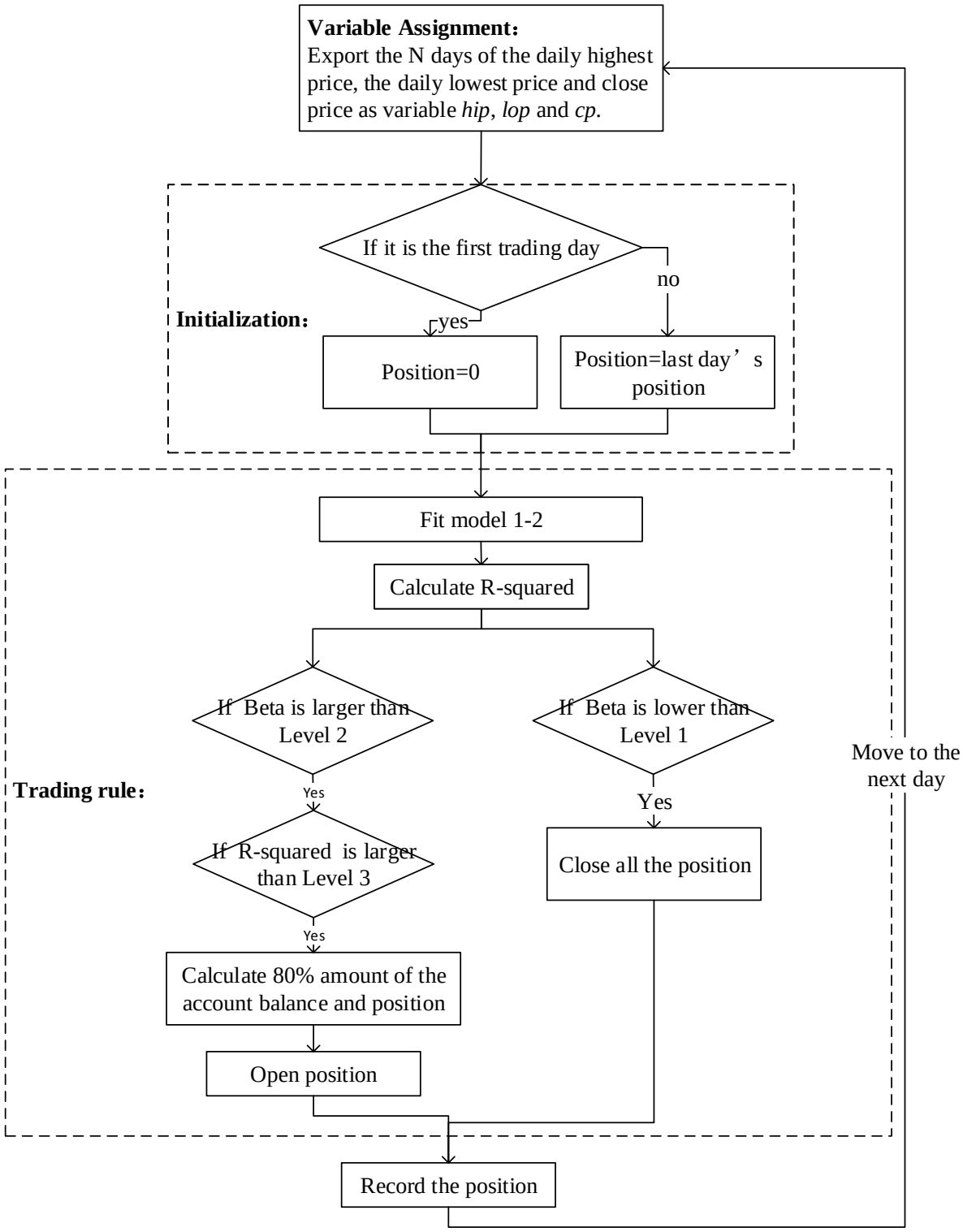

Figure 3-1 Trading Logic of Strategy with R^2

3.1.2 Determination of Level 3

Theoretically, R^2 lays between 0 and 1. According to the distribution and statistics of R^2, the mean of R^2 could be a reasonable threshold for filtering the efficiency of the model fitting. Therefore, I set Level 3=0.8061.

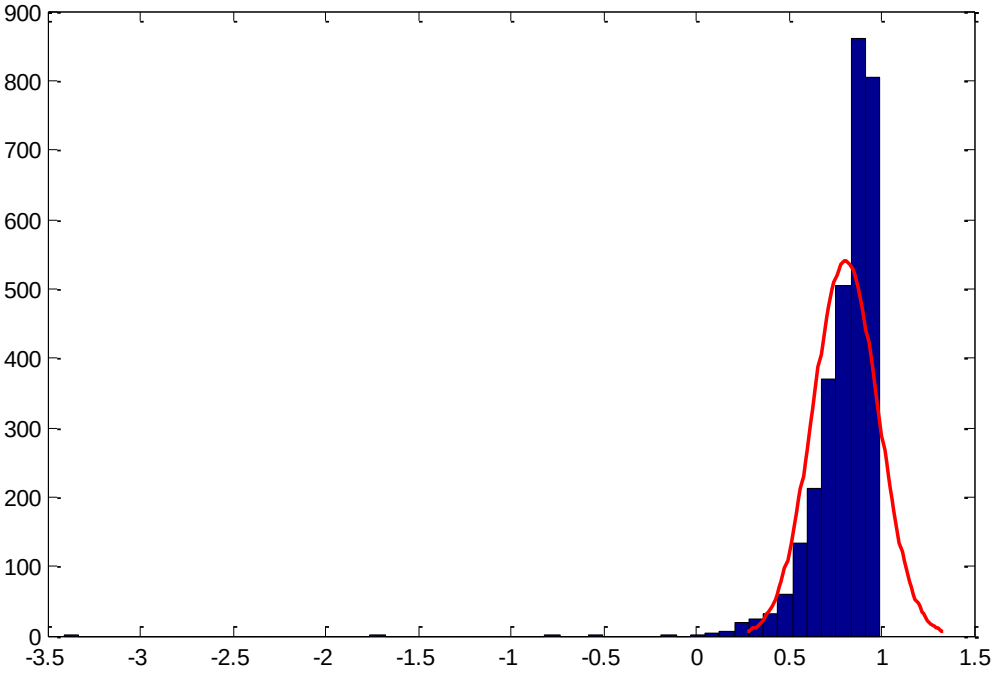

Figure 3-2 Distribution of R^2

Table 3-1 Statistics of R^2

Statistic	Mean	Median	Standard Deviation	Skewness	Kurtosis
Value	0.8061	0.8532	0.1763	-6.731	127.627

3.1.3 Back-testing

The program files are in folder *srrs with R2*. The main function is showing below.

```
function [ newStateMatrix ] = srrs( decisionData, stateMatrix )

% set Level 1, Level 2 and Level 3
 l1=0.8707;
 l2=1.0227;
 l3=0.8061;

% get exchange number, stock code of the trading object
  exchange=decisionData.tickerMap{1,2};
  symbol=decisionData.tickerMap{1,3};

% get acount serial
  AccountSerialID=1;

% get 15 days data of daily high and daily low price of the trading objec
  hip=decisionData.HIP_DAY01.data;
  lop=decisionData.LOP_DAY01.data;

% standardize the original hip and lop
  hip=(hip-mean(hip))/var(hip);
  lop=(lop-mean(lop))/var(lop);

% the statematrix is empty for the first day, so the innitial position
% will be set to 0.
  if isempty(stateMatrix)
      stateMatrix.volume=0;
  end

% fit the model, get beta
  beta=polyfit(lop,hip,1);
  beta=beta(1);

% calculate R-SQUARE
  tss=0;
  ess=0;
  mhip=mean(hip);
  mlop=mean(lop);
```

```
38
39 –      for j=1:n
40 –        tss=(hip(j)-mhip)^2+tss;
41 –        ess=(lop(j)-mlop)^2+ess;
42 –      end
43
44 –      r2=ess*beta^2/tss;
45
46        % open a position with 80% amount of the account balance when beta is
47        % larger than l2 and R-SQUARE islarger than l3
48 –      if ((beta>l2)&&(r2>l3))
49 –        vol=floor(AccountBalance(AccountSerialID)/hip(length(hip))*0.8);
50 –        PlaceOrder (exchange, symbol,1,vol, 0, 1, AccountSerialID);
51 –      end
52
53
54        % get positionid now, close all the position when beta is lower than l1
55 –      positionid = SelectPsnBySymbol(symbol, exchange, AccountSerialID,1 );
56
57 –      if (mdfbeta<l1)
58 –        ClosePosition( positionid, stateMatrix.volume, 0);
59 –      end
60
61
62        % record the position now and assign it to the new state matrix
63 –      if positionid>0
64 –        volume= PositionVolume( );
65 –      else
66 –        volume=0;
67 –      end
68
69 –      newStateMatrix.volume = volume;
70
71 –    end
```

Before back-testing, we set level 1, level 2, N, trading cost, trading delay, trading price, initial equity as the same in chapter 2.2 to keep the back test results between modified Strategy and the original strategy comparable.

First, from table 3-2 the modified strategy works worse than the original strategy in that the cumulative yield is 345.79% compared to 585.17%. The annualized yield is only 1.37%

higher than the market annualized yield. In addition, total loss, number of losing transactions, single biggest loss and number of consecutive losing transactions are all higher than the original strategy.

Table 3-2 Back-testing Results of Modified Strategy and Original Strategy

Item	Modified Strategy	Original Strategy	Change
Final equity	445792.5559	685171.018	-34.94%
Cumulative profit	345792.5559	585171.018	-40.91%
Cumulative yield (%)	345.79	585.17	-40.91%
Annualized yield (%)	14.44	18.97	-23.88%
Annual excess yield (%)	1.37	5.96	-77.01%
Total profit	539552.1034	719388.7107	-25.00%
Total Loss	-199922.7675	-143776.9727	39.05%
Profit and loss ratio	2.6988	5.0035	-46.06%
Total number of transactions	38	40	-5.00%
Winning to losing ratio (%)	52.63	75	-29.83%
Number of winning transactions	20	30	-33.33%
Number of losing transactions	18	10	80.00%
Single biggest profit	94822.182	133424.7014	-28.93%
Single biggest loss	-29030.4437	-28982.9485	0.16%
Maximum profit/total profit	0.1757	0.1855	-5.28%
Maximum loss/total loss	0.1452	0.2016	-27.98%
Net profit/single biggest loss	11.9114	20.1902	-41.00%
Number of consecutive winning transactions	5	8	-37.50%

Number of consecutive losing transactions	4	2	100.00%
Trading cost	953.5651	1223.3205	-22.05%
Maximum consecutive losses	91734.5033	104982.5864	-12.62%
Maximum consecutive profit	145579.8122	273609.7959	-46.79%
Sharpe ratio	0.7851	1.0777	-27.15%
Average profit	26977.6052	23979.6237	12.50%
Average loss	-11106.8204	-14377.6973	-22.75%
Maximum consecutive profitability ratio (%)	26.98	38.03	-29.06%
Maximum drawdown rate	23.94	36.62	-34.63%
Maximum drawdown start time	2010/11/8	2008/1/14	/
Maximum drawdown end time	2014/3/20	2008/11/4	/

However, the maximum consecutive losses and average loss are lower. And the maximum drawdown rate is 34.63% lower. Additionally, when looking into figure 3-3, it is clear that the cumulative yield for modified strategy is higher than the original strategy during the bear market of 2008 in spite of its worse yield afterwards. Then, after taking a step to closely analyze the buy orders during the bear market of 2008 of the modified strategy and the original strategy, it can be seen that modified strategy places buy orders a little later than the original strategy although the two strategies both place buy order for three times from table 3-3. Secondly, the order volume for the earliest order in modified strategy is lower than the original strategy whereas the order volume for the latter order in modified strategy is higher than the original strategy. That is to say that the modified strategy tends to buy more when the decreasing trend is closer to the bottom and this explains why the modified strategy performs a little better during the bear market of 2008.

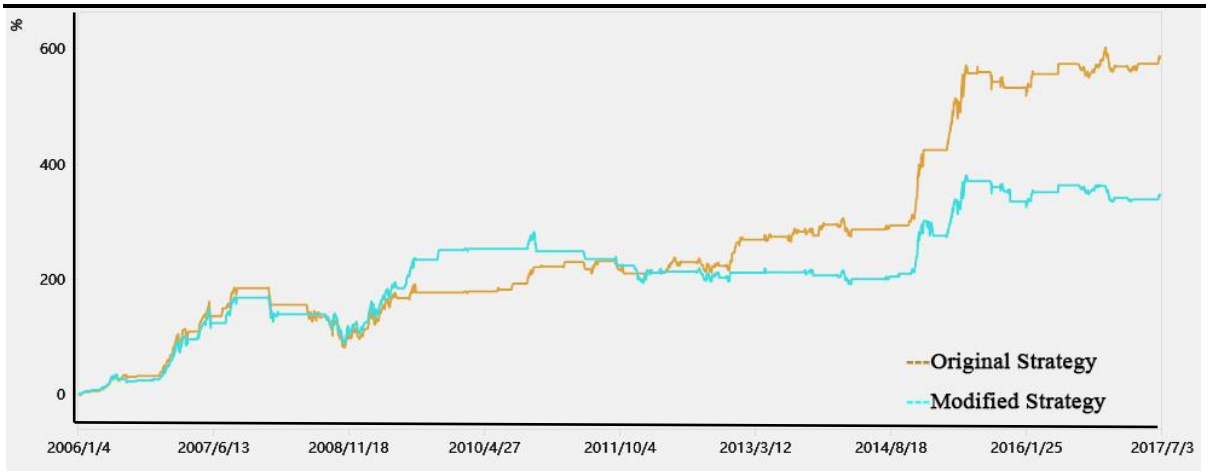

Figure 3-3 Cumulative Yield Compare between Modified Strategy and the Original Strategy

Table 3-3 Buy Order Record during Bear Market of 2008

Modified Strategy		Original Strategy	
Order Time	Order Volume	Order Time	Order Volume
2008/9/11	84	2008/9/1	79
2008/8/21	81	2008/6/10	57
2008/1/11	38	2008/1/10	40

In conclusion, the modified β strategy with R^2 gets rid of the weakness that the original strategy buys early when the market is still going down by going better bottom fishing. However, the improvement is not quite significant. In addition, when the market goes into an oscillation after 2011, the modified strategy performs not as well as the original strategy. Thus, it is necessary to seek other improvement to get better back-testing result.

3.2 Strategy with MACD

The modified strategy with R^2 does little help for avoiding buying when the market is still going down. At a second thought, it is a solution that adding one more condition about the

market trend to filter the trading opened when the trend is going down. An easy and efficient way to check if the market is up is to use Moving Average Convergence Divergence.

MACD（Moving Average Convergence Divergence) is proposed by Gerald Appel in 1970 [3]. He uses the convergence and divergence of the long-term and short-term exponential moving averages (EMA) as the technical indicator for buy or sell. The calculation is the following process. First, calculate the short-term and long-term EMA, get DIF by subtracting the short-term EMA by the long-term EMA. Then calculate the moving average of DIF to get DEA. In the sustained increase, DIF will be above the DEA and the positive difference between them will get bigger and bigger. Conversely, in a decline, the difference will be negative, which is also getting bigger and bigger.

3.2.1 Trading Logic

1）Variable Assignment

Export the N days of the daily highest price, the daily lowest price and close price as variable *hip*, *lop* and *cp*.

2）Initialization

The initial position is 0 or it will be assigned to the last day's position.

3）Trading rule

（1）Calculate β_{DIF} and β_{DEA}

First, calculate close price EMAs of period 1 and period 2. Then, calculate DIF and its EMA of period 3 to get DEA. Calculate the slope of DIF and DEA of M-day as β_{DIF} and β_{DEA}.

（2）Fit the model 1 with variable *hip* and *lop* to get β.

（3）Conditions for open and close positions.

If β is larger than Level 2 and β_{DIF} is larger than β_{DEA}, open a position with 80% amount of the account balance. If β is lower than Level 1, close all the position.

The trading logic is showing in the flow figure 3-4.

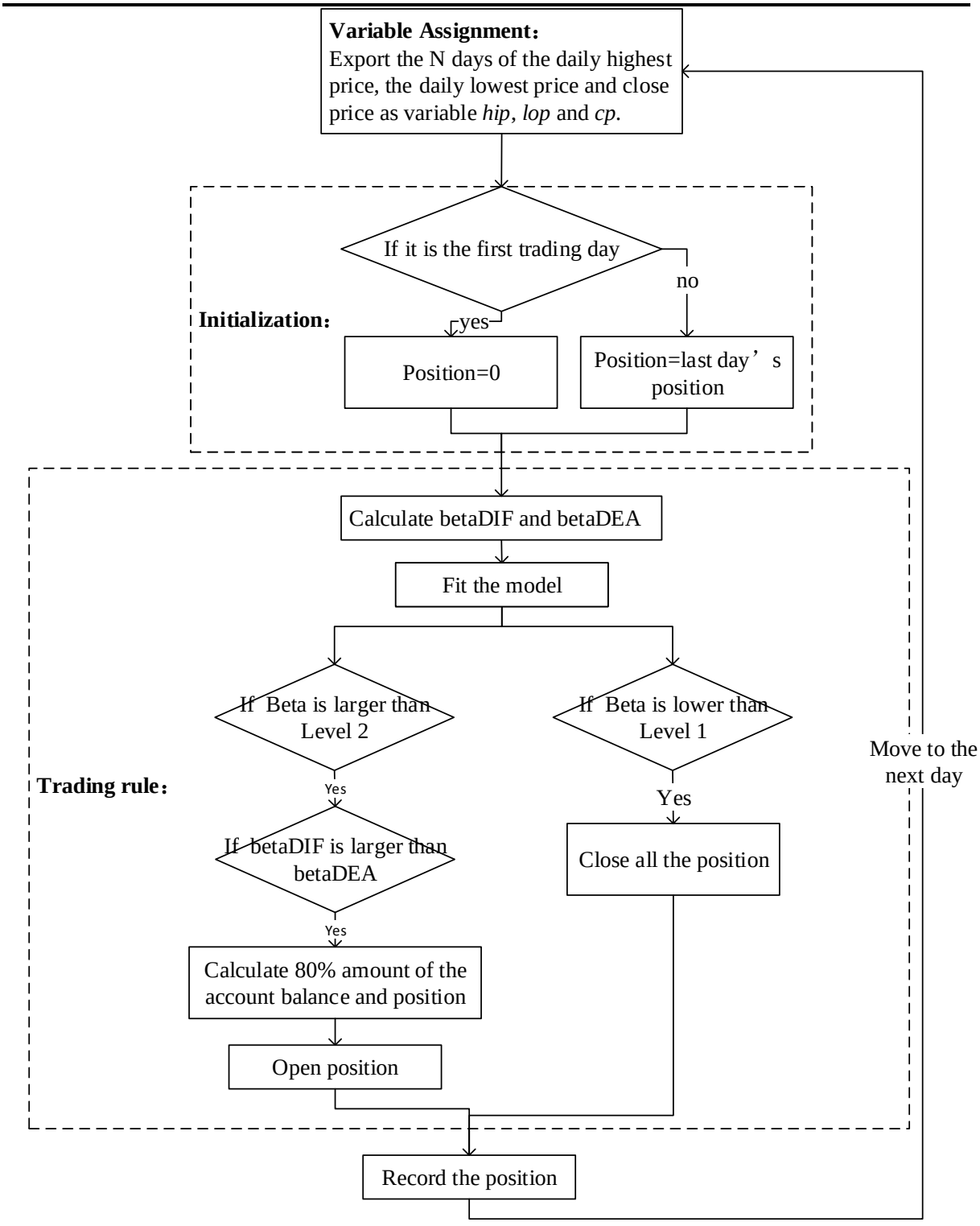

Figure 3-4 Trading Logic of Strategy with MACD

3.2.2 Determination of Period 1, 2, 3 and M

I set period 1, 2, 3 as 12 days, 26 days, and 9 days since they are the most frequently used ones in practice. Then I set M as 3 so that we could observe the change of the short-term slope.

3.2.3 Back-testing

The program files are in folder *srrs with MACD*. The main function is showing below.

```
function [ newStateMatrix ] = srrs( decisionData, stateMatrix )

% set Level 1 and Level 2
 l1=0.8707;
 l2=1.0227;

% get exchange number, stock code of the trading object
  exchange=decisionData.tickerMap{1,2};
  symbol=decisionData.tickerMap{1,3};

% get acount serial
  AccountSerialID=1;

% get 15 days data of daily high and daily low price of the trading object
  hip=decisionData.HIP_DAY01.data;
  lop=decisionData.LOP_DAY01.data;

% standardize the original hip and lop
  hip=(hip-mean(hip))/var(hip);
  lop=(lop-mean(lop))/var(lop);

% calculate DIF and DEA with function MACD
  CP=decisionData.CP_DAY01.data;
  n=length(CP);
  [dif, dea]= MACD(CP, 12, 26, 9 );

```

```
% the statematrix is empty for the first day, so the innitial position
% will be set to 0.
  if isempty(stateMatrix)
     stateMatrix.volume=0;
  end

% fit the model and get beta
  beta=polyfit(lop,hip,1);
   beta=beta(1);
% open a position with 80% amount of the account balance when beta is
% larger than l2 and the slope of DIF is larger than the slope of DEA
  if (beta>l2)&&((dif(n)-dif(n-3))>(dea(n)-dea(n-3)))
     vol=floor(AccountBalance(AccountSerialID)/hip(length(hip))*0.8);
    PlaceOrder (exchange, symbol,1,vol, 0, 1, AccountSerialID);
  end

% get positionid now, close all the position when beta is lower than l1
  positionid = SelectPsnBySymbol(symbol, exchange, AccountSerialID,1 );

  if (beta<l1)
     ClosePosition( positionid, stateMatrix.volume, 0);
  end

% record the position now and assign it to the new state matrix
  if positionid>0
    volume= PositionVolume( );
  else
     volume=0;
  end

  newStateMatrix.volume = volume;

end
```

I set other parameters the same as chapter 2 since there is no change in the condition for β and this could make the back-testing result comparable to the original result.

Figure 3-5 shows the comparison of the cumulative yield of strategy with MACD and original strategy. It is clear that strategy with MACD performs better during the bear market 0f 2008 and stays better cumulative yield after 2008 for quite a long period although it performs slightly worse than the original strategy during the most recent year.

Figure 3-5 Cumulative Yields of Strategy with MACD and Original Strategy

Then, looking into the detailed back-testing result for the strategy, the cumulative profit as well as cumulative yield decrease by 3.3289% and the annualized yield decreases by 1.6342%.

The total profit decreases by 14.1380% whereas the total loss decreases much more by 57.4097%. This significantly increases the profit and loss ratio to 10.0871 in contrast to the original 5.0035.

The total number of transactions decreases to 23, which reduces the trading cost by 39.7747%. The winning to losing ratio also improves. The single biggest profit gains and the single biggest loss reduce at the same time. Similarly, average profit gains and average loss reduce at the same time. In addition, the sharpe ratio increases from 1.0777 to 1.3021 by more than 20%.

Most of the changes indicates the new strategy performs better than the original one except for those about the final yield because of the maximum drawdown happening from 2015/6/8 to 2016/9/26. However, the maximum drawdown rate is only 7.05%, 80.75% decrease from the original strategy. In addition, the modified strategy with MACD overcomes the weakness of the original one which buys three times during the bear market of 2008 with

a loss of RMB101283. The strategy with MACD only opens position once in 2008/1/11 and sells quickly in 2008/1/23 and causes a loss of RMB26815.

Table 3-4 Back-testing Results of Strategy with MACD and Original Strategy

Item	Strategy with MACD	Original Strategy	Change
Final equity	665691.1333	685171.018	-2.8431%
Cumulative profit	565691.1333	585171.018	-3.3289%
Cumulative yield (%)	565.69	585.17	-3.3289%
Annualized yield (%)	18.66	18.97	-1.6342%
Total profit	617681.3338	719388.7107	-14.1380%
Total Loss	-61235.0305	-143776.9727	-57.4097%
Profit and loss ratio	10.0871	5.0035	101.6009%
Total number of transactions	23	40	-42.5000%
Trading cost	736.7482	1223.3205	-39.7747%
Winning to losing ratio (%)	78.26	75	4.3467%
Number of winning transactions	18	30	-40.0000%
Number of losing transactions	5	10	-50.0000%
Single biggest profit	134695.4128	133424.7014	0.9524%
Single biggest loss	-26809.2274	-28982.9485	-7.5000%
Maximum profit/total profit	0.2181	0.1855	17.5741%
Maximum loss/total loss	0.4378	0.2016	117.1627%
Net profit/single biggest loss	21.1006	20.1902	4.5091%
Number of consecutive winning transactions	8	8	0
Number of consecutive losing transactions	2	2	0
Maximum consecutive losses	47974.8435	104982.5864	-54.3021%
Maximum consecutive profit	263195.2288	273609.7959	-3.8064%
Sharpe ratio	1.3021	1.0777	20.8221%
Average profit	34315.6297	23979.6237	43.1033%
Average loss	-12247.0061	-14377.6973	-14.8194%
Maximum consecutive profitability ratio (%)	42.61	38.03	12.0431%

Maximum drawdown rate (%)	7.05	36.62	-80.7482%
Maximum drawdown start time	2015/6/8	2008/1/14	/
Maximum drawdown end time	2016/9/26	2008/11/4	/

3.3 Strategy with VMACD

In chapter 3.2, the strategy is modified together with the closing price. It is also a feasible modification to combine the strategy with market volume to assess the market condition. Via analogical method, I use VMACD (Volume Moving Average Convergence Divergence) as the indicator in which DIF and DEA are calculated with daily volume instead of closing price. Generally speaking, volume indicators are leading indicators which would give an earlier signal for operation than price indicators.

3.3.1 Trading logic and Determination of parameters

This strategy uses the same trading logic and period 1, 2, 3 in chapter 3.2. However, as VMACD is a leading indicator, it is more reasonable to calculate the slope one day before operation as $\beta_{DIF,t-1}$ and $\beta_{DEA,t-1}$ to check the market condition. As for M, I tried from 2-7 and get the following annual yields in table 3-5. The differences are quite small, so I set M=4 which has the biggest annual yield and analyze it later in this chapter.

Table 3-5 Annual Yields for Different M-day Slope in Strategy with VMACD

M	2	3	4	5	6	7
Annual Yield (%)	17.42	18.20	18.43	17.98	17.74	17.65

3.3.2 Back-testing

I set other parameters the same as chapter 2 since there is no change in the condition for β and this could make the back-testing result comparable to the original result.

Figure 3-5 shows the comparison of the cumulative yield of strategy with MACD and

original strategy. It is displayed directly that the original strategy performs better than strategy with VMACD during the whole back-testing period. Does this mean that the strategy with VMACD does not make any improvement? Therefore, I study further into the back-testing result in detail.

Figure 3-5 Cumulative Yields of Strategy with VMACD and Original Strategy

First, similar to strategy with MACD in chapter 3.2, final equity, cumulative profit, cumulative yield and annualized yield all decrease slightly. The results about loss, for example, total loss single biggest loss, maximum consecutive losses and average loss all improve. Nevertheless, unlike the strategy with MACD, strategy with VMACD still experiences maximum drawdown during the bear market of 2008. The maximum drawdown rate is still above 30%. Maximum loss/total loss increased by 46.9742%. In addition, the sharpe ratio only improves by 5.8736% from 1.0777 to 1.141. In conclusion, the strategy with VMACD sacrifices the profit by reducing loss, but it does not overcome the weakness of the large maximum drawdown during the bear market in 2008.

Table 3-6 Back-testing Results of Strategy with VMACD and Original Strategy

Name	Strategy with VMACD	Original Strategy	Change
Final equity	651451.156	685171.018	-4.9214%

Cumulative profit	551451.156	585171.018	-5.7624%
Cumulative yield (%)	551.45	585.17	-5.7624%
Annualized yield (%)	18.43	18.97	-2.8466%
Total profit	596099.2538	719388.7107	-17.1381%
Total Loss	-53704.2578	-143776.9727	-62.6475%
Profit and loss ratio	11.0997	5.0035	121.8387%
Total number of transactions	30	40	-25.0000%
Winning to losing ratio (%)	80	75	6.6667%
Number of winning transactions	24	30	-20.0000%
Number of losing transactions	6	10	-40.0000%
Single biggest profit	127253.1378	133424.7014	-4.6255%
Single biggest loss	-15914.7662	-28982.9485	-45.0892%
Maximum profit/total profit	0.2135	0.1855	15.0943%
Maximum loss/total loss	0.2963	0.2016	46.9742%
Net profit/single biggest loss	34.6503	20.1902	71.6194%
Number of consecutive winning transactions	9	8	12.5000%
Number of consecutive losing transactions	1	2	-50.0000%
Trading cost	893.0973	1223.3205	-26.9940%
Maximum consecutive losses	75372.8131	104982.5864	-28.2045%
Maximum consecutive profit	237643.3784	273609.7959	-13.1451%
Sharpe ratio	1.141	1.0777	5.8736%
Average profit	24837.4689	23979.6237	3.5774%
Average loss	-8950.7096	-14377.6973	-37.7459%
Maximum consecutive profitability ratio (%)	39.87	38.03	4.8383%
Maximum drawdown rate (%)	30.98	36.62	-15.4014%
Maximum drawdown start time	2007/5/29	2008/1/14	/
Maximum drawdown end time	2008/11/4	2008/11/4	/

3.4 Summary of strategy improvement

In order to avoid the strategy from opening position when the market is still going down especially in the bear market of 2008 and decrease the maximum drawdown rate, I use three

methods to modify the original strategy.

According to their back-testing results respectively, the first modification strategy with R^2 improves by buying when the bear market is about to end whereas it sacrifices too much profit. The third strategy with VMACD performs very close to the original strategy and it also does not eliminate the problem of large maximum drawdown rate. The second strategy with MACD sacrifices little profit in exchange for overcoming the weakness in down trend market and decreases the maximum drawdown rate significantly. The strategy with MACD is the best improvement among these three modified strategies.

4 Back-testing in Other Markets

4.1 Trading Objects

SI 100 stands for the main board stock market. It is also important to check the effectiveness of the strategy in other financial markets. In this chapter, I will back-testing the best modified strategy, strategy with MACD, in China small and medium enterprise board market, second board market and future market separately. For the first two markets, I choose the corresponding index as trading object. For future market, I choose AG1709 (Silver future) representing future market. By doing so, there will be a more comprehensive assessment of support resistance relative strength strategy with MACD.

4.2 Back-testing Results

The following figures are the back testing results comparing the strategy to the corresponding trading object respectively. It is clear that the support resistance relative strength strategy with MACD performs better than the benchmark in all the three markets.

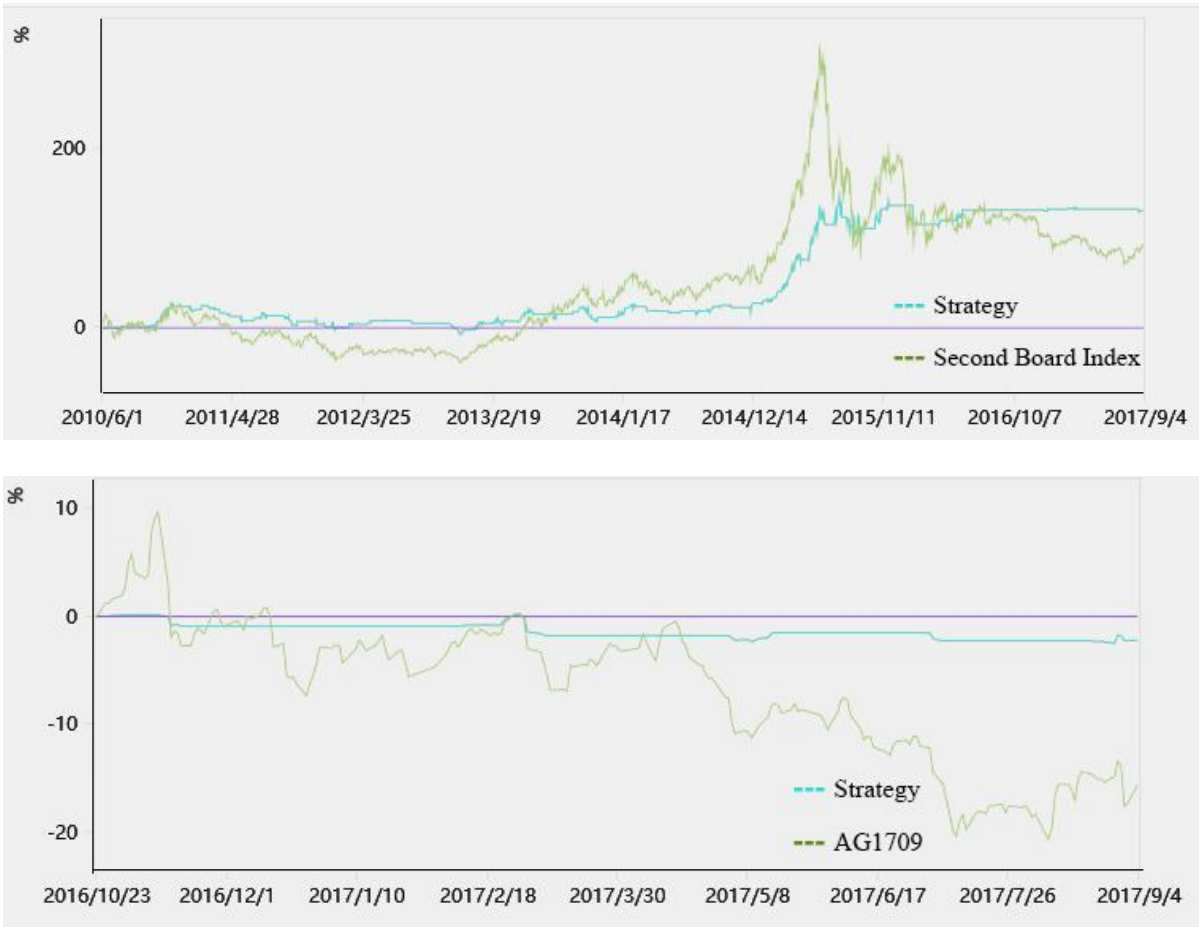

Figure 4-1 Cumulative Yields of Strategy with MACD and Benchmark

Looking into details of the back-testing results, for small and medium enterprise board market, the strategy performs well and the annualized yield is 55% higher than the benchmark. Although the winning to losing ratio is not high, the sharpe ratio is positive of 0.5178. Next, for second board market, the annualized yield is 33.23% higher than the benchmark. The sharpe ratio is 0.6424. However, in almost half of the trading days, the strategy performs worse than the benchmark. Last, for the future market, the strategy reduces loss by 85.53% comparing to the benchmark whereas the yield is still negative and the sharpe ratio is also a negative number of -1.6852.

Table 4-1 Back-testing Results of Four Trading Objects

Item	Small and medium enterprise board	Second board	AG1709
Annualized yield (%)	7.37	12.67	-2.57
Benchmark annualized yield (%)	4.76	9.51	-17.76
Annul excess yield (%)	2.61	3.16	15.19
Profit and loss ratio	2.8366	2.1328	0.1692
Total number of transactions	29	70	13
Winning to losing ratio (%)	58.62	61.43	30.77
Number of winning transactions	17	43	4
Number of losing transactions	12	27	9
Net profit/single biggest loss	6.8612	6.1544	-2.9446
Number of consecutive winning transactions	5	8	2
Number of consecutive losing transactions	2	5	8
Sharpe ratio	0.5178	0.6424	-1.6852
Maximum consecutive profitability ratio (%)	64.55	41.79	58.31
Maximum drawdown rate (%)	16.67	18.69	2.65

What are the reasons for making the support resistance relative strength strategy with MACD performs differently in different markets? By studying further into the characteristics of these markets, I figure out the following reasons.

First, the futures are trading no more than one year in future market. The trading period is so short that the strategy only trades for 13 times for AG1709. The support resistance relative

strength strategy tends to be efficient in a long-term horizon.

Second, in the future market, the investors can short selling without borrowing from others first. However, in my strategy I do not consider the issues about short selling. As a result, in the future market, the strategy does not take the advantage to make profit when the market is going down. From figure 4-1, for AG1709, it is always in a decreasing trend there is no way for the strategy to gain profit by only holding long position.

Third, modern financial theory holds that price should have both functions of clearing the market and transmitting information, and the process of reflecting information is an important bridge linking prices and information. Market efficiency refers to the degree to which stock prices reflect all available, relevant information. Weak form efficiency is one of the three different degrees of efficient market hypothesis (EMH) proposed by Eugene Fama [4]. It claims that stock prices reflects all the current market information and past information has no effect on the current market prices. That is to say that technical analysis only works in inefficient market. The Chinese equity market is efficient in the short-term whereas in the long run it is not of weak form efficiency [5]. In contrast, China's silver futures market has reached the weak form efficiency [6]. Therefore, my strategy as a technical analysis method performs efficiently in equity market but not in future market.

In conclusion, the strategy works well in the market in China small and medium enterprise board market, second board market and future market, but not in future market. The strategy still needs improvement if applied in future market.

5 Conclusion and Outlook

5.1 Conclusion

In this project, I conduct a comprehensive study on this support resistance relative strength strategy in china stock and future markets.

In order to overcome the weaknesses of present support and resistance strategy, first, I quantity support resistance relative strength by fitting the liner model of daily high price and daily low price and use the slope as the relative strength. Then I implement the support resistance relative strength strategy in CSI 300 as a representation and get annualized yield of 18.97% and annual excess yield of 5.96%. This strategy performs well during the oscillation period and is insensitive to trading cost.

However, the maximum drawdown rate is quite high of 36.62% in the bear market of 2008. Therefore, I improve the original strategy combined with R^2, MACD and VMACD indicators. For strategy with R^2, I add one more condition that the coefficient of determination should be large than mean of R^2 before opening position. Although the modified strategy with R^2 avoids maximum drawdown during the bear market of 2008 with a lower maximum drawdown rate of 23.94%, it loses too much of the excess yield by 40.91%. Next, for strategy with MACD, I add one more condition that β_{DIF} is larger than β_{DEA} before opening position. This strategy sacrifices little profit by only 3.33% in exchange for overcoming the weakness in down trend market lowering the maximum drawdown rate by 80.75%. For the strategy with VMACD, the condition is the same as strategy with MACD but in accordance to daily market

volume. This strategy performs very close to the original strategy with similar annual yield of 18.43% and large maximum drawdown rate of 30.98%.

As the strategy combining better with MACD, I test this strategy in other markets, China small and medium enterprise board market, second board market and future market. I find that strategy with MACD could gain excess yield in all the market whereas could not get positive sharpe ratio in future market. The strategy still needs improvement if applied in future market.

5.2 Outlook

Although after the improvement, support resistance relative strength strategy with MACD performs better than the trading objects' benchmark in all the stock markets and future market of china, there are also modifications could be implement.

First, I set fixed parameters of N days' data using to fit the model, threshold level 1 and level 2 as well as the slope of DIF and DEA of M days according to experience and normal practice. It is better to do an optimization study about all these parameters according to different trading objects in different markets. In this way, the back testing results could be more robust.

Second, because of the limitation of my computer's function, I choose one trading object from each market. I could test more objects in each market to decrease the bias and get more convincing results for the efficiency of my strategy.

Last but not least, since I am not familiar with the trading rules of future market, the strategy do not consider the unique characteristics of futures, for example short selling and short trading term. In future study, I could learn more knowledge about the future market and modify the strategy to see if it could work well in the future market.

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