BACKTESTING A SIMPLE TRADING STRATEGY

KARTHIK IYER

Overview

The goal of this project is to back test a trading strategy in R. We will use the R package *quantstrat* for the back testing. We work with a widely used indicator, Relative Strength Index, or RSI which is defined as $100 - \frac{100}{1+RS}$ where RS, meaning Relative Strength, is the ratio of $MA(n)$ of up prices to $MA(n)$ of down prices over a period of n days. Here MA denotes the moving average. For this project, we use $n = 14$, unless noted otherwise.

The strategy works as follows: When the RSI value signals overselling, one enters the market. A typical setting for this signal is 30%. When the RSI signals overbuying, eg 70%, this is a signal to exit the market.

Data

We use daily data for the Vanguard REIT Index ETF (symbol: VNQ) from 1 October 2004 through 26 May 2017 to test the strategy.

1. Part (a): Set up the strategy

We use the following variable definitions:

symbols: ETF symbol

initDate: Initial date startDate: Start date for both the fund data and the strategy

endDate: Start date for both the fund data and the strategy

initEq: Initial equity; set to 0 (we will need it to be zero for Part(e), and it doesn't affect us otherwise)

.nShs: Number of shares to be bought at each entry; set to 1000

strat.st: Strategy name; set to "rsi"

portfolio.st: Portfolio name; set same as strategy name

account.st: Account name; set same as strategy name

.n: Number of days in moving average; set to 14

.maType: Type of moving average; set this to indicate a simple moving average

.rsiOb: The overbought RSI value; set to 60 (it is expressed as a percentage)

.rsiOs: The oversold RSI value; set to 40 (it is also expressed as a percentage)

Remark: .rsiOb and .rsiOs will vary in later parts of the project.

We now set up the strategy in *quantstrat* to enter the market with a market order to buy when the market is oversold, and to exit completely when it is overbought, according to the RSI value.

We display in our output the following:

(1) A positions plot that also shows the ETF equity curve and the RSI technical indicator movement.

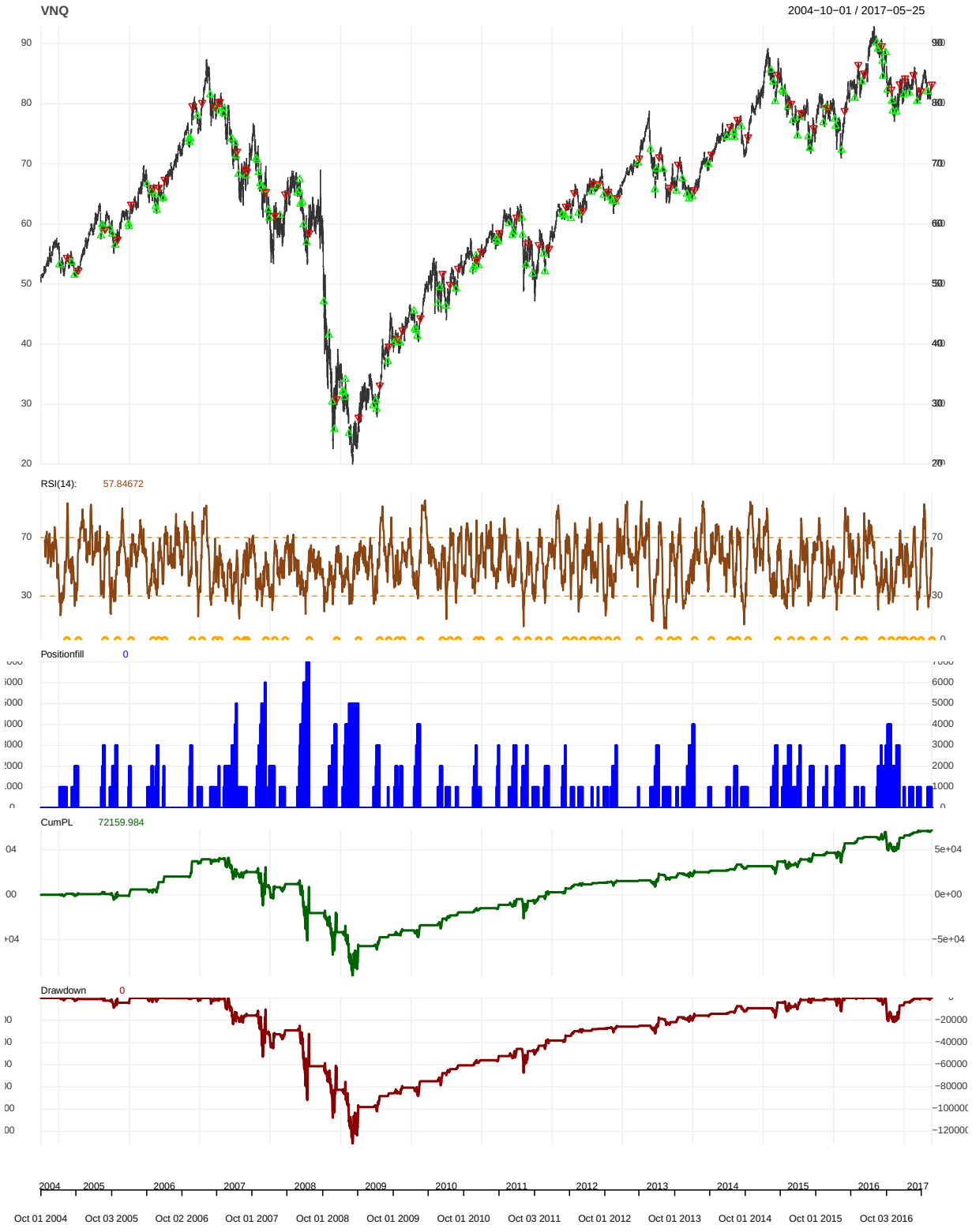

FIGURE 1. Equity curve for VNQ along with the RSI indicator movement

(2) The MAE plot.

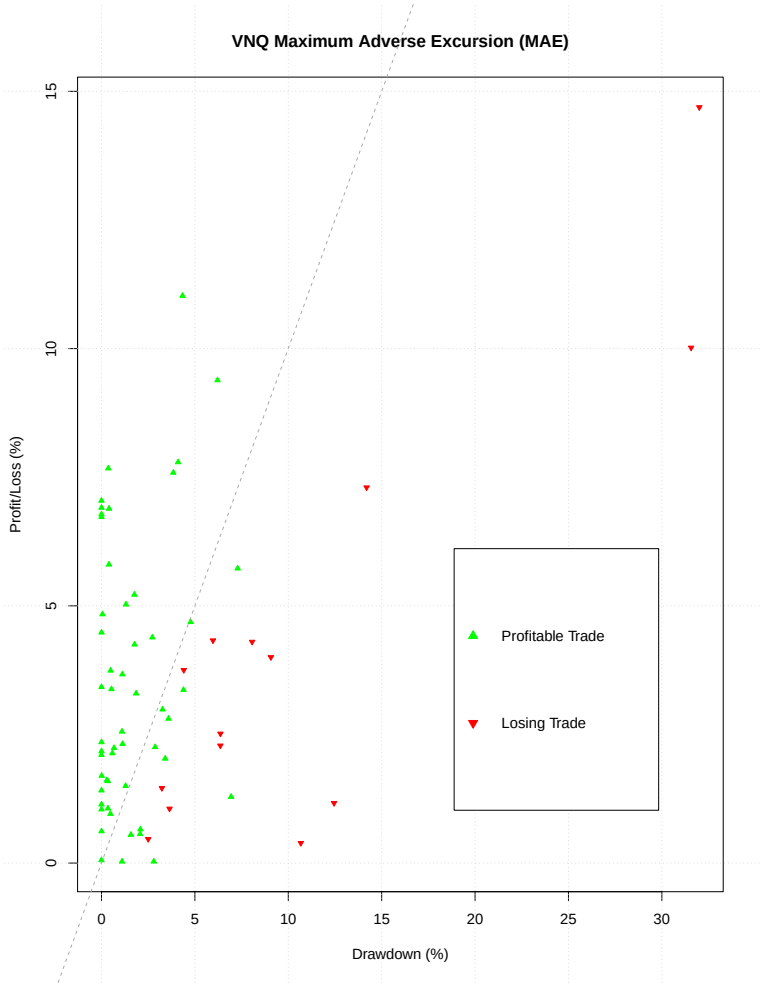

FIGURE 2. MAE plot for the no stop loss strategy

(3) Results for Net P/L and Maximum Drawdown.

Answer: We obtain the following trade statistics.

Net P/L 72159.98
Max Drawdown -131430
Annualized Sharpe ratio 2.27832

2. PART (B): ADDING A STOP LOSS

Question: Using the MAE plot from Part (A), let us determine the best level at which to place stop-loss orders in our strategy, to the nearest 10th. We set it in the variable stopLoss and implement the stop-loss logic in our code.

Answer: From the MAE plot in part (A), we note that the best level to place stop loss orders is at around 2%. We introduce a new variable *stopLoss* and set it equal to 0.02.

We now run the code, and display in our output the following:

(1) A positions plot that shows the ETF equity curve and the RSI technical indicator movement.

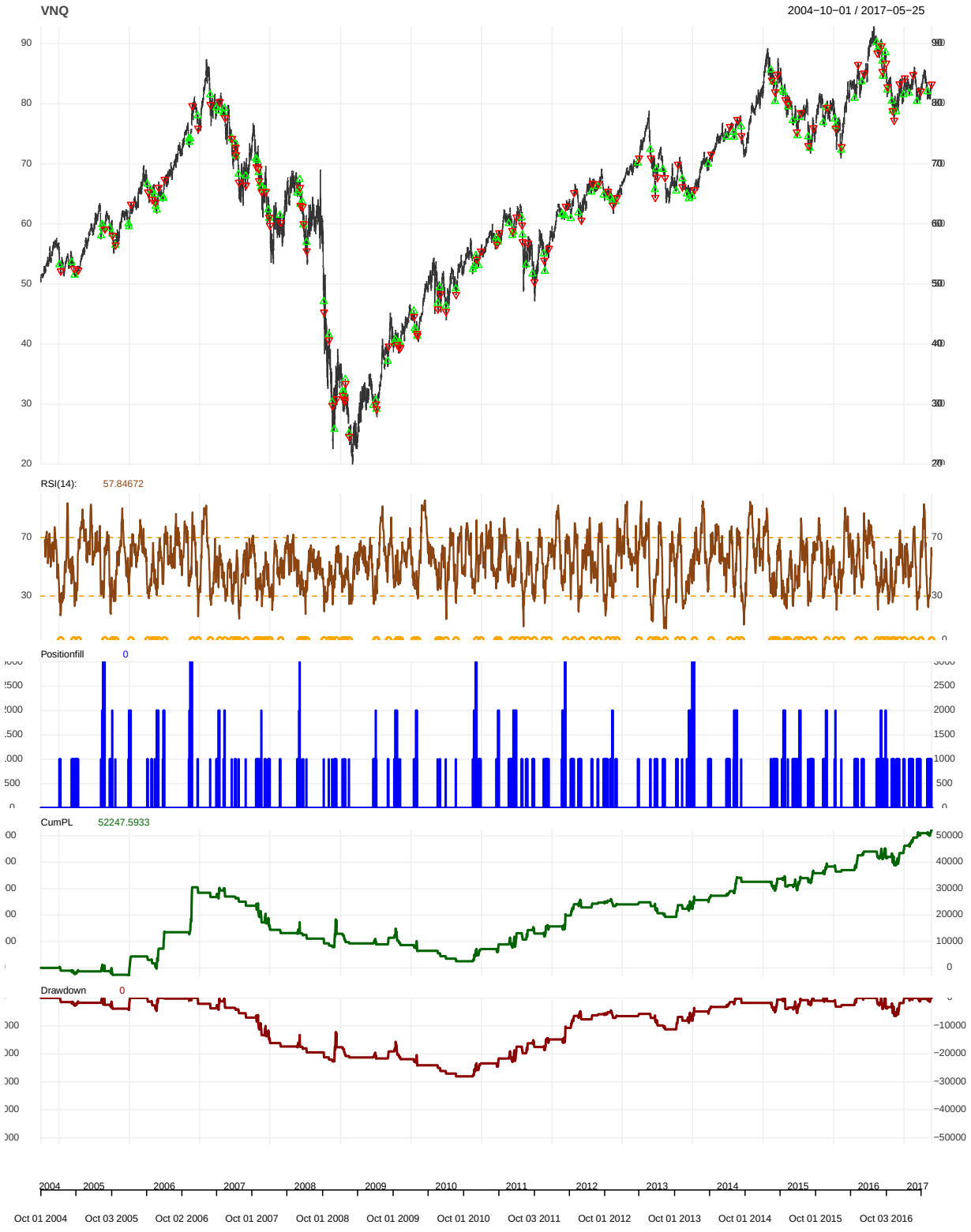

FIGURE 3. Equity curve for VNQ along with the RSI indicator movement with stop loss = 0.02

(2) The MAE plot.

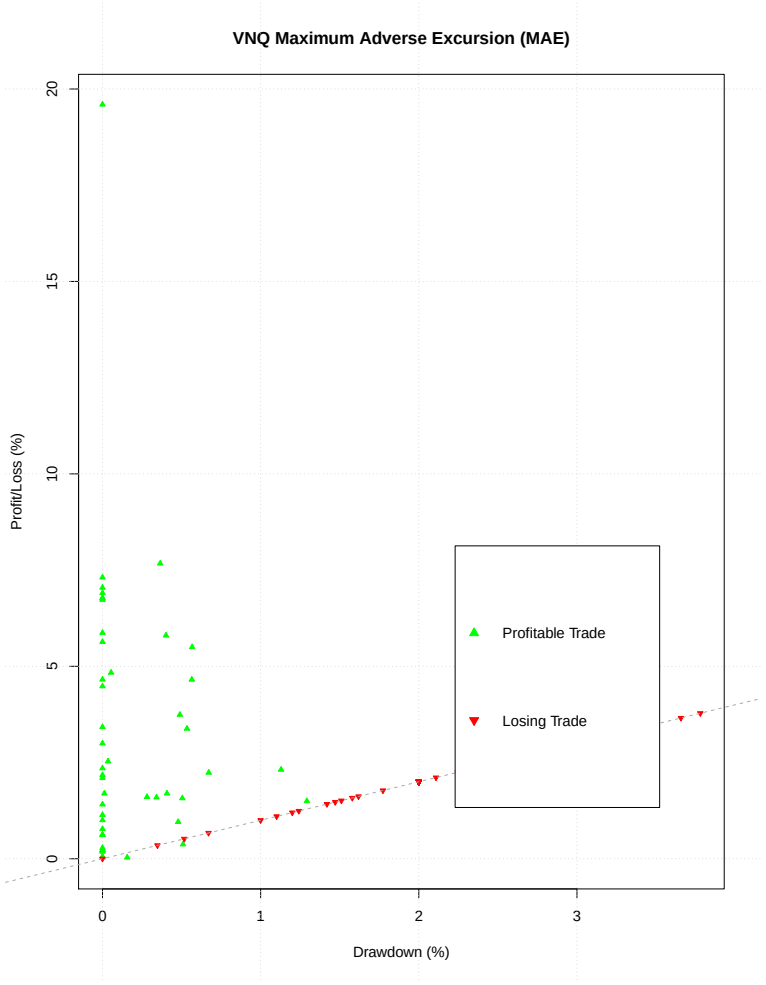

FIGURE 4. MAE plot for with stop loss = 0.02

(3) A comparison of the Net P/L and Maximum Drawdown with those from Part (A).

Answer: On placing a stop loss at 2%, we get the following trade statistics,

Net P/L 52247.59
Max Drawdown -28031.41
Annualized Sharpe ratio 2.603419

We note that the the Net P/L has reduced compared to the non stop loss strategy implemented in Part (A), but the Max Drawdown has reduced considerably. Moreover, Profit to Max drawdown ratio has substantially improved and we see an increase in the Annualized Sharpe ratio values.

3. PART (C): OPTIMIZING THE STRATEGY

In this part, we will vary the values of the overbought and oversold RSI parameter values to optimize our strategy, but holding all other settings and logic the same otherwise. First, we define the ranges for the parameters to use for the optimization, as follows:

.rsiObRange ("overbought"): Range from 50 to 75, in increments of 5

.rsiOsRange ("oversold"): Range from 20 to 40, in increments of 5

Also, we put *paramset.label* = "OPT_RSI" where required

Now, we run the optimization, and display a heat map showing our results for levels of Profit/Max Drawdown.

Attached is the heat map for Profit/ MaxDrawdown using Stop loss = 0.02. We see a local maximum for Oversold near 40 and Overbought near 75 and 50.

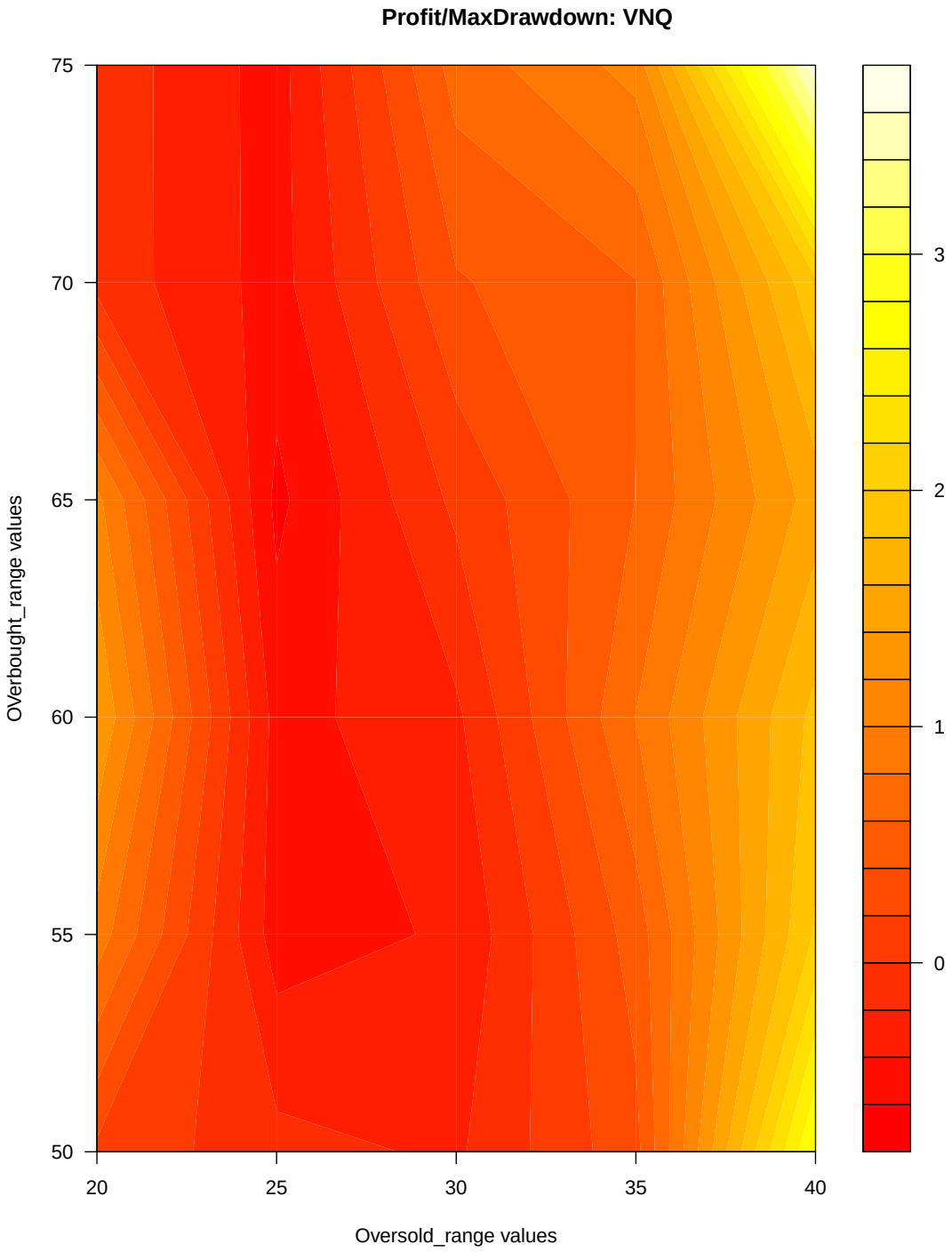

FIGURE 5. Heat map with stop loss = 0.02. Observe the maximum near Oversold = 40 and Overbought near 75 and 50

We now reset the Overbought and Oversold ranges to be of narrower width. As noticed in Figure 5, we obtain a local maximum for Profit/Max Drawdown for Overbought near 75 and Oversold near 40. We reset the Overbought range to be in [35,75] and Oversold range in [30,40] and re-run the optimization.

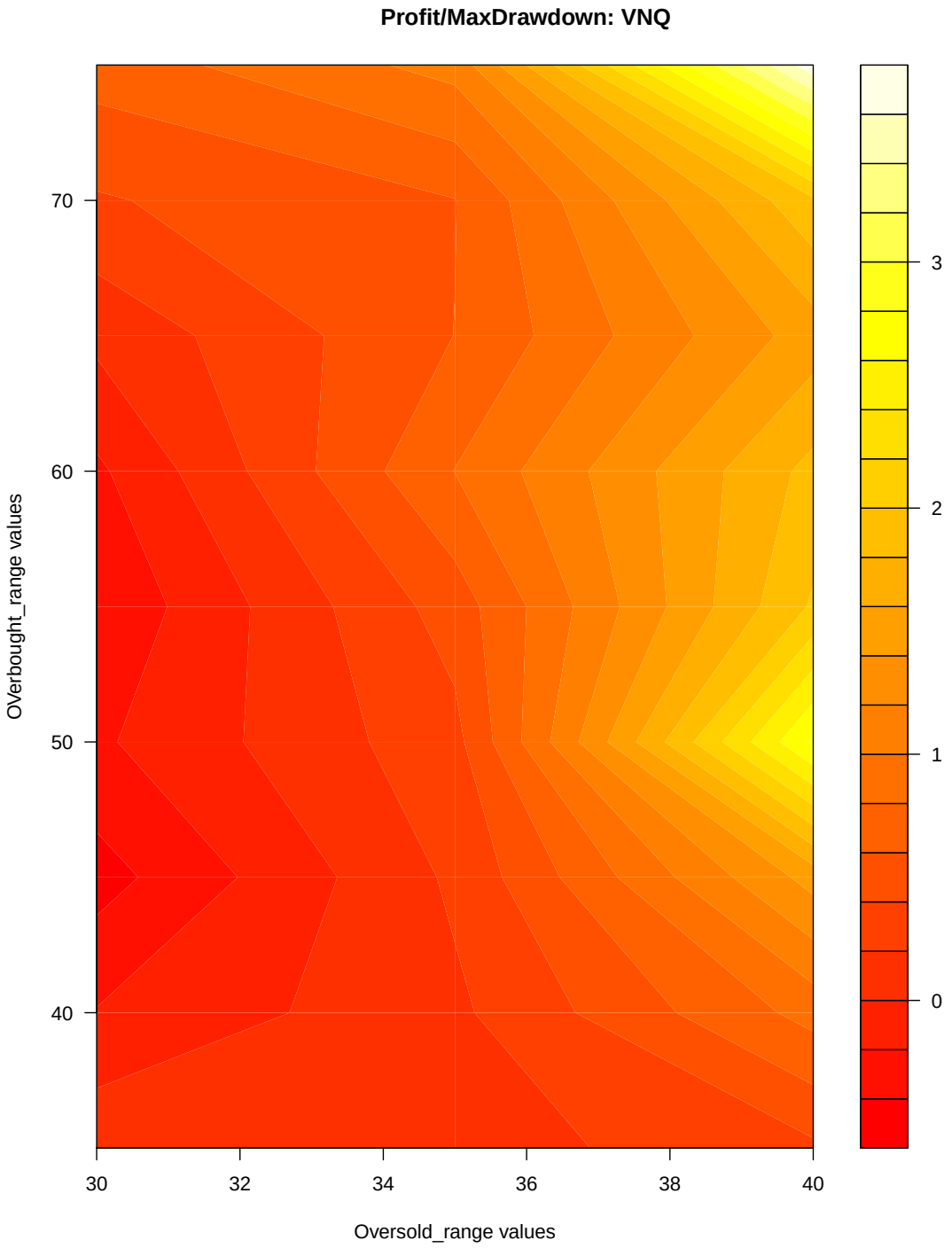

FIGURE 6. New Heat map with stop loss = 0.02 with narrower Oversold and Overbought ranges

4. PART (D): COMPARING THE OPTIMIZATION CANDIDATES

From Part(C), we have one local optimizing pair for overbought and oversold percentages of (40, 50), and another from the results we obtained from the heatmap. In this part, we go back to our setup in Part (B), but run the script with the corresponding values of .rsiOb and .rsiOs for each pair. We have the following comparisons:

(1) The positions plot that also shows the ETF equity curve and the RSI technical indicator movement, for each optimizing pair.

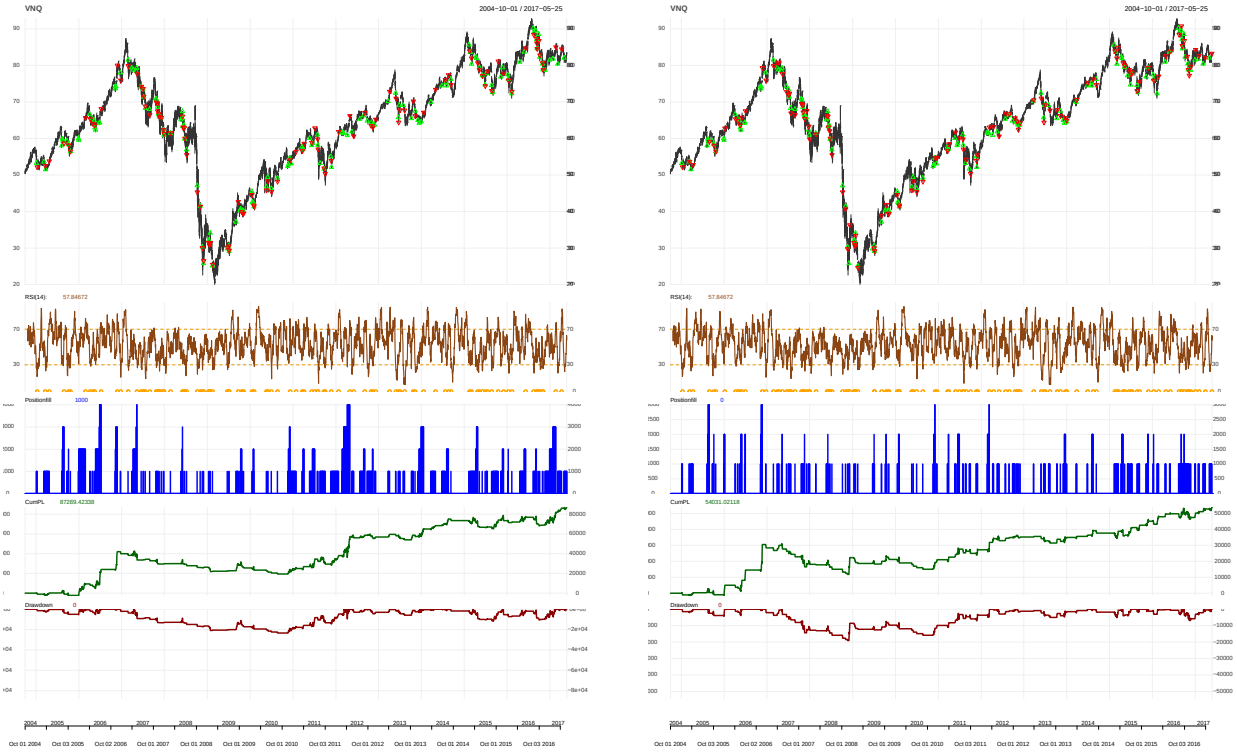

FIGURE 7. Position Plot along with RSI technical indicator. The left plot is for (oversold, overbought) = (40,75). The right plot is for (oversold, overbought) = (40,50)

(2) The MAE plot for each optimizing pair.

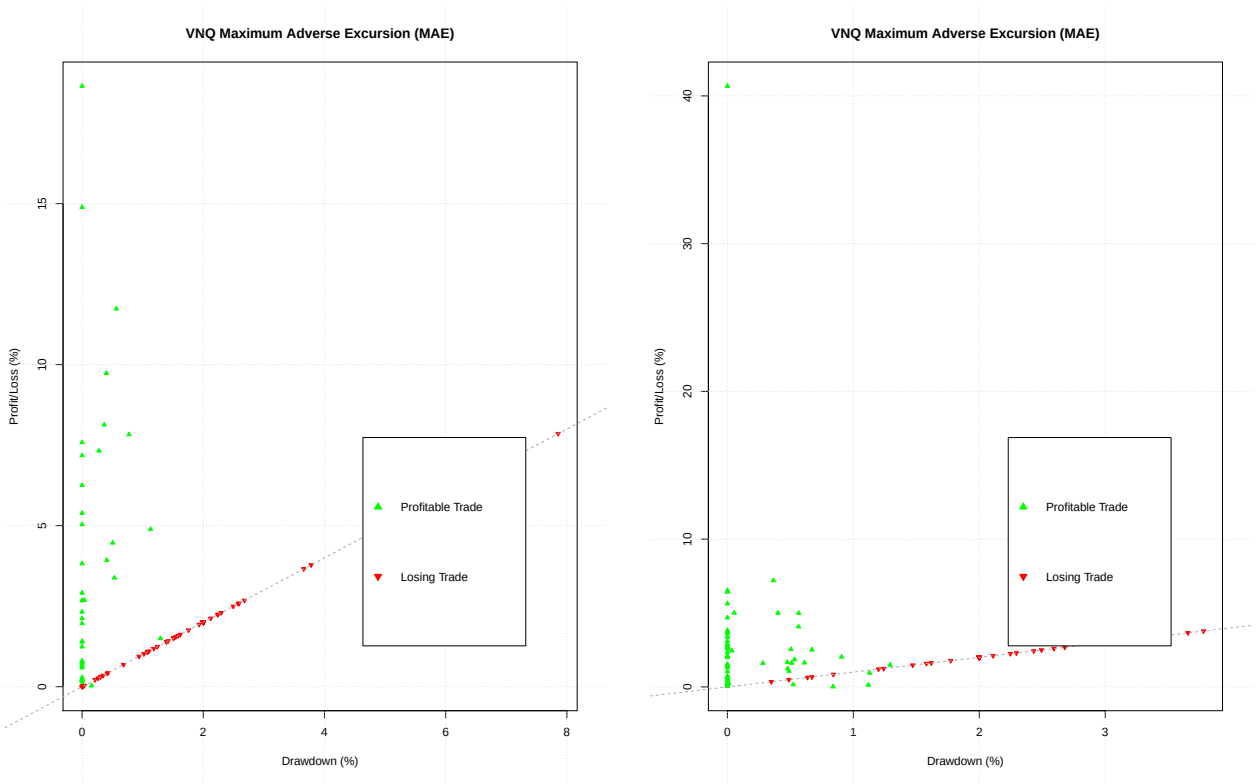

FIGURE 8. MAE plot.
The left plot is for (oversold, overbought) = (40,75). The right plot is for (oversold, overbought) = (40,50)

(3) A comparison of the Net P/L and Maximum Drawdown results for each optimizing pair.

(oversold, overbought) = (40,75) pair

Net Trading P/L 87289.42
Max Drawdown -23387.81
Annualized Sharpe Ratio 2.97026

(oversold, overbought) = (40,50) pair

Net Trading P/L 54031.02
Max Drawdown -19058.39
Annualized Sharpe Ratio 2.769007

(4) A description of which parameter pair yields the better result.

Answer: Both the Profit/Max Drawdown and Annualized Sharpe ratio for the (oversold, overbought) = (40,75) pair is better.

(5) A description of any downsides to the overall optimizing result.

Answer: The optimization for the Oversold and Overbought parameters (while keeping Stop Loss fixed at 0.02) has indeed resulted in a better performance (as measured by Profit/Max Drawdown and Annualized Sharpe ratio) as compared to the non-optimized parameters used in Part (B). Optimization in this case helps and the backtest performance has improved.

5. Part (e): Monte Carlo Simulation

In this part, we run a Monte Carlo simulation on transactions, using *mcsim(.)*, sampling with replacement, and using 1000 paths.

We set *.rsiObRange* and *.rsiOsRange* to the optimizing values determined in Part (D), and run the simulation. In our results, we show the following:

(1) A plot of the sample paths.

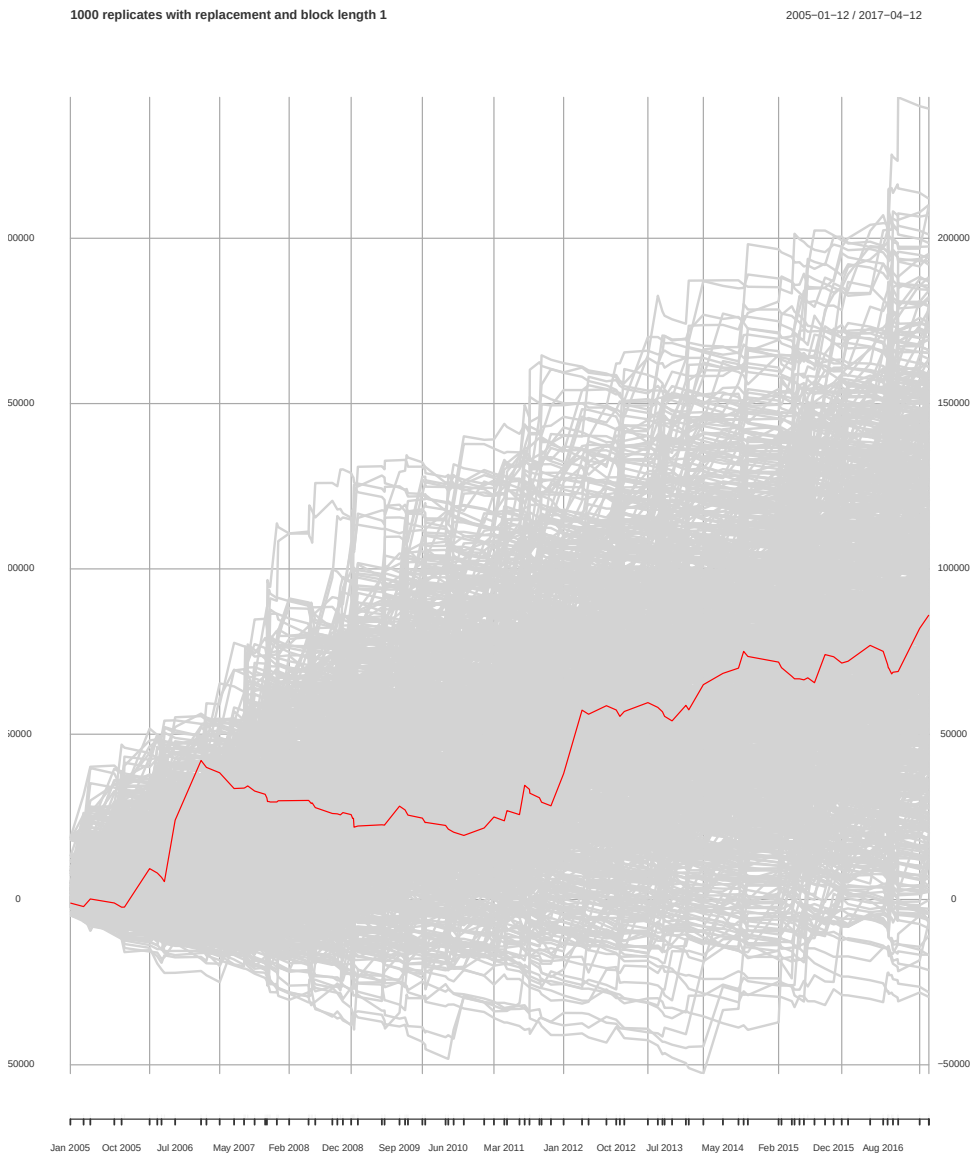

Figure 9. 1000 simulated paths

(2) The 95% confidence interval for the mean P/L.

Answer: The 95% confidence interval for the mean P/L is (-0.5580261, 1594.8396832).

(3) The 95% confidence interval for mean Max Drawdown.

Answer: The 95% confidence interval for the mean P/L is (-3.143061e+04,-4510.5319392).

6. Part (f): Walk Foward Analysis

In this part, we use the *walk.forward()* function to run walk forward analysis.

We first reset the following parameters:

.rsiObRange: Range from 50 to 80, by = 5 (same as in Part (C))

.rsiOsRange: Range from 20 to 40, by = 5 (again, same as in Part (C))

We include *audit.prefix=wfa* in the parameters for *walk.forward()*, and use the rolling window method in the analysis. We now run the walk forward analysis with training periods of 4 years, and test periods of one year and display the following

(1) The trade statistics for the concatenated results for all of the out-of-sample tests.

Walk forward analysis with training period of 4 years and testing period of 1 year (80:20 rule!) gives the following trade statistics.

VNQ	
Portfolio	"rsi"
Symbol	"VNQ"
Num.Txns	116
Num.Trades	39
Net.Trading.PL	109410
Avg.Trade.PL	2805.384
Med.Trade.PL	3389.999
Largest.Winner	17980
Largest.Loser	-14810
Gross.Profits	147120
Gross.Losses	-37710.03
Std.Dev.Trade.PL	5628.218
Percent.Positive	84.61538
Percent.Negative	15.38462
Profit.Factor	3.90135
Avg.Win.Trade	4458.182
Med.Win.Trade	3590.004
Avg.Losing.Trade	-6285.005
Med.Losing.Trade	-4990.006
Avg.Daily.PL	2805.384
Med.Daily.PL	3389.999
Std.Dev.Daily.PL	5628.218
Ann.Sharpe	7.912646
Max.Drawdown	-56980.01
Profit.To.Max.Draw	1.920147
Avg.WinLoss.Ratio	0.7093363
Med.WinLoss.Ratio	0.7194389
Max.Equity	109410
Min.Equity	-35490.01
End.Equity	109410

(2) A position chart of the concatenated test periods.

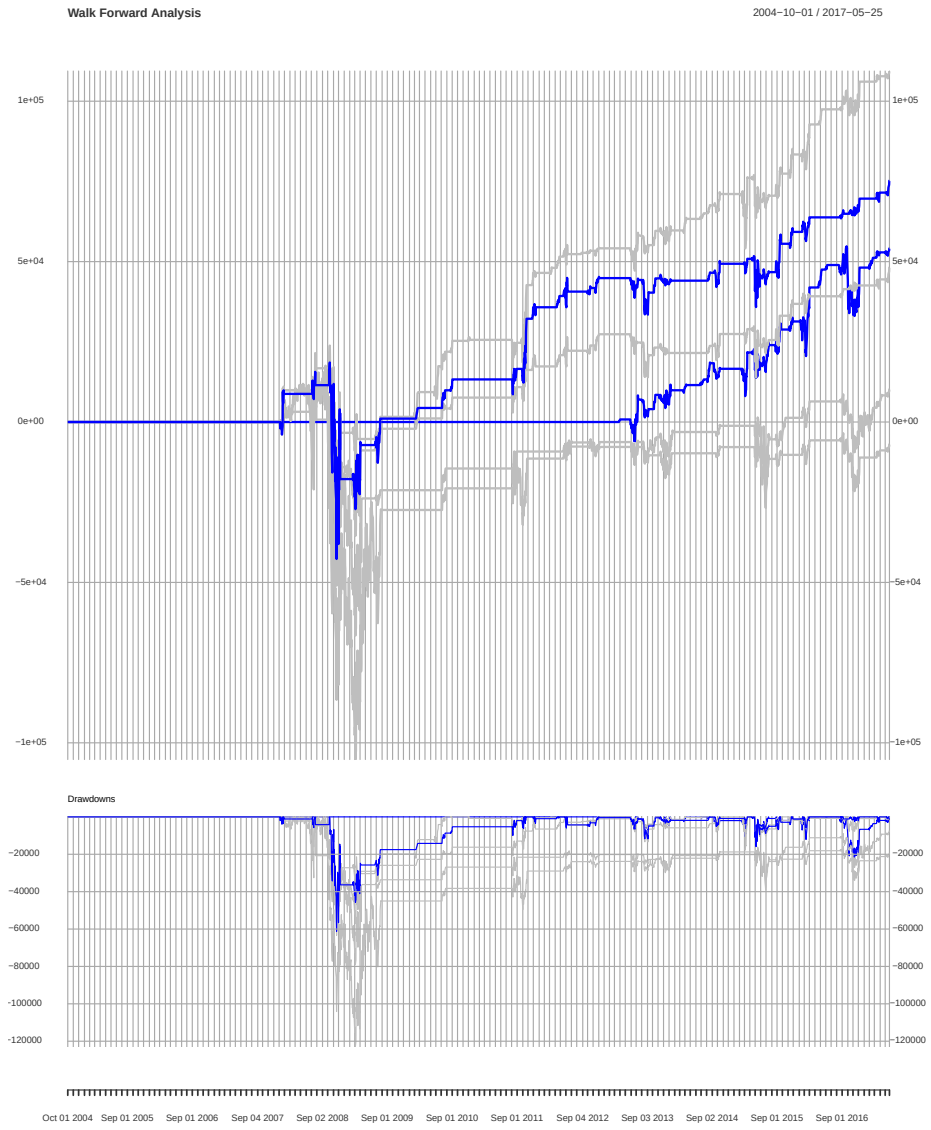

FIGURE 10. A position chart of the concatenated test periods

7. CONCLUSION

RSI strategy with no stop loss works pretty well on our test data. Profit to Max Drawdown and Profit Factor are quite high. Causes for concern are that the equity falls and stays below zero for some time as seen in the position chart and the that largest winner and largest loser are close to each other. But overall Gross profits are substantially higher than Gross Losses and the Annualized Sharpe ratio is very high. We can go ahead with the next step and back test this strategy for different asset classes.