Design Report

-By Team 04

OUTLINE

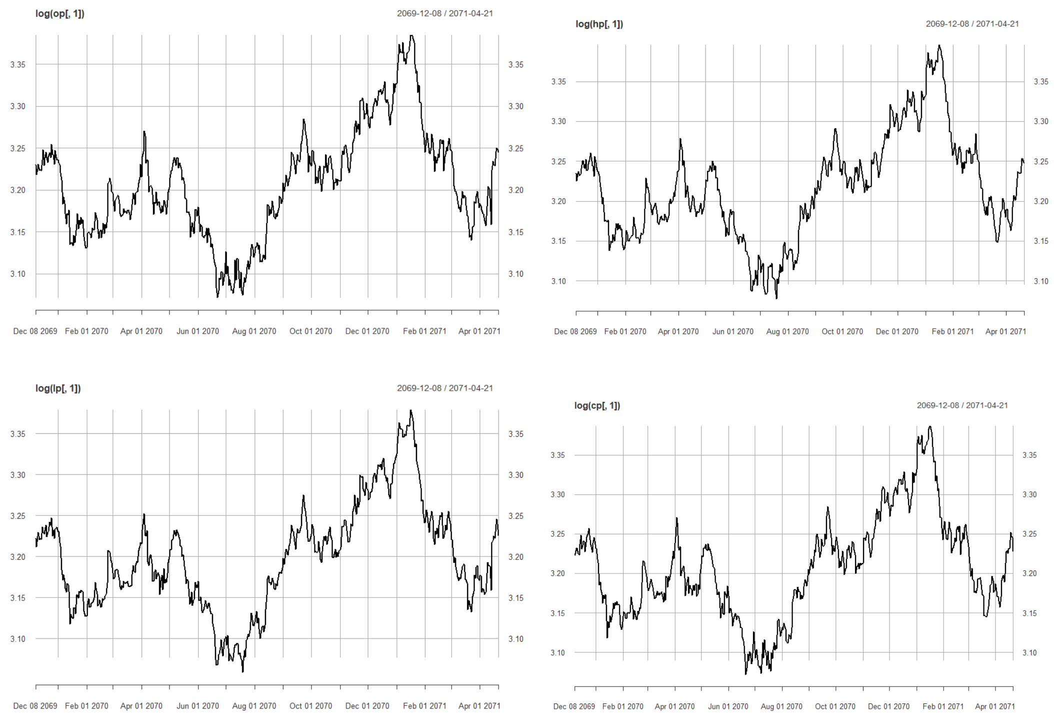
1 Analysis of time series

1.1 Basics Exploration

The OHLCV need to be explored at the beginning of designing any trading strategy. In this part, the first 500 days as in-sample data of Part 1 will be explored.

Firstly, the data needs to be logged before analysis, because logging reduces noise and makes the distribution smoother, which is better for observing changes in trends. Secondly, it is not only necessary to observe the trend and fluctuation of each individual series, but also to check whether there is a correlation or cointegration between different series.

Series 1 OHLC data will be posted below as an example, all other OHLCV data are in the appendix A:



Graph 1. Series 1 OHLC price

From graph 1, as can be seen, trends and changes in volatility are nearly identical and therefore only one of the OHLC will be selected for further analysis in the next steps. And the close price will be chosen because it is the up-to-date data of the day and reduces the bias of using historical data to predict tomorrow's trends.

Based on the log close price graph, it can be concluded that series 2, 3, 4 and 10 are in downtrend, series 7, 8 and 9 are in uptrend and these three series are very similar, while series 1, 5 and 6 have no clear trend and are more volatile over time.

Graph 2. Close price correlation map

According to the rule of thumb of correlation, when the correlation between two series is greater than 0.8 or less than -0.8, it is considered to have a strong positive or negative correlation.

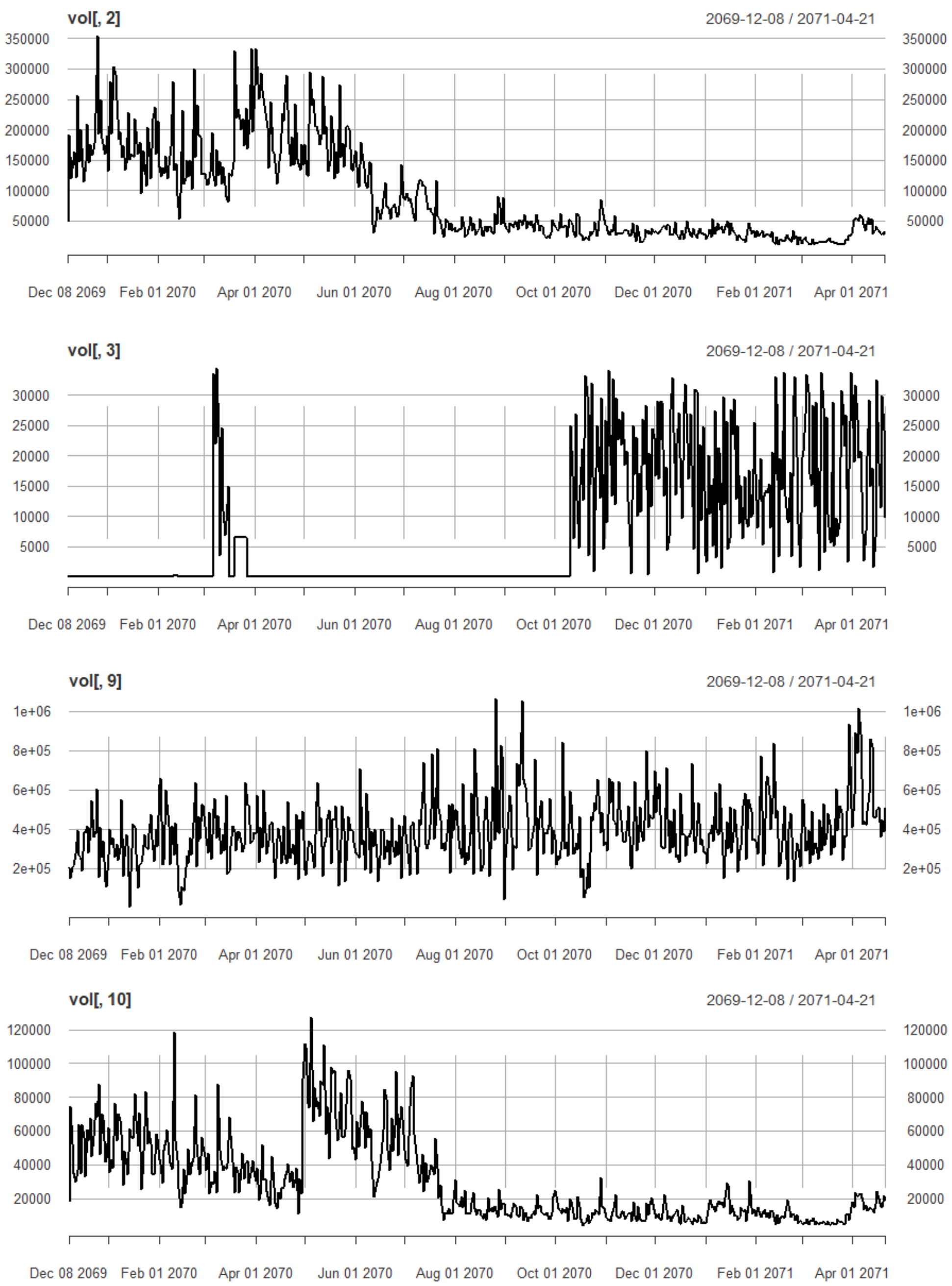
According to graph 2, we can conclude that series 10 has a strong positive correlation with series 2,3,4 and a strong negative correlation with series 7, 8 and 9; series 4 has a strong negative correlation with series 5.

Based on this conclusion, we conjecture that the price trend of series 10 may precede the arrival of the price trend of 6 series, series 2,3,4,7,8 and 9. If this precedence is proven to exist, then we can design trend strategies to use price of series 10 as reinforcing signals to judge the rise and fall of series 2,3,4 and series 7,8,9. To prove this hypothesis, we calculated the number of ups and downs for six series after each time series 10 had gone up or down respectively.

Table 1. up and down movements of series 2,3,4/7,8,9 after series 10 up and down

up&down times/Series	10	2	3	4	7	8	9
up/up	225	105	100	102	97	111	109
up/down		114	122	120	120	106	104
down/up	258	105	119	125	134	125	131
down/down		144	129	124	114	123	116

Table 1 shows that after series 10 up or down, the prices of the other 6 series did not follow the up/down trend of series 10 and would not lead the other 6 series to show significant price movements, so it cannot be used as a leading indicator for the two pairs of series 2,3,4 and series 7,8,9.

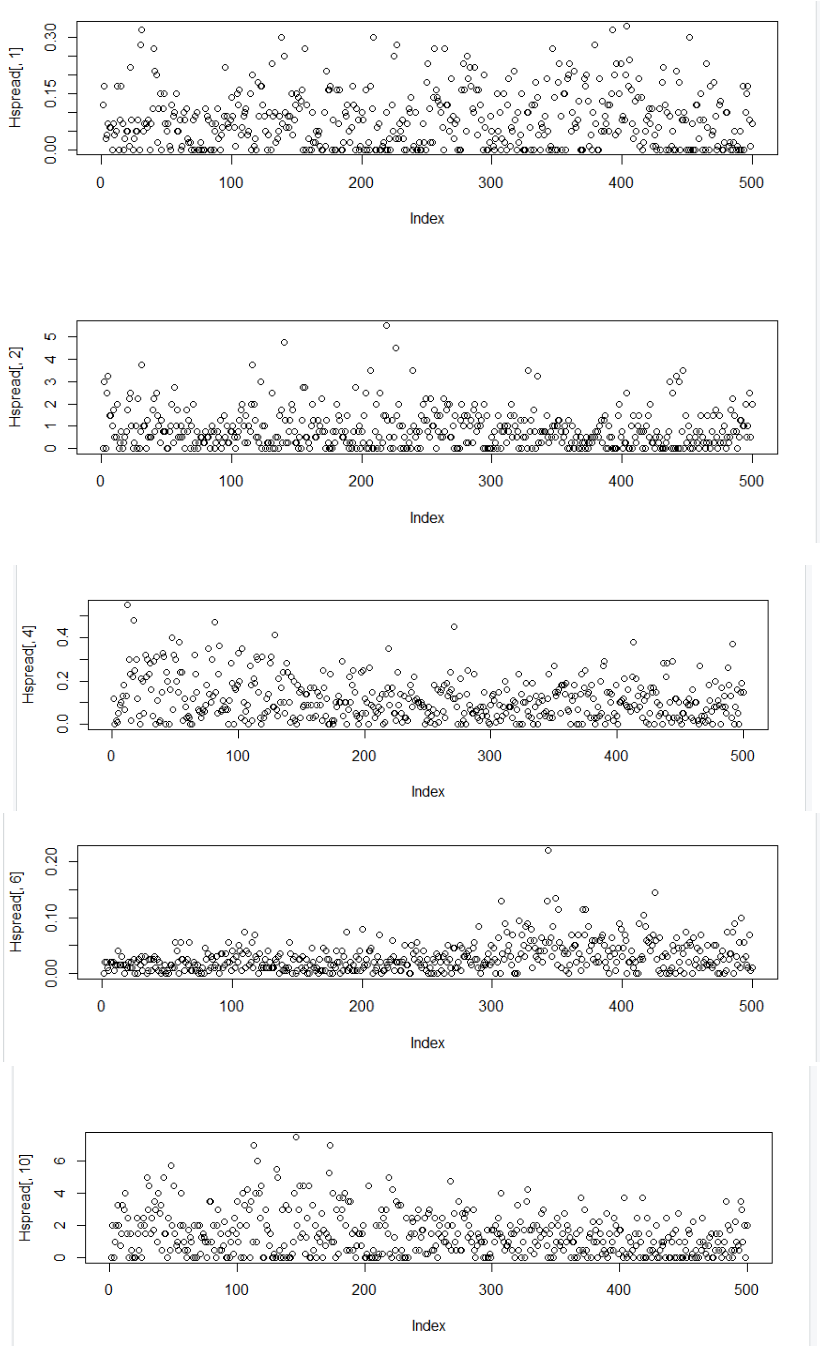


Graph 3. Volume for series 2, 3, 9, 10

Based on graph 3, some anomalies have been found that series 2, 3 and 9 all show very uncommon volumes at different periods thus signal filtering will be needed to prevent trading strategies from falling into false signal traps or suffering extreme risks (e.g., sudden delisting or suspension).

Series 2 and 10 also have a very strong positive correlation in terms of volume (0.72), with a high probability of homogeneity. They may be very similar in nature, such as the relationship between Google's parent company alphabet and Google. None of the other series show a particularly significant correlation in terms of volume.

From descriptive statistics, in terms of daily spread, the series 1 is very high and where its highest is 0.3. the average spread is about 0.1, which means that market marking strategy can be used and set the volatility of 0.1 bilateral limit order to make profit from this series.

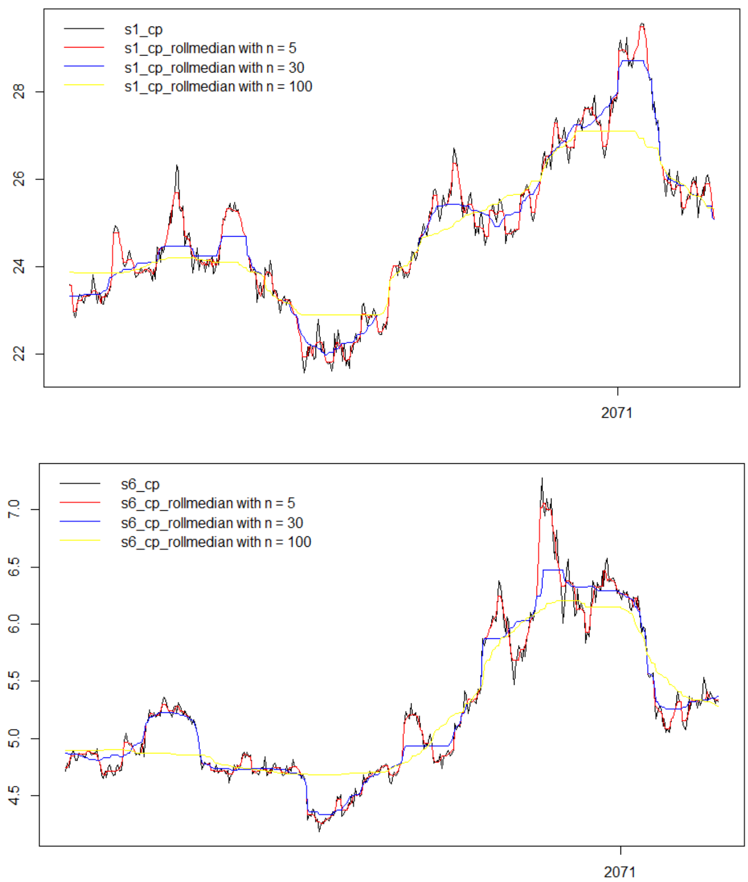


Graph 4. Daily spread for series 1, 2, 4, 6, 10

From graph 4, it is obvious that series 1,2,4,6,10 can be arbitrage with spread trading or market marking strategy by taking advantage of the bilateral limit order. In addition, series 2 and 10 are more volatile and have a higher volatility range and frequency.

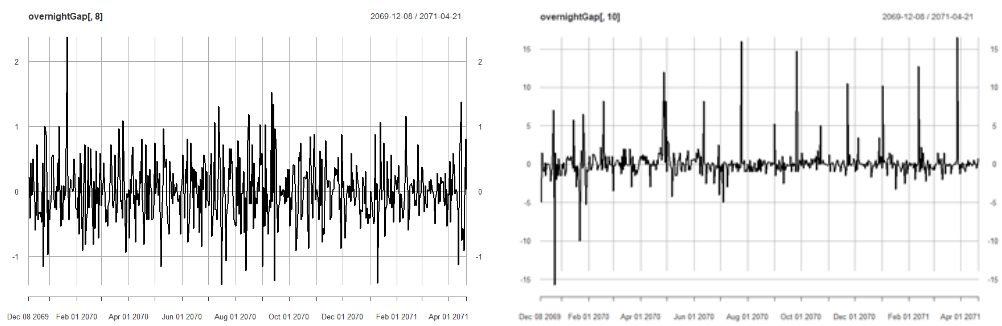
According to Appendix A Graph A.20, it was found that the trending of VWAP is more foreseeable in direction than OHLC. For stationary series, it would be easier and more frequent to trigger trend signals if we use VWAP to construct factors, while too much entry into positions in oscillating market would lead us to lose slippage frequently.

In accordance with Graph 5, rolling medians for series1 and 6 always fall off a cliff after rising to new high, resulting in high volatility for both. Hence this pattern may be tried in part 2 with trend strategy to test if this idea is solid.



Graph 5. Close price and rolling medians for series 1, 6

Based on graph 6, the overnight gap of series 8 and 10 are highly volatile across the first 500 days.



Graph 6. Overnight gap for series 8, 10

1.2 Basics Statistics Testing

The Dickey-Fuller test can observe whether the data is stationary or not.

Table 2. Dickey-Fuller test results for close price for 10 series

series	tau1 statistic	tau1 95% critical value	stationary
1	-0.1195607	1.95	stationary
2	-1.742317	1.95	stationary
3	-1.547832	1.95	stationary
4	-0.9461022	1.95	stationary
5	0.8367743	1.95	stationary
6	-0.2815926	1.95	stationary
7	1.018251	1.95	stationary
8	1.339446	1.95	stationary
9	1.339882	1.95	stationary
10	-1.825916	1.95	stationary

According to table 2, it can be concluded that all the close prices are stationary.

It is also important to test whether the time series is lagged, and this can be done by using the Ljung-Box test to determine whether the series is stochastic.

Table 3. Ljung-Box test results for close price for 10 series

series	CP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

The table 3 shows that the close price of each series is non-white noise, which means that the patterns we concluded from close price can be trusted.

The cointegration test showed whether there is a cointegration relationship between the two sets of data, and thus determines whether a pair trading strategy can be devised.

```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , with linear trend

Eigenvalues (lambda):
 [1] 0.3721529598 0.0929146426 0.0855103747 0.0606051996 0.0412756301 0.0396997391 0.0315908840 0.0242244536 0.0069764818 0.0001996895

Values of teststatistic and critical values of test:

           test 10pct  5pct  1pct
r <= 9 |   0.10  6.50  8.18 11.65
r <= 8 |   3.49 12.91 14.90 19.19
r <= 7 |  12.21 18.90 21.07 25.75
r <= 6 |  15.99 24.78 27.14 32.14
r <= 5 |  20.17 30.84 33.32 38.78
r <= 4 |  20.99 36.25 39.43 44.59
r <= 3 |  31.13 42.06 44.91 51.30
r <= 2 |  44.52 48.43 51.07 57.07
r <= 1 |  48.56 54.01 57.00 63.37
r = 0  | 231.80 59.00 62.42 68.61

Eigenvectors, normalised to first column:
(These are the cointegration relations)

             a.l2         b.l2        c.l2         d.l2         e.l2         f.l2        g.l2         h.l2         i.l2          j.l2
a.l2   1.00000000    1.0000000   1.0000000     1.000000   1.00000000   1.00000000  1.00000000  1.000000000   1.00000000  1.000000e+00
b.l2  -0.04131573    0.2908269   1.0664889     2.388202   0.09104705  -0.01049434 -0.26150312 -0.043880459  -0.07478396  3.766011e-03
c.l2 366.98535362 -321.8761550 241.4349995 10537.125404 -22.77297134 -71.34151472 83.85257792 53.389300540 188.68139252 -1.192521e+02
d.l2  -2.10631440   14.6602061   0.9814125   -67.075829  -0.56383160   0.19681388 -0.50967021  0.172031685  -1.53399492  8.592145e-01
e.l2  -0.33969687    4.2830188   2.4243507   -26.993416  -0.69115792   0.24710021  0.30644764  0.091946433   1.26388978 -8.712495e-01
f.l2   1.27324770   -8.7419186  -2.7094368  -286.163670   2.26623206  -2.19502460  3.35987788 -0.567718632  11.80000609  2.036341e-02
g.l2  37.74253449  -47.0657096  49.0315047  -202.901382   3.69949523   1.53131976  5.57979096 -0.026770907 -12.81803575  3.213670e+00
h.l2 -30.00541039   -1.6201518   2.2881511    33.848192  -1.36315573   0.05939971  0.45165027  0.001378267  -1.26515939  1.267465e+00
i.l2  14.21716803    5.8645202  -7.0353324    33.762908  -0.99274923  -0.35590655 -1.64809007  0.141350010   3.27672217 -5.889193e-01
j.l2   0.19789308   -0.8371368  -0.5241784    -2.492442  -0.16223992   0.02178916  0.06291508  0.030266933   0.12745798 -4.279355e-02

Weights W:
(This is the loading matrix)

             a.l2          b.l2          c.l2          d.l2          e.l2          f.l2          g.l2          h.l2          i.l2          j.l2
a.d  1.513102e-04 -1.023121e-03  1.186732e-03 -1.782842e-04 -6.464035e-03 -2.285756e-02  2.590636e-03 -1.451913e-02  4.700336e-05 -6.115699e-05
b.d  1.729894e-03  1.329374e-03  2.079831e-02  3.459636e-04 -8.618180e-02 -1.043387e-01  1.312160e-01  1.050889e-02 -4.302486e-03  3.032961e-03
c.d  9.589957e-07 -1.063833e-05 -1.704281e-05 -2.502917e-06  5.638832e-06  1.993381e-05 -1.420302e-06  8.728690e-06 -7.043663e-06  1.555859e-06
d.d -1.423802e-03 -4.485158e-03 -3.182509e-03  4.005977e-04 -4.170203e-03  6.510740e-04  2.133033e-03 -5.992552e-03 -1.045906e-04  1.303023e-04
e.d -7.730412e-04  7.723812e-04 -6.925601e-04  2.288711e-04  8.213636e-03 -4.697756e-02 -4.121759e-04  1.459899e-02 -9.237127e-04 -3.308723e-04
f.d  1.740495e-04  9.038573e-05  4.976602e-04  2.711819e-05 -3.607412e-03  4.181241e-03 -1.421101e-03  3.877799e-04 -1.932959e-04 -2.793264e-05
g.d -1.183024e-03  1.323363e-03 -1.848979e-03 -8.651534e-06 -9.269852e-04  1.717479e-03  6.341427e-04 -5.081390e-03  5.584059e-06 -9.582272e-05
h.d  1.325696e-02  5.738812e-04 -1.383268e-03 -2.117336e-05  3.254386e-04  5.154927e-03  9.086909e-04 -3.945963e-03 -3.217727e-05 -1.568900e-04
i.d -4.234682e-03  1.998524e-03 -3.237798e-03 -8.490236e-05  5.863858e-03  2.159282e-02  7.092534e-03 -1.630812e-02 -5.608793e-04 -1.190437e-03
j.d  6.255898e-03  1.005277e-02  4.148212e-02  2.225365e-03  9.902399e-03 -6.234911e-03  7.369435e-02 -2.822541e-01 -1.011754e-02  6.620518e-03

> slotNames(cotest)
 [1] "x"          "Z0"         "Z1"         "ZK"         "type"       "model"      "ecdet"      "lag"        "P"          "season"     "dumvar"     "cval"
[13] "teststat"   "lambda"     "Vorg"       "V"          "W"          "PI"         "DELTA"      "GAMMA"      "R0"         "RK"         "bp"         "spec"
[25] "call"       "test.name"
```

Table 4. Cointegration test results for close price for 10 series

According to table 4, there are 9 cointegration vectors which means pair trading is viable in 10 series.

Other statistical test was carried out on all the basics to exclude some basics or a few series-basics combinations that were not suitable for signal processing or different strategies. (See Appendix B)

1.3 Technical Indicator Data Analysis

The data analysis and statistical tests allow the conclusions of technical indicator to have been drawn. (See Appendix C)

Indicator	Conclusion
Conclusion	1. Series 2, 8, 9 are quite stationary 2. Series 1, 3, 4, 5, 6, 10 are highly volatile 3. Highly related to the up-down direction 4. The scales of momentum for different series are different, we need to change it to percentage if needed
Stochastic Oscillator / Stochastic Momentum Index	1. Series 1, 5, 6, 7, 8, 9 are more often overbought 2. Series 2, 3, 10 are more often oversold 3. Series 3, 4 have frequent crossover breakouts above and below 50, indicating that its buy-sell signals are less credible
SMI	1. For Series 1, 3, 4, 6, 7, 10 trends and OHLC trends are basically synchronized 2. Series 2, 8 downtrends does not fit OHLC trend, but uptrend fits well 3. Series 5, 9 uptrends does not fit OHLC trend, but downtrend fits well 4. All non-stationary for 10 series which means we can't use it for trend prediction
ADX	1. For Series 1, 3, 4, 6, 7, 10 trends and OHLC trends are basically synchronized 2. Series 2, 8 downtrends do not fit OHLC trend, but uptrend fits well 3. Series 5, 9 uptrends do not fit OHLC trend, but downtrend fits well 4. All non-stationary for 10 series which means we can't use it for trend prediction
RSI	1. The RSI values of Series 1, 2, 3, 9, 10 are not above 80, which means there are no selling points, so these series are not applicable to RSI 2. Series 4, 6 are found to be mostly concentrated in the range 20-50, and there are few opportunities for sell points, so the market characteristics are extremely weak, and the use of RSI is not recommended 3. Series 5, 7, 8 have the most sell points and most of them are concentrated in the 50-80 buy range, so they have strong market characteristics 4. All series pass stationary test, meaning mean-reversion strategy might work using this indicator.
OBV	1. For series1, OBV trend is irrelevant to OHLC trend 2. For series 9 uptrend is relevant to OHLC trend, but downtrend is obviously irrelevant 3. Except series 7, all series pass stationary test, meaning mean-reversion strategy might work using this indicator
MACD	1. For series1, OBV trend is irrelevant to OHLC trend 2. For series 9 uptrend is relevant to OHLC trend, but downtrend is obviously irrelevant 3. Except series 7, all series pass stationary test, meaning mean-reversion strategy might work using this indicator
Aroon	1. Aroon has long entered too many times in ten series and is not suitable for Trend trading 2. ALL series are non-stationary, meaning mean-reversion strategy might not work using this indicator
BBands	1. All series pass stationary test, meaning mean-reversion strategy might work using this indicator
ATR	1. All series pass stationary test, meaning mean-reversion strategy might work using this indicator
TR	1. ALL series are non-stationary, meaning mean-reversion strategy might not work using this indicator
MFI	1. All series pass stationary test, meaning mean-reversion strategy might work using this indicator 2. No obvious relationship with OHLC trend
KDJ	1. By the rule of if the number of K values greater than 80 and the number of K values less than 20 are many indicates that 10 series are suitable for KDJ, series 1, 3, 5, 6, 7, 8, 9 are suitable, series 2, 4, 10 are not

2 Trading Strategies

2.1 Hierarchical Design

Some investment philosophy will be obeyed in our strategy:

1. Never put eggs in one basket

A FOF like strategy management system will be implemented in our project. Because diversifying our investments in different strategies can gain us more profit by allocation funds to different strategies depending on data. Also, diversification of strategy and series can effectively reduce systematic risk instead of putting money heavily in minority bets.

2. Using leverage can bring more profit

Cases may happen at period when a strategy generally holds short positions which give us more money temporarily and such that we can invest more in other long viable strategies temporarily to exploit the maximum profit. In our project, 200% leverage that can be used at maximum should be considered in our strategy level and series level allocating strategy. But proper leverage level will be testing via position sizing and risk management exploration in Part 2.

3. Never risk losing all in one bet

In order to not lose all money in one bet, we plan to implement not only risk management measures but also a long-term effective position sizing strategy. Furthermore, some anomalies in data have been found about huge drop in volume at suspicious periods should be considered. In order to prevent extreme risk like the black swan, we will add market condition filters to stop trading at hazardous periods or extreme patterns depending on further data exploration and testing in Part 2.

4. All strategies are wrong, but some are useful

We found that all our strategies cannot make money from all series the whole time and this is expected. Thus, trading timing filters and market condition filters will be added to avoid those bad trading decisions. For example, we might want to classify our strategy as long-like and short-like strategy depending on their performance or characteristics. Likewise, some strategy might perform better in bear market which is a hard to define terminology which we need to explore market condition quantitatively using combination of basics or indicators depending on further data analysis in Part 2.

One idea in mind is to use multiple signals to double confirm instead of one single signal or one plain triggering point. Also, we can define enter and exit points in different strategies with different ideas, so we will test each of them to find the best one. Last but not least is to choose the right parameters or technical indicators depending on the conclusion derived from our Part 1 data analysis.

2.2 Trading Ideas

2.2.1 Triple Moving Average Strategy

According to Singh, D. (quantinsti blog, 2017), by using three moving averages of different lookback periods, the trader can confirm whether the market has actually witnessed a change in trend or whether it is only resting momentarily before continuing in its previous state. The buy signal is generated early in the development of a trend and a sell signal is generated early when a trend ends.

In a nutshell, following trading rules will be implemented:
Long signal: short > medium > long
Short signal: short < medium < long

```
# main strategy
getOrders.tma<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init today's enter positions on each series
  pos <- allzero

  # default exit yesterday's overall positions
  marketOrders <- -currentPos

  # we need to wait until day 101 so that we have ma100 signal
  if(store$iter > params$lookback){
    for(i in params$series){
      # everyday re-calculate today's ma5/ma30/ma100
      sma5 <- last(SMA(store$op[1:store$iter,i],5))
      sma30 <- last(SMA(store$op[1:store$iter,i],30))
      sma100 <- last(SMA(store$op[1:store$iter,i],100))

      # enter conditions

      # long enter when ma5 > ma30 > ma100
      if((sma5 > sma30) &  (sma30 > sma100)){
        pos[i] <- params$posSizes[i]
      # short enter when ma5 < ma30 < ma100
      }else if((sma5 < sma30) & (sma30 < sma100)){
        pos[i] <- -params$posSizes[i]
      }
```

```
      # exit conditions

      if(currentPos[i] > 0){  # when in long position
        # long exit when new close is no longer the new highest close
        if (store$cl[store$iter, i] < store$cl[store$iter-1, i]){
          pos[params$series[i]] <- 0
        }

      }else if (currentPos[i] < 0){  # when in short position
        # short exit when new close is no longer the new lowest close
        if (store$cl[store$iter, i] > store$cl[store$iter-1, i]){
          pos[params$series[i]] <- 0
        }
      }
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=allzero,limitPrices1=allzero,
              limitOrders2=allzero,limitPrices2=allzero))
}
```

2.2.2 Relative Strength Strategy

From Faber, M. (CAMBRIA INVESTMENT MANAGEMENT, 2010), a strategy idea and example has been introduced as followed.

According to this trading idea, we designed a similar version which has long 3 series with strongest 12-month momentum and short 3 series with weakest 12-month momentum into our portfolio and weights them equally. Rebalance once every month.

```r
# main strategy
getOrders.rs<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init today's enter positions on each series
  pos <- allzero

  # default exit yesterday's overall positions
  marketOrders <- allzero

  # we need to wait until day 366 so that we have open price 1 yr earlier
  # and the day must be 30 days after last trading day
  # (the first trading day should be day 366)
  if((store$iter > params$lookback) & ((store$iter-365)  %% 30 == 1)){
    # default exit yesterday's overall positions
    marketOrders <- -currentPos

    # init mtm/max 3 mtm series/min 3 mtm series
    mtm <- allzero
    max3mtm_series <- allzero
    min3mtm_series <- allzero

    for(i in params$series1){
      # re-calculate today's pricechange = today's open - open 1 year earlier
      # we use change in percentage to represent pricechange
      # to eliminate the differences in price measurement
      mtm[i] <- (store$op[store$iter,i]-store$op[store$iter-365,i]) /
        (store$op[store$iter-365,i])
    }
```

```r
    # the best 3 momentum series
    max3mtm_series <- order(mtm,decreasing=TRUE)[1:3]
    # the worst 3 momentum series
    min3mtm_series <- order(mtm,decreasing=FALSE)[1:3]

    for(i in params$series){
      # long enter
      if(i %in% max3mtm_series){
        pos[i] <- params$posSizes*1000000/store$cl[store$iter,i]
      }
      # short enter
      else if(i %in% min3mtm_series){
        pos[i] <- - params$posSizes*1000000/store$cl[store$iter,i]
      }
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=allzero,limitPrices1=allzero,
              limitOrders2=allzero,limitPrices2=allzero))
}
```

2.2.3 Market Making Strategy

Market Making strategy will be implemented in high volatility series.
The trading mechanism is quite simple:

Like arbitrage, ordering two sides (long and short) limit orders at the same position but with different prices depending on daily spread. If two trades executed, then profit gains.

In our trading idea, we trade every day and set the limit price to be daily (high-low)/2 +/- (spread in percentage) * open and when accumulated positions reach a high level which we set as twice betting sizes as each bet will trigger our exit condition to clear out all positions in one series.

```r
# main strategy
getOrders.mm<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init today's enter positions on each series
  pos <- allzero

  # if our positions reach 2 times betting level then exit yesterday's overall positions
  marketOrders<- ifelse(abs(currentPos)>2*params$posSizes, -currentPos, 0)

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init limitPrices1/limitPrices2/limitOrders1/limitOrders2
  limitPrices1<- allzero; limitOrders1<- allzero
  limitPrices2<- allzero; limitOrders2<- allzero
  if(store$iter > params$lookback){
    for(i in params$series){
      # market making - betting on both sides
      limitOrders1[i]<- params$posSizes[i]
      limitPrices1[i]<- (store$hi[store$iter,i]+store$lo[store$iter,i])/2-params$spread*store$cl[store$iter,i]
      limitOrders2[i]<- -params$posSizes[i]
      limitPrices2[i]<- (store$hi[store$iter,i]+store$lo[store$iter,i])/2+params$spread*store$cl[store$iter,i]
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=limitOrders1,limitPrices1=limitPrices1,
              limitOrders2=limitOrders2,limitPrices2=limitPrices2))
}
```

2.2.4 The Jump Trading Strategy

The Jump Trading System is using in a downtrend where prices fluctuate around the lower end of the box range for 5 to 10 days, then open sharply lower below the trend line with extreme selling sentiment, and if it then rebounds to yesterday's lows, it indicates a reversal of market energy, and another bullish upward move is ready to take place. Trading rules are as follow:

1. Close 4% below the five-day average price to ensure the signal occurs on a down trend
2. Open price of 1% below yesterday's low
3. Close price rally above yesterday's minimum price

However, when testing this strategy with Part 1 data, we found that this strategy never triggered with no matter what indicator or parameter we tried so we will drop it.

```r
# main strategy
getOrders.jt<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init today's enter positions on each series
  pos <- allzero

  # default exit yesterday's overall positions
  marketOrders <- -currentPos

  # we need to wait until day 101 so that we have ema100 signal
  if(store$iter > params$lookback){
    for(i in params$series){
      # everyday re-calculate today's ema5
      ema5 <- last(EMA(store$cl[1:store$iter,i],5))

      # long enter
      if(((store$cl[store$iter,i] - ema5) / ema5 <= -0.04) &
         ((store$op[store$iter,i] - store$lo[store$iter-1,i]) / store$lo[store$iter-1,i] <= -0.01) &
         (store$cl[store$iter,i] > store$lo[store$iter-1,i])){
        pos[i] <- params$posSizes[i]
```

```r
      # exit when direction turned again
      }else if(((currentPos[i] != 0) &
                (store$cl[store$iter,i] < store$cl[store$iter-1,i]))){
        pos[i] <- 0

      # hold when still in the trend
      }else if(((currentPos[i] != 0) &
                (store$cl[store$iter,i] >= store$cl[store$iter-1,i]))){
        pos[i] <- currentPos[i]
      }
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=allzero,limitPrices1=allzero,
              limitOrders2=allzero,limitPrices2=allzero))
}
```

2.2.5 Lawrence Macmillan Volatility Trading System

Lawrence Macmillan Volatility Trading System is using volatility as the rate at which stock prices change and can be calculated using the standard deviation formula and by comparing historical volatility over different lengths of time, such as 10, 20 and 50 days, and 100 days. However, the exit signals are not clear yet which we will explore in Part 2.

Trading rules are as follow:
1. Historical volatility is short aligned, i.e., the range of volatility is getting narrower, suggesting the calm before the storm.
2. Calculate historical volatility at 5, 10, 20, 30 and 100 days and find its standard deviation.
3. AC and AO indicators fall for 5 consecutive days. (This is not added to Part 1 code yet).

```
# main strategy
getOrders.lmv<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init today's enter positions on each series
  pos <- allzero

  # default exit yesterday's overall positions
  marketOrders <- -currentPos

  # we need to wait until day 101 so that we have ema100 signal
  if(store$iter > params$lookback){
    for(i in params$series){
      # everyday re-calculate today's ema5/ema10/ema20/ema30/ema100
      ema5 <- last(EMA(store$cl[1:store$iter,i],5))
      ema10 <- last(EMA(store$cl[1:store$iter,i],10))
      ema20 <- last(EMA(store$cl[1:store$iter,i],20))
      ema30 <- last(EMA(store$cl[1:store$iter,i],30))
      ema100 <- last(EMA(store$cl[1:store$iter,i],100))

      # everyday re-calculate today's std5/std10/std20/std30/std100
      std5 <- store$cl[store$iter,i] - ema5
      std10 <- store$cl[store$iter,i] - ema10
      std20 <- store$cl[store$iter,i] - ema20
      std30 <- store$cl[store$iter,i] - ema30
      std100 <- store$cl[store$iter,i] - ema100
```

```
      # long enter when the volatility is getting smaller and in the down trend
      if((std5<std10) &
           (std10<std20) &
           (std20<std30) &
           (std30<std100) &
           (std5 < 0)){
        pos[i] <- params$posSizes[i]

      # long exit when direction turned up
      if((currentPos[i] > 0)
                  & (ema5 >= 0)){
        pos[i] <- 0
      }
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=allzero,limitPrices1=allzero,
              limitOrders2=allzero,limitPrices2=allzero))
}
```

2.2.6 BBands based Strategy (Mean-reversion)

BBands will be used as the basic signal to decide long (short) on contract whenever the close is below (above) the lower (upper) Bollinger Band of the close due to the statistical facts of data distribution given different confidence levels. Meanwhile, after breakthroughs the 'reasonable' range, returning to a short-term average price is expected in this idea which is different from the sample strategy.

```r
# main strategy
getOrders.bb<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init today's enter positions on each series
  pos <- allzero

  # default exit yesterday's overall positions
  marketOrders <- -currentPos

  # we need to wait until lookback to get the bbands signal
  if (store$iter > params$lookback){
    for (i in params$series){
      # calculate everyday bbands upper/lower bounds
      up <- last(BBands(store$cl[1:store$iter,i], sd=params$sdParam)[,3])
      dn <- last(BBands(store$cl[1:store$iter,i], sd=params$sdParam)[,1])

      # everyday re-calculate today's ma30
      sma30 <- last(SMA(store$op[1:store$iter,i],30))

      # long enter when cross the upper bound
      if(store$cl[store$iter, i] > up){
        pos[params$series[i]] <- -params$posSizes[i]

        # short enter when cross the lower bound
      } else if(store$cl[store$iter, i] < dn){
        pos[params$series[i]] <- params$posSizes[i]
      }
```

```r
      if(currentPos[i] > 0){  # when in long position
        # long hold when not reach MA
        if ((pos[params$series[i]] > 0) |
            (store$cl[store$iter, i] > sma30)){
          pos[params$series[i]] <- currentPos[i]
          next
        }

      }else if (currentPos[i] < 0){  # when in short position
        # short hold when not reach MA
        if ((pos[params$series[i]] < 0) |
            (store$cl[store$iter, i] < sma30)){
          pos[params$series[i]] <- currentPos[i]
          next
        }
      }
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=allzero,limitPrices1=allzero,
              limitOrders2=allzero,limitPrices2=allzero))
}
```

2.2.7 BBands based Strategy (Trend-following)

BBands will be used in trend following strategy to decide short(long) on contract whenever the close is below(above) the lower(upper) Bollinger Band of the close due to the belief that small probability cases happen with reason. When price breakthrough their 'reasonable' ranges, this trend will be continued. But unlike sample strategy, we set an exit condition where new close price is no longer the new highest/lowest then we will exit our positions.

```r
# main strategy
getOrders.bb<- function(store, newRowList, currentPos, info, params){
  # used for initializing vectors
  allzero  <- rep(0,length(newRowList))

  # init store
  if (is.null(store)) {
    store <- initStore(newRowList,params$series)}else{
      store <- updateStore(store, newRowList, params$series)
    }

  # init today's enter positions on each series
  pos <- allzero

  # default exit yesterday's overall positions
  marketOrders <- -currentPos

  # we need to wait until lookback to get the bbands signal
  if (store$iter > params$lookback){
    for (i in params$series){
      # calculate everyday bbands upper/lower bounds
      up <- last(BBands(store$cl[1:store$iter,i], sd=params$sdParam)[,3])
      dn <- last(BBands(store$cl[1:store$iter,i], sd=params$sdParam)[,1])

      # long enter when cross the upper bound
      if(store$cl[store$iter, i] > up){
        pos[params$series[i]] <- params$posSizes[i]

      # short enter when cross the lower bound
      } else if(store$cl[store$iter, i] < dn){
        pos[params$series[i]] <- -params$posSizes[i]
      }
```

```r
      if(currentPos[i] > 0){  # when in long position
        # hold when still in the long trend
        if ((pos[params$series[i]] > 0) |
            (store$cl[store$iter, i] > store$cl[store$iter-1, i])){
          pos[params$series[i]] <- currentPos[i]
          next
        }

      }else if (currentPos[i] < 0){  # when in short position
        # hold when still in the short trend
        if ((pos[params$series[i]] < 0) |
            (store$cl[store$iter, i] < store$cl[store$iter-1, i])){
          pos[params$series[i]] <- currentPos[i]
          next
        }
      }
    }
  }
  marketOrders <- marketOrders + pos
  return(list(store=store,marketOrders=marketOrders,
              limitOrders1=allzero,limitPrices1=allzero,
              limitOrders2=allzero,limitPrices2=allzero))
}
```

2.3 Preliminary Strategy Performance

In the following analysis, we aim to find the best indicators and strategies.
No parameter optimization techniques will be used in the following analysis because we solely want to see if our plain trading ideas work in the easiest way.

2.3.1 Indicator Analysis

Different alternative indicators will be tested in the following steps.

2.3.1.1 Triple Moving Average Strategy

Part 1 day 1-500 with 0.2 slippage

Indicator/Slippage	PD ratio	PnL	Activeness
SMA	-29037.53	-29037.53	77%
VWAP	-41863.15	-41863.15	78%
EMA	-86263.66	-86263.66	79%
Rolling Median	-62488.88	-62488.88	76%

Part 1 day 1-500 without slippage

Indicator/Slippage	PD ratio	PnL	Activeness
SMA	1.23	53237.92	77%
VWAP	0.97	40088.46	78%
EMA	0.09	7343.56	79%
Rolling Median	-15972.56	-15972.56	76%

2.3.1.2 Relative Strength Strategy

Part 1 day 1-500 with 0.2 slippage

Indicator/Slippage	PD ratio	PnL	Activeness
Stochastic Oscillator	-83609.15	-83609.15	27%
SMI30	0.71	51440.48	27%
SMI100	1.1	97236.07	27%
ADX30	-42865.13	-42865.13	27%
ADX100	-63516.43	-63516.43	27%
Momentum	-36916.8	-36916.8	27%
Triple Exponential Moving Average30	0.37	51218.15	27%
Triple Exponential Moving Average40	0.66	83840.37	27%
RSI30	-64204.87	-64204.87	27%
RSI100	0.69	107325.94	27%

Part 1 day 1-500 without slippage

Indicator/Slippage	PD ratio	PnL	Activeness
Stochastic Oscillator	-83609.15	-83609.15	27%
SMI30	0.71	51440.48	27%
SMI100	1.1	97236.07	27%
ADX30	-42865.13	-42865.13	27%
ADX100	-63516.43	-63516.43	27%
Momentum	-34969.65	-34969.65	27%
Triple Exponential Moving Average30	0.37	51218.15	27%
Triple Exponential Moving Average40	0.66	83840.37	27%
RSI30	-64204.87	-64204.87	27%
RSI100	0.69	107325.94	27%

2.3.1.3 Market Making Strategy

No alternative indicators for this strategy yet.

2.3.1.4 The Jump Trading Strategy

This strategy does not trigger any transactions.

2.3.1.5 Lawrence Macmillan Volatility Trading System

Using EMA, ATR and Spread to represent volatility are completely different in nature. Thus, their performance cannot simply compare. We will explore it with different enter logic further in Part 2. (See Appendix E)

2.3.1.6 BBands based Strategy (Mean-reversion)

Part 1 day 1-500 with 0.2 slippage

Indicator/Slippage	PD ratio	PnL	Activeness
SMA	-58218.8	-58218.8	28%
VWAP	-45318.14	-45318.14	51%
EMA	-58218.8	-58218.8	28%
Rolling Median	-18312.19	-18312.19	89%

Part 1 day 1-500 without slippage

Indicator/Slippage	PD ratio	PnL	Activeness
SMA	-43300.78	-43300.78	28%
VWAP	-30351.83	-30351.83	51%
EMA	-43300.78	-43300.78	28%
Rolling Median	-9254.32	-9254.32	89%

2.3.1.7 BBands based Strategy (Trend-following)

No alternative indicators for this strategy yet.

2.3.2 Strategy Comparable Analysis

In order to test our strategy objectively, comparable analysis will be implemented among strategies and benchmark which have been given in Lecture 226 as sample strategies.

Because parameters in the sample strategies have been optimized, in the following comparable analysis, wager for each strategy, each series and each enter point will be re-adjusted to the same as 1 unit of series per time. Also, all strategies (11 sample and 7 ours) trading with 10 series over time. (See Appendix F)

Part 1 day 1-500 with 0.2 slippage and 1 unit fixed wager

Strategy/Performance Measurement	PD Ratio	PnL	Activeness
Bankrupt	−1184169.61	−1184169.61	2%
BBands contrarian	−24.12	−24.12	75%
BBands holding period	−28.22	−28.22	86%
BBands trend following	−7.1	−7.1	78%
Big spender	−58873.53	−58873.53	100%
Copycat	−194.39	−194.39	100%
Extreme limit	−7539.21	−7539.21	0
Fixed (buy & hold)	−275.63	−275.63	100%
Random	3.64	138229.89	100%
Rsi contrarian	−3.94	−3.94	3%
Simple limit	−1188.76	−1188.76	100%
Triple moving average Strategy (with SMA5/30/100)	-66.72	-66.72	77%
Relative strength Strategy (with MTM365)	-70.22	-70.22	27%
Market making Strategy (no indicator)	4.47	18.29	67%
The Jump Trading Strategy (with EMA5)	0	0	0
Lawrence Macmillan Volatility Trading System (with SD5/10/20/30/100)	-99.21	-99.21	34%
BBands based Strategy (Mean-reversion) (with SMA30)	-18.9	-18.9	27%
BBands based Strategy (Trend-following) (with no indicator)	-40.4	-40.4	32%

Part 1 day 1-500 without slippage and 1 unit fixed wager

Strategy/Performance Measurement	PD Ratio	PnL	Activeness
Bankrupt	−1626623.2	−1626623.2	2%
BBands contrarian	−22.81	−22.81	92%
BBands holding period	0.29	14.94	86%
BBands trend following	0.07	3.68	86%

Big spender	−58483.06	−58483.06	100%
Copycat	0.35	68.71	100%
Extreme limit	−7539.21	−7539.21	0
Fixed (buy & hold)	−267.59	−267.59	100%
Random	−125498.86	−125498.86	100%
RSI contrarian	−2.63	−2.63	3%
Simple limit	−1182.18	−1182.18	100%
Triple moving average Strategy (with SMA5/30/100)	0.14	19.57	77%
Relative strength Strategy (with MTM365)	-70.16	-70.16	27%
Market making Strategy (no indicator)	4.52	18.36	67%
The Jump Trading Strategy (with EMA5)	0	0	0
Lawrence Macmillan Volatility Trading System (with SD5/10/20/30/100)	-58.26	-58.26	34%
BBands based Strategy (Mean-reversion) (with SMA30)	0.3	6.45	27%
BBands based Strategy (Trend-following) (with no indicator)	-17.23	-17.23	32%

In part 2, we will also explore the winning rate, losing rate, winning times, losing times, triggering times and odds for each strategy for each series further due to the complexity of coding.

```r
# example parameters setting in our benchmark strategies
example_params <- list(
               "fixed"=list(sizes=rep(1,10)),
               "big_spender"=list(sizes=rep(1,10)),
               "bankrupt"=list(leverage=40000000),
               "copycat"=NULL,
               "random"=list(maxLots=100),
               "rsi_contrarian"=list(lookback=10,threshold=25,series=1:10),
               "bbands_contrarian"=list(lookback=20,sdParam=1.5,series=1:10, posSizes=rep(1,10)),
               "bbands_trend_following"=list(lookback=50, sdParam=1.5, series=1:10, posSizes=rep(1,10)),
               "bbands_holding_period"=list(lookback=50,sdParam=1.5,series=1:10, posSizes=rep(1,10),holdPeriod=6),
               "simple_limit"=list(spreadPercentage=0.001,inventoryLimits=rep(10,10)),
               "extreme_limit"=list(spreadPercentage=0.001,inventoryLimits=rep(10,10))
                    )
```

3 Risk management

3.1 Position sizing

3.1.1 Wager strategy

3.1.1.1 Fixed Size wager (benchmark)

By assigning fixed size wager for each series for each bet, we can get a fair performance benchmark in the simplest way.

3.1.1.2 Performance based weighted average size wager (benchmark)

Similar to 3.1.1.1, we can re-allocate our money depending on the PD ratio or PnL of our strategy on each series.

For instance, we have 2 series and first time we allocate 50/50 wager equally in them. After a month, we observed that 1 series make $500 profit in total, but the other one only makes $30 so that we can re-allocate 500 / (500+30) = 94.33% of our balance in the first series and put the rest in the other series.

3.1.1.3 Volatility based weighted average size wager (benchmark)

The idea of volatility-based wager strategy solely introduce volatility into consideration. From data analysis, there is huge volatility in several series in OHLCV which related to the profitability of volatility-based trading strategies. Besides, more volatility often means more price changes in short-term which is in nature beneficial to almost all trading ideas.

3.1.1.4 Kelly formula (Optimal Position)

In short, here are the pros and cons about the implementation of this formula in reality:

Pros:
1. Maximizing profit in the long term.
2. Without bankruptcy concerns.

Cons:
1. Need to re-balance on a regular basis which will cost slippage.
2. Optimal positions may not meet in the real world due to the equation assumes that money and gambling are infinitely divisible.
3. Hard to decide on the frequency of re-balance.

This strategy will be tried in our cross-strategy and cross-series level wager strategies. Firstly, Part 1 in-sample data will be used to find respective winning and losing probability and the expected amount gained with a win and a loss at each series.

Secondly, the optimal positions derived from the formula will be put in the strategies in the Part 1 out-of-sample data.

Thirdly, optimal weights in each series and each strategy will be re-calculated per 30 days. If the next optimal positions change more than 10% than its previous positions, then positions will be re-assigned at cross-strategy and cross-series level. 10% rule is introduced by industry to avoid over frequently changing positions might lose more trading cost.

3.1.1.5 Martingale

By setting fairly small wager for each trade in the beginning, we are able to use Martingale strategy. For example, when triggering enter point, we put in $1. If we lose, we double our wager to $2 in the next triggering enter point until winning. After winning once, our wager return to the initial amount.

Here are the pros and cons of the implementation of this strategy:

Pros:
When one wins (each time is considered a 100% win/loss of the bet), not only will he recover the previous loss, but he will also gain the total amount of the first bet. Assuming that one has an infinite amount of money, the strategy must be able to achieve its purpose.

Cons:
1. The average trading cost after the second entry will be higher than the current market price.
2. Small short-term profits will be followed by the possibility of large losses
3. Potentially unlimited loss.
4. No stop-loss positions, account losses and then re-enter the positions.
5. Floating losses can cause problems with allocating funds throughout the portfolio.

3.1.1.6 Reversed Martingale

In contrast to martingale, Reversed Martingale is to double the wager every time you win until you return the wager to the initial unit when there is a loss. In theory this strategy is more suitable for use in trend strategy, as trading with the trend has a high winning rate.
Here are the pros and cons of the implementation of this strategy:

Pros:

1. The average trading cost after the second entry will be lower than the current market price.
2. Small short-term losses will be followed by the possibility of large profits.
3. Potential unlimited profit.
4. Have a stop-loss position and will not add to it after a loss.

Cons:
The floating profit will help the whole portfolio allocate funds loosely.

3.1.2 Capital Utilization Rate

By calculating the time spent by the strategy on each series position, we can get the strategy's capital utilization rate on each series.

In part 2, capital utilization analysis will implement to measure the performance of strategy.

3.1.3 Leverage rate

As mentioned in 2.1, leverage can bring more profit or more risks into our portfolio, so further exploration on leverage effect is needed in part 2.
Here are the pros and cons of leverage:

Pros:

1. Leveraged investments allow investors to invest high amounts of money in the market with less capital, which greatly saves on transaction costs and especially improves capital utilization rate
2. With the use of leverage, the profit result will increase exponentially if they make a profit

Cons:

1. The greater the leverage used, the greater the percentage of position, and the greater the probability that the portfolio will experience losses and bankruptcy if judgment is faulty.

Therefore, different levels of leverage rate will be tested in Part 2 to utilize this tool but with the minimal probability of brokage.

3.2 Risk Control

3.2.1 Stop Gain

The 5 most common take-profit strategies will be tested in Part 2 as listed:

1. Valuation Take Profit Strategy
2. Annualised Return Take Profit Strategy
3. Enhanced Annualised Return Stop Out Method
4. Split Take Profit Strategy
5. Retracement/peak-right take-profit

3.2.2 Stop Loss

Like stop gain, there are also 11 most common ways of setting stop loss triggering points listed and will be tested:

1. Chandelier stop loss
2. YOYO Stops
3. ATR indicator in the application of stop loss
4. Time Stops
5. Time + Spread Ladder Stops
6. Capital preservation
7. Support/pressure levels
8. Trailing Stops
9. Ladder Stops
10. Spread Stop Loss
11. Limit Stops/Stop Losses

3.2.3 VaR

Historical method of VaR will be tested in Part 2, which looks at previous earnings history and ranks them in order from greatest loss to greatest gain.

```
# VaR control to prevent extreme cases happen
# Calculate returns
rtn<- diff(log(store$cl[1:store$iter,which(params$series==i)]))
if(VaR(rtn,p=0.99)>0.05){
    marketOrders[i] <- marketOrders[i]
    next
}
```

3.2.3 ES (Expected Shortfall)

ES is a more practical method than VaR across investment industry, so it will also be tried in Part 2.

3.2.4 Holding Period

Like 3.1.2, a holding period limit can prevent one strategy having a low capital utilization rate but taking up most of positions. In addition, the average profitable periods can be calculated in each trade, so a reasonable holding period can be calculated like the concept of duration.

3.3 Strategy Exit Mechanism

A real-time monitor for the performance of our strategies by setting strategy exit mechanism is needed. For example, limit the maximum drawdown to less than 20%, if this limit has been broken, then stop trading. However, this kind of mechanism may also affect the activity level of strategy which need to be further analyzed in Part 2.

3.4 Liquidity Assessment

Due to investment duration constraints, there may be days when all trades cannot be satisfied at the same time, and it is necessary to evaluate the priority of all trades on the same day as which ones should be satisfied more and which ones can be cancelled. What's more, due to the existence of leverage, to prevent the occurrence of extreme risk, it is necessary to keep a certain amount of cash. But keeping too much cash will not enable us to maximize profits. In Part 2 we will explore the relationship between cash, profit and risk.

4 Plan

1. With part 1 of the data, the performance of strategy on the in-sample data will be utilized to optimize parameters, parameter approximation and find the best performance indicators

2. Using the out-of-sample data to test and optimize our indicators, trading mechanisms and parameters

3. Rolling window method will be implemented to check strategy performance across time to check if performance of portfolio swings rapidly

4. Meanwhile, other methods like simulation that randomizing different factors will also be tried. The most stable, robust and superior parameter, series for each strategy and indicator will be chosen eventually.

5. Part 2 data will be used to verify the out-of-distribution performance and robustness of mix portfolio. If performance finally goes bad, trading ideas will be back to factory and do root cause analysis part by part.

4.1 Parameter Optimization

4.1.1 Grid Search

Grid Search is solely using violent search for every possibility of parameter set that we put in like an example code below.

```r
# grid search with cross validation ---------------------------------------

# insample series
# the first 500 rows of data in datalist
insample<- lapply(dataList, function(x) x[1:500,])

# RSI trading parameters Optimization
# (n & lev)
sMult <- 0.2 # slippage multiplier
nSeq<- c(12,14,16,18,20,22,24,26,28)
levSeq  <- c(10,15,20,25,30,35,40)
paramsList<- list(nSeq, levSeq)
numberComb <- prod(sapply(paramsList,length))

resultsMatrixRSI <- matrix(nrow=numberComb,ncol=3)
colnames(resultsMatrixRSI) <- c("n","lev","PD Ratio")
pfolioPnLList <- vector(mode="list",length=numberComb)

count <- 1
for (n in nSeq) {
  for (lev in levSeq) {
    INparams.rsi<- list(lookback=33, series=1:10,posSizes=rep(0.01,10),n=n,lev=lev ) # tbd
    results <- backtest(insample, getOrders.RSI, INparams.rsi, sMult)
    pfolioPnL <- plotResults(insample,results)
    resultsMatrixRSI[count,] <- c(n,lev,pfolioPnL$fitAgg)
    pfolioPnLList[[count]]<- pfolioPnL
    cat("Just completed",count,"out of",numberComb,"\n")
    print(resultsMatrixRSI[count,])
    count <- count + 1
  }
}
INn<- resultsMatrixRSI[order(resultsMatrixRSI[,"PD Ratio"]),][nrow(resultsMatrixRSI),1]
INlev<- resultsMatrixRSI[order(resultsMatrixRSI[,"PD Ratio"]),][nrow(resultsMatrixRSI),2]
```

4.1.2 Evolutionary Algorithms

By setting a target like PD Ratio of our portfolio and running simulations with different random combinations of parameter. In each epoch, we drop the combination with the worst performance valued by our pre-set target. After several epochs, the algorithm will be stopped and select the Top-K combinations. But the result of the best combination is highly sensitive to the functions we selected.

4.1.3 Rolling Window Method

This is a process for testing a trading strategy by finding its optimal trading parameters in the in-sample time period and checking the performance of those parameters across the out-of-sample time period.

```
# rolling window method
window <- 200
intl <- 50
i = 0
resagg <- NULL
outdta <- outSample
while((i+window) < nrow(outdta[[1]])){
  ddta <- lapply(outdta, function(x) x[(i+1):(i + window),])
  test <- backtest(ddta, getOrders.bb, params.bb, sMult=0.2)
  pfolioPnL <- plotResults(ddta, test, plotType='ggplot2')
  perf <- pfolioPnL$fitAgg
  resagg<- c(resagg, perf)
  i <- i+intl
}
plot(resagg,type="l")
title(c('pd ratio of cumulative pnl over period'))
```

4.2 Parameter Approximation

4.2.1 Bisection Method

Bisection method will be implemented to find the reasonable range of parameters. First, 2 numbers of one parameter will be selected and test the strategy performance. Afterwards, a new greater/smaller number than the previous one that has better performance which is in our favor. And iterate this process many times until the performances are relatively stable so that we can know the proper range of that parameter.

4.2.2 Newton-Raphson Method

Like Bisection Method, but Newton-Raphson Method is solely much quicker. So, if our computation power is not enough, we will try this method.

4.3 Market Condition Identification and Signal Filtering

There are many anomalies in OHLCV and indicators as graph 3 showed. For preventing uncertain market conditions, a proper range of OHLCV need to be established. Secondly, strategies only work in certain periods. Strategy can perform completely differently in such as bull and bear market. Thus, in part 2, we will further analyze data about the basics and indicators to find their mutual patterns or common behaviors to identify different market conditions.

4.4 Robustness Testing

4.4.1 Make use of In Sample and Out of Sample periods

The most basic test for robustness is testing the strategy on out-of-sample data. If we run genetic evolution, the strategy is evolved only on the In-sample part of data. The out-of-sample part is “unknown” to the strategy, so it can be used to determine if the strategy performs also on unknown part of data.

The blue part of each chart is the Out of Sample (unknown) data., We can see that the strategy on the left performs well also on this part, while strategy on the right fails on the unknown data – it is almost certain to be over-fitted.

4.4.2 Test strategy on multiple symbols

Second test for robustness is very tough – it means testing the same strategy on different symbol(s). Robust strategy should ideally work on multiple symbols.

In reality, because each market has its own characteristics, daily volatility, etc., it will be not easy to find a strategy that has the same perfect performance on multiple symbols using just one set of settings.

We can be satisfied if the strategy performs on other markets with at least some degree of profitability, or just slightly losing.

4.4.3 Monte-Carlo method

This simply repeatedly tests the strategy with different random changes in the input parameters and data performing Monte Carlo simulation.

The idea behind this robustness testing is to verify how well the strategy performs when there are small changes in inputs, history data or other components of the strategy.

For instance, we can randomize several factors that might affect the performance of our strategy:

1. Randomize Trades Order
2. Randomly Skip Trades

3. Randomize Trades Type (market order/limit order)
4. Randomize Starting trade day
5. Randomize Strategy Parameters
6. Randomize History Data (by adding noise)

4.4.4 Use Rolling-Window Matrix as a robustness test

As mentioned in section 4.1.3, if the strategy passes this test, it means that with the help of parameter re-optimization it is adaptable to a wide range of market conditions.

5 Breakdown of teamwork

Shuying Zhai

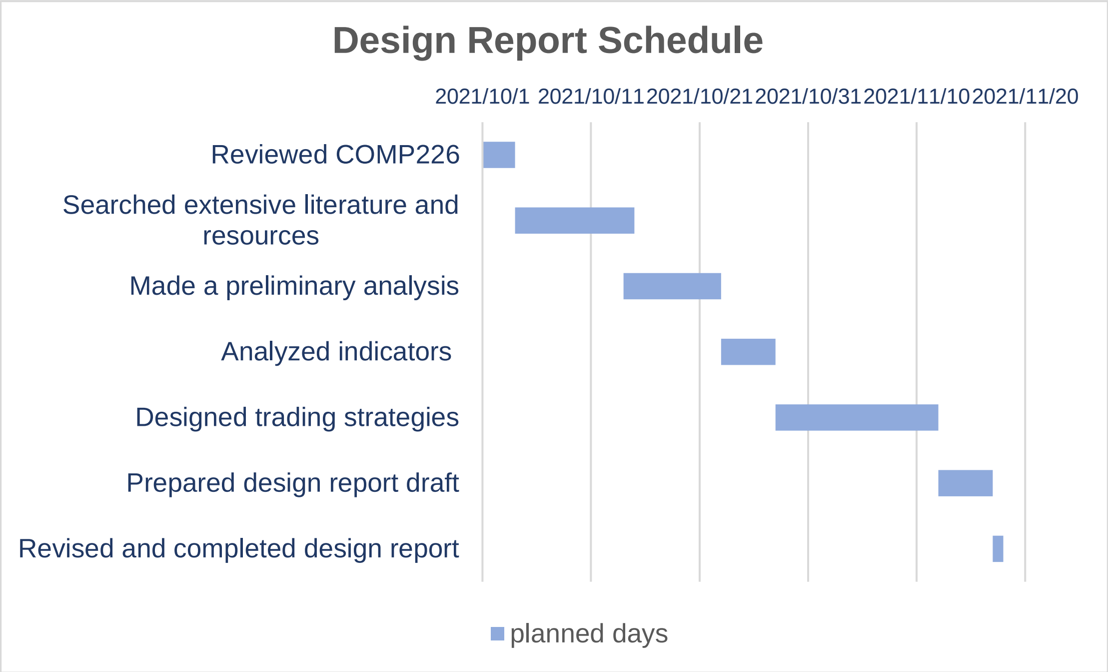
1. Consulted relevant information on statistical tests and indicators;
2. Analysed the trend and volatility of the high and low prices of each series;
3. Conducted preliminary analysis using rolling median and open to open difference methods;
4. Analysed each indicator in momentum and mean reversion;
5. Designed the relative strength strategy, Bbands based Strategy, Jump Trading Strategy and Market Making Strategy;
6. Prepared design reports.

Yushan Zhang

1. Reviewed relevant information on trading strategies and indicators;
2. Analyzed the trend and volatility of the opening price and volume of each series;
3. Conducted preliminary analysis using overnight gap, VWAP and other methods;
4. Analysed the indicators in trend trading;
5. Designed the relative strength strategy, Bbands based Strategy, The Jump Trading Strategy and Market Making Strategy;
6. Prepared design reports.

Chia-Wei Liu

1. Reviewed relevant information on parameter optimization and risk control;
2. Analyzed the trend and volatility of the closing price of each series;
3. Conducted preliminary analysis using EMA, SMA, daily spread, and other methods;
4. Analysed each indicator in volatility;
5. Designed the Triple moving average Strategy, Lawrence Macmillan Volatility Trading System and Market Making Strategy;
6. Prepared design reports.



(Count: 4660 words)

6 References

Zach, V., 2021. *Augmented Dickey-Fuller Test in R (With Example)*. [online] Statology. Available at: <https://www.statology.org/dickey-fuller-test-in-r/> [Accessed 15 November 2021].

Quantstart.com. *Johansen Test for Cointegrating Time Series Analysis in R | QuantStart*. [online] Available at: <https://www.quantstart.com/articles/Johansen-Test-for-Cointegrating-Time-Series-Analysis-in-R/> [Accessed 15 November 2021].

Otexts.com. 2018. *Chapter 8 ARIMA models | Forecasting: Principles and Practice (2nd ed)*. [online] Available at: <https://otexts.com/fpp2/arima.html> [Accessed 15 November 2021].

School.stockcharts.com. *Technical Indicators and Overlays [ChartSchool]*. [online] Available at: <https://school.stockcharts.com/doku.php?id=technical_indicators> [Accessed 15 November 2021].

Trading Technologies. *List of Technical Indicators | Trading Technologies*. [online] Available at: <https://www.tradingtechnologies.com/xtrader-help/x-study/technical-indicator-definitions/list-of-technical-indicators/> [Accessed 15 November 2021].

Tradingsim. 2021. *How to Day Trade with the Triple Exponential Moving Average (TEMA)*. [online] Available at: <https://tradingsim.com/blog/triple-exponential-moving-average/> [Accessed 15 November 2021].

Faber, M., 2010. *Relative Strength Strategies for Investing*. [online] Cambriainvestments.com. Available at: <https://www.cambriainvestments.com/wp-content/uploads/2018/01/Relative-Strength-Strategies-for-Investing.pdf> [Accessed 15 November 2021].

Singh, D., 2017. *Moving Average Trading Strategies*. [online] Blog.quantinsti.com. Available at: <https://blog.quantinsti.com/moving-average-trading-strategies/> [Accessed 15 November 2021].

Xiong, Y., Yamada, T. and Terano, T., 2015. *COMPARISON OF DIFFERENT MARKET MAKING STRATEGIES FOR HIGH FREQUENCY TRADERS*. [online] Informs-sim.org. Available at: <https://www.informs-sim.org/wsc15papers/027.pdf> [Accessed 15 November 2021].

McMillan, L., 2013. *Mcmillan on options*. Hoboken, N.J.: Wiley.

Yoder, N., 2021. *The Kelly Criterion - Quantitative Trading*. [online] Nick Yoder. Available at: <https://nickyoder.com/kelly-criterion/> [Accessed 15 November 2021].

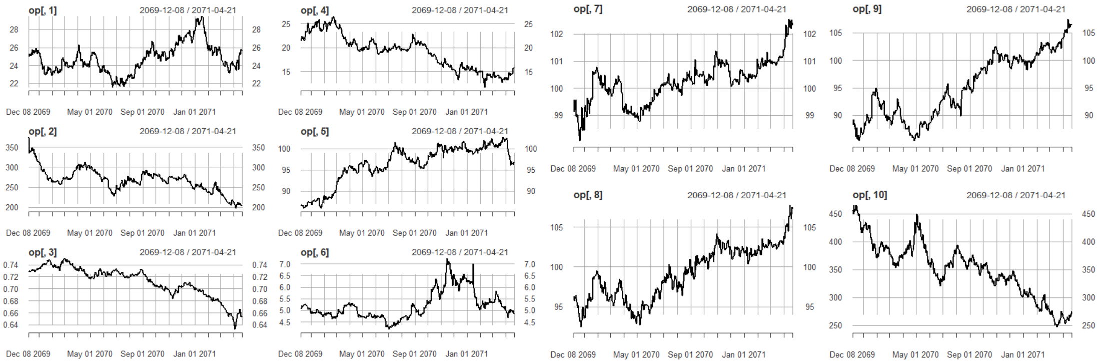
Forex Training Group. *Martingale and Anti-Martingale Trading Strategies - Forex Training Group*. [online] Available at: <https://forextraininggroup.com/martingale-and-anti-martingale-trading-strategies/> [Accessed 15 November 2021].

Engineering Education (EngEd) Program | Section. 2021. *Using Grid Search to Optimize Hyperparameters*. [online] Available at: <https://www.section.io/engineering-education/grid-search/> [Accessed 15 November 2021].

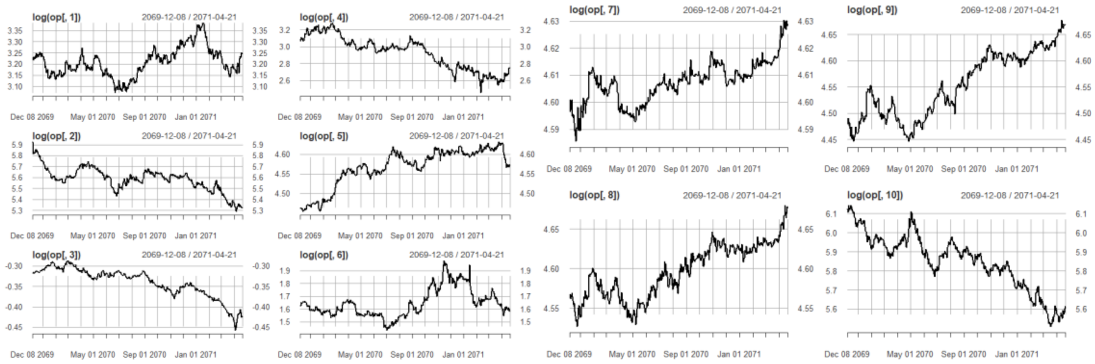
BRIE, L., GENEST, B. and ARSAC, M., 2021. [online] Chappuishalder.com. Available at: <https://chappuishalder.com/wp-content/uploads/2020/02/Whitepaper-ES-BT_GRA_Vdef_20180402_LON_.pdf> [Accessed 15 November 2021].

Dawson, T., 2017. Top Gambling Strategies That Could Help You Win More Often. [online] Legitgamblingsites.com. Available at: <https://www.legitgamblingsites.com/blog/betting-strategies-that-work-at-least-some-of-the-time/> [Accessed 15 November 2021].

Appendix A



Graph A.1: Open price graph



Graph A.2: Log open price graph

```
> basicStats(op)
                     Op1          Op2        Op3         Op4          Op5         Op6          Op7          Op8
nobs          500.000000 5.000000e+02 500.000000  500.000000   500.000000  500.000000   500.000000   500.000000
NAs             0.000000 0.000000e+00   0.000000    0.000000     0.000000    0.000000     0.000000     0.000000
Minimum        21.580000 1.982500e+02   0.632800   11.700000    85.950000    4.190000    98.046898    92.437500
Maximum        29.500000 3.750000e+02   0.751000   26.600000   102.700000    7.250000   102.562500   107.781197
1. Quartile    23.695000 2.519375e+02   0.698000   15.590000    94.755000    4.765000    99.781197    96.242201
3. Quartile    25.625000 2.820000e+02   0.730525   21.337500    99.855000    5.396250   100.650349   102.101602
Mean           24.783140 2.674850e+02   0.712042   19.058620    96.345760    5.210850   100.213405    99.174189
Median         24.650000 2.695000e+02   0.720550   19.580000    97.275000    5.070000   100.269501    99.062500
Sum         12391.570000 1.337425e+05 356.020800 9529.310000 48172.880000 2605.425000 50106.702675 49587.094651
SE Mean         0.073157 1.269559e+00   0.001126    0.161937     0.200944    0.027054     0.034511     0.148895
LCL Mean       24.639407 2.649907e+02   0.709829   18.740459    95.950959    5.157696   100.145600    98.881652
UCL Mean       24.926873 2.699793e+02   0.714254   19.376781    96.740561    5.264004   100.281210    99.466727
Variance        2.675938 8.058898e+02   0.000634   13.111717    20.189322    0.365966     0.595508    11.084799
Stdev           1.635830 2.838820e+01   0.025177    3.621010     4.493253    0.604951     0.771692     3.329384
Skewness        0.565977 1.005500e-01  -0.872998    0.042221    -0.920215    1.047088     0.067581    -0.006506
Kurtosis        0.221414 7.374890e-01   0.126498   -1.002581    -0.224933    0.555945     0.428472    -0.997450
                     Op9         Op10
nobs          500.000000   500.000000
NAs             0.000000     0.000000
Minimum        85.312500   246.750000
Maximum       107.531200   466.000000
1. Quartile    89.585975   321.000000
3. Quartile   100.257800   383.250000
Mean           95.135250   350.905500
Median         94.609400   357.000000
Sum         47567.624800 175452.750000
SE Mean         0.261457     2.223954
LCL Mean       94.621557   346.536033
UCL Mean       95.648942   355.274967
Variance       34.179913  2472.985165
Stdev           5.846359    49.729118
Skewness        0.061656    -0.104917
Kurtosis       -1.324605    -0.443161
```

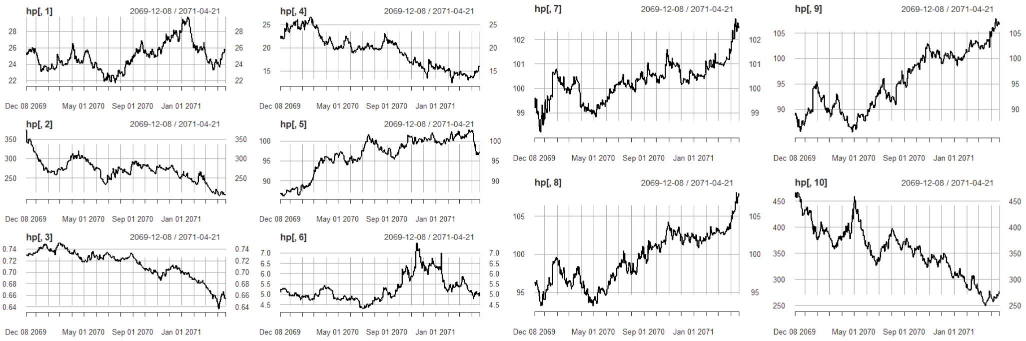
```
> logop<-log(op)
> basicStats(logop)
                    Op1         Op2         Op3         Op4         Op5        Op6         Op7         Op8
nobs         500.000000  500.000000  500.000000  500.000000  500.000000 500.000000  500.000000  500.000000
NAs            0.000000    0.000000    0.000000    0.000000    0.000000   0.000000    0.000000    0.000000
Minimum        3.071767    5.289529   -0.457601    2.459589    4.453766   1.432701    4.585446    4.526533
Maximum        3.384390    5.926926   -0.286350    3.280911    4.631812   1.981001    4.630472    4.680103
1. Quartile    3.165264    5.529181   -0.359536    2.746629    4.551295   1.561298    4.602980    4.566868
3. Quartile    3.243568    5.641907   -0.313992    3.060466    4.603719   1.685704    4.611653    4.625968
Mean           3.208029    5.583367   -0.340257    2.928938    4.566823   1.644427    4.607272    4.596315
Median         3.204777    5.596568   -0.327740    2.974509    4.577542   1.623341    4.607862    4.595751
Sum         1604.014734 2791.683295 -170.128487 1464.468971 2283.411726 822.213253 2303.636192 2298.157348
SE Mean        0.002913    0.004804    0.001608    0.008710    0.002136   0.004958    0.000344    0.001503
LCL Mean       3.202307    5.573928   -0.343417    2.911826    4.562628   1.634686    4.606596    4.593362
UCL Mean       3.213752    5.592805   -0.337097    2.946050    4.571019   1.654167    4.607949    4.599267
Variance       0.004241    0.011539    0.001293    0.037930    0.002280   0.012290    0.000059    0.001129
Stdev          0.065126    0.107421    0.035962    0.194756    0.047752   0.110861    0.007699    0.033605
Skewness       0.383432   -0.312332   -0.947930   -0.234154   -0.986113   0.807996    0.039704   -0.056338
Kurtosis      -0.008941    0.562185    0.302486   -1.028495   -0.116980   0.086889    0.401543   -1.023845
                    Op9        Op10
nobs         500.000000  500.000000
NAs            0.000000    0.000000
Minimum        4.446321    5.508376
Maximum        4.677781    6.144186
1. Quartile    4.495199    5.771441
3. Quartile    4.607745    5.948687
Mean           4.553414    5.850125
Median         4.549757    5.877736
Sum         2276.706961 2925.062356
SE Mean        0.002750    0.006524
LCL Mean       4.548012    5.837307
UCL Mean       4.558816    5.862943
Variance       0.003780    0.021282
Stdev          0.061485    0.145883
Skewness       0.000116   -0.428268
Kurtosis      -1.341267   -0.382027
```

```
> scale_op<-scale(op)
> basicStats(scale_op)
                   op1        op2        op3        op4        op5        op6        op7        op8        op9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -1.958114  -2.438866  -3.147382  -2.032201  -2.313638  -1.687492  -2.807477  -2.023404  -1.680148
Maximum       2.883467   3.787313   1.547381   2.082673   1.414174   3.370769   3.044084   2.585165   2.120286
1. Quartile  -0.665192  -0.547675  -0.557716  -0.957915  -0.354033  -0.737002  -0.560079  -0.880640  -0.949185
3. Quartile   0.514638   0.511304   0.734139   0.629349   0.781002   0.306471   0.566215   0.879266   0.876195
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.081390   0.070980   0.337943   0.143987   0.206808  -0.232829   0.072691  -0.033547  -0.089945
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.565977   0.100550  -0.872998   0.042221  -0.920215   1.047088   0.067581  -0.006506   0.061656
Kurtosis      0.221414   0.737489   0.126498  -1.002581  -0.224933   0.555945   0.428472  -0.997450  -1.324605
                  op10
nobs        500.000000
NAs           0.000000
Minimum      -2.094457
Maximum       2.314429
1. Quartile  -0.601368
3. Quartile   0.650414
Mean          0.000000
Median        0.122554
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.104917
Kurtosis     -0.443161
```

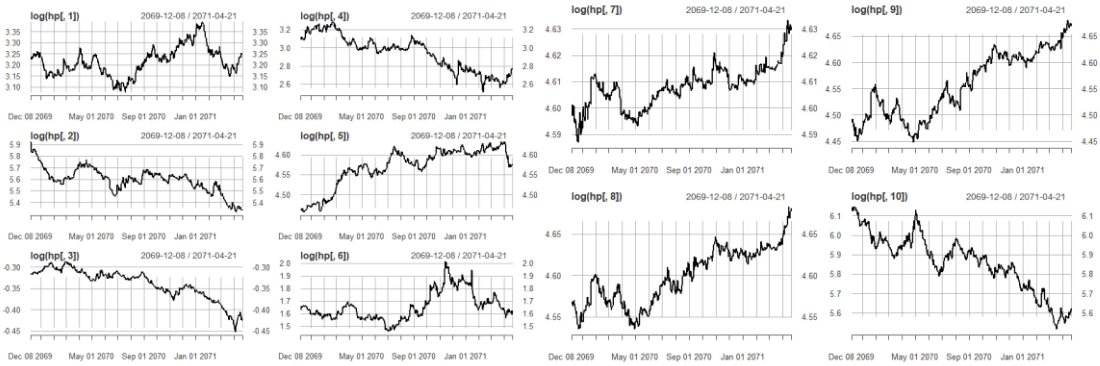
```
> logOp<-log(Op)
> scale_logOp<-scale(logOp)
> basicStats(scale_logOp)
                   Op1        Op2        Op3        Op4        Op5        Op6        Op7        Op8        Op9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -2.092284  -2.735392  -3.262953  -2.409935  -2.367605  -1.909826  -2.834924  -2.076557  -1.741773
Maximum       2.707985   3.198261   1.498989   1.807253   1.360964   3.036001   3.013323   2.493362   2.022722
1. Quartile  -0.656656  -0.504425  -0.536092  -0.936089  -0.325198  -0.749847  -0.557547  -0.876271  -0.946818
3. Quartile   0.545693   0.544965   0.730349   0.675348   0.772653   0.372336   0.568925   0.882429   0.883645
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.049943   0.122898   0.348043   0.233989   0.224462  -0.190199   0.076526  -0.016775  -0.059479
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.383432  -0.312332  -0.947930  -0.234154  -0.986113   0.807996   0.039704  -0.056338   0.000116
Kurtosis     -0.008941   0.562185   0.302486  -1.028495  -0.116980   0.086889   0.401543  -1.023845  -1.341267
                  Op10
nobs        500.000000
NAs           0.000000
Minimum      -2.342620
Maximum       2.015728
1. Quartile  -0.539360
3. Quartile   0.675624
Mean          0.000000
Median        0.189268
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.428268
Kurtosis     -0.382027
```

Figure A.3: Basic statistical data of open price

Graph A.4：Correlation graph of open price



Graph A.5: High price graph



Graph A.6: Log high price graph

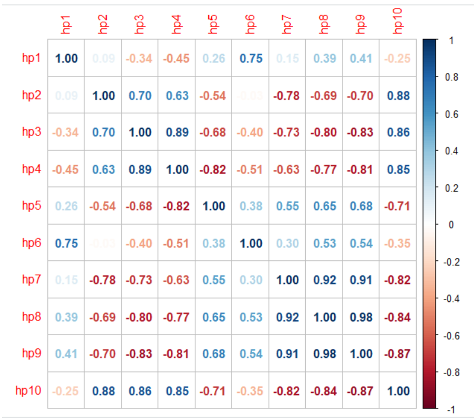
```
> basicStats(hp)
                    hp1          hp2        hp3         hp4          hp5         hp6          hp7          hp8
nobs         500.000000 5.000000e+02 500.000000  500.000000   500.000000  500.000000   500.000000   500.000000
NAs            0.000000 0.000000e+00   0.000000    0.000000     0.000000    0.000000     0.000000     0.000000
Minimum       21.700000 2.037500e+02   0.636300   12.350000    86.190000    4.285000    98.203102    93.218803
Maximum       29.830000 3.750000e+02   0.751200   26.740000   102.820000    7.500000   102.867203   108.156197
1. Quartile   23.850000 2.556250e+02   0.698575   15.800000    95.065000    4.825000    99.839878    96.437500
3. Quartile   25.822500 2.847500e+02   0.731425   21.575000   100.250000    5.476250   100.742203   102.312500
Mean          24.985920 2.700775e+02   0.712883   19.345320    96.617820    5.276810   100.280611    99.409186
Median        24.865000 2.722500e+02   0.721150   19.795000    97.520000    5.120000   100.335899    99.375000
Sum        12492.960000 1.350388e+05 356.441400 9672.660000 48308.910000 2638.405000 50140.305702 49704.592849
SE Mean        0.074008 1.274189e+00   0.001117    0.163128     0.202098    0.027984     0.034935     0.149338
LCL Mean      24.840514 2.675741e+02   0.710688   19.024818    96.220753    5.221829   100.211973    99.115777
UCL Mean      25.131326 2.725809e+02   0.715078   19.665822    97.014887    5.331791   100.349250    99.702595
Variance       2.738616 8.117787e+02   0.000624   13.305338    20.421732    0.391553     0.610234    11.150935
Stdev          1.654876 2.849173e+01   0.024984    3.647648     4.519041    0.625742     0.781175     3.339302
Skewness       0.579777 8.540200e-02  -0.849850    0.057444    -0.927626    1.088783     0.170078     0.028098
Kurtosis       0.214213 7.074170e-01   0.039918   -1.012181    -0.212090    0.670524     0.616340    -0.954563
                    hp9          hp10
nobs         500.000000    500.000000
NAs            0.000000      0.000000
Minimum       85.437500    248.750000
Maximum      107.937500    467.500000
1. Quartile   89.968800    325.500000
3. Quartile  100.656200    387.625000
Mean          95.489313    354.552500
Median        94.968800    360.500000
Sum        47744.656700 177276.250000
SE Mean        0.262748      2.248637
LCL Mean      94.973085    350.134537
UCL Mean      96.005542    358.970463
Variance      34.518273   2528.184488
Stdev          5.875225     50.281055
Skewness       0.067721     -0.105904
Kurtosis      -1.307702     -0.467690
```

```
> loghp<-log(hp)
> basicStats(loghp)
                    hp1         hp2         hp3         hp4         hp5        hp6         hp7         hp8
nobs         500.000000  500.000000  500.000000  500.000000  500.000000 500.000000  500.000000  500.000000
NAs            0.000000    0.000000    0.000000    0.000000    0.000000   0.000000    0.000000    0.000000
Minimum        3.077312    5.316894   -0.452085    2.513656    4.456554   1.455121    4.587038    4.534949
Maximum        3.395515    5.926926   -0.286083    3.286161    4.632980   2.014903    4.633439    4.683576
1. Quartile    3.171784    5.543711   -0.358713    2.760010    4.554561   1.573811    4.603568    4.568895
3. Quartile    3.251246    5.651612   -0.312761    3.071535    4.607667   1.700420    4.612565    4.628032
Mean           3.216165    5.593076   -0.339065    2.944199    4.569636   1.656758    4.607942    4.598681
Median         3.213461    5.606721   -0.326908    2.985429    4.580057   1.633154    4.608524    4.598901
Sum         1608.082578 2796.537847 -169.532266 1472.099733 2284.818178 828.378950 2303.971057 2299.340582
SE Mean        0.002921    0.004778    0.001593    0.008625    0.002142   0.005049    0.000348    0.001503
LCL Mean       3.210426    5.583689   -0.342195    2.927253    4.565427   1.646838    4.607258    4.595728
UCL Mean       3.221904    5.602463   -0.335935    2.961146    4.573845   1.666678    4.608626    4.601634
Variance       0.004266    0.011414    0.001269    0.037199    0.002295   0.012747    0.000061    0.001129
Stdev          0.065316    0.106836    0.035622    0.192872    0.047903   0.112901    0.007785    0.033606
Skewness       0.399106   -0.322404   -0.921351   -0.213288   -0.993724   0.845540    0.140009   -0.023598
Kurtosis      -0.022356    0.554222    0.198445   -1.049664   -0.101470   0.131263    0.578910   -0.993146
                    hp9        hp10
nobs         500.000000  500.000000
NAs            0.000000    0.000000
Minimum        4.447785    5.516448
Maximum        4.681552    6.147399
1. Quartile    4.499463    5.785359
3. Quartile    4.611711    5.960038
Mean           4.557125    5.860451
Median         4.553548    5.887492
Sum         2278.562271 2930.225391
SE Mean        0.002753    0.006528
LCL Mean       4.551716    5.847625
UCL Mean       4.562533    5.873276
Variance       0.003788    0.021307
Stdev          0.061550    0.145968
Skewness       0.004844   -0.424549
Kurtosis      -1.329026   -0.406601
```

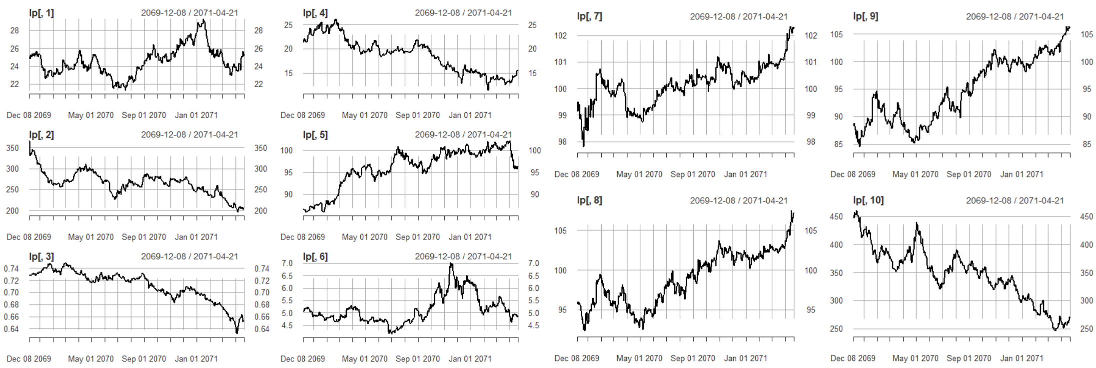
```
> scale_hp<-scale(hp)
> basicstats(scale_hp)
                   hp1        hp2        hp3        hp4        hp5        hp6        hp7        hp8        hp9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -1.985598  -2.327956  -3.065318  -1.917762  -2.307529  -1.585015  -2.659468  -1.853796  -1.710881
Maximum       2.927155   3.682560   1.533692   2.027246   1.372455   3.552887   3.311155   2.619413   2.118759
1. Quartile  -0.686408  -0.507252  -0.572687  -0.971947  -0.343617  -0.722039  -0.564193  -0.889912  -0.939626
3. Quartile   0.505524   0.514974   0.742174   0.611265   0.803750   0.318726   0.590894   0.869438   0.879436
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.073069   0.076250   0.330905   0.123279   0.199640  -0.250599   0.070775  -0.010237  -0.088595
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.579777   0.085402  -0.849850   0.057444  -0.927626   1.088783   0.170078   0.028098   0.067721
Kurtosis      0.214213   0.707417   0.039918  -1.012181  -0.212090   0.670524   0.616340  -0.954563  -1.307702
                  hp10
nobs        500.000000
NAs           0.000000
Minimum      -2.104222
Maximum       2.246323
1. Quartile  -0.577802
3. Quartile   0.657753
Mean          0.000000
Median        0.118285
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.105904
Kurtosis     -0.467690
```

```
> loghp<-log(hp)
> scale_loghp<-scale(loghp)
> basicStats(scale_loghp)
                   hp1        hp2        hp3        hp4        hp5        hp6        hp7        hp8        hp9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -2.125879  -2.585104  -3.172737  -2.232279  -2.360648  -1.785968  -2.685052  -1.896430  -1.776441
Maximum       2.745893   3.124889   1.487298   1.772998   1.322328   3.172208   3.274928   2.526183   2.021582
1. Quartile  -0.679485  -0.462059  -0.551568  -0.954985  -0.314709  -0.734690  -0.561874  -0.886327  -0.936830
3. Quartile   0.537101   0.547905   0.738409   0.660209   0.793910   0.386734   0.593761   0.873372   0.886864
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.041399   0.127720   0.341257   0.213768   0.217546  -0.209064   0.074683   0.006529  -0.058101
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.399106  -0.322404  -0.921351  -0.213288  -0.993724   0.845540   0.140009  -0.023598   0.004844
Kurtosis     -0.022356   0.554222   0.198445  -1.049664  -0.101470   0.131263   0.578910  -0.993146  -1.329026
                  hp10
nobs        500.000000
NAs           0.000000
Minimum      -2.356698
Maximum       1.965832
1. Quartile  -0.514441
3. Quartile   0.682255
Mean          0.000000
Median        0.185254
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.424549
Kurtosis     -0.406601
```

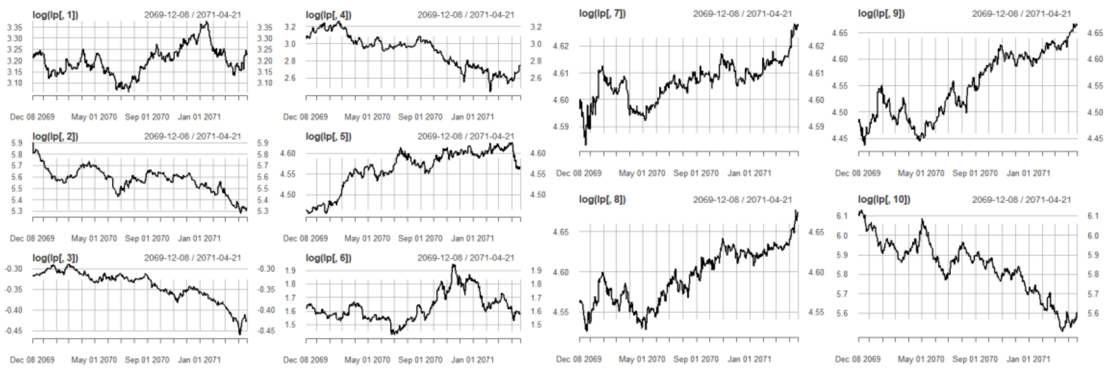
Figure A.7: Basic statistical data of high price



Graph A.8：Correlation graph of high price



Graph A.9: Low price graph



Graph A.10: Log low price graph

```
> basicStats(lp)
                    lp1          lp2         lp3         lp4          lp5         lp6          lp7          lp8
nobs         500.000000 5.000000e+02 500.000000  500.000000   500.000000  500.000000   500.000000   500.000000
NAs            0.000000 0.000000e+00   0.000000    0.000000     0.000000    0.000000     0.000000     0.000000
Minimum       21.300000 1.960000e+02   0.631000   11.400000    85.940000    4.145000    97.796898    92.343803
Maximum       29.330000 3.670000e+02   0.750000   26.250000   102.240000    7.030000   102.351601   107.531197
1. Quartile   23.507500 2.489375e+02   0.696675   15.317500    94.457500    4.720000    99.732449    95.960977
3. Quartile   25.400000 2.802500e+02   0.730000   21.052500    99.505000    5.325000   100.578102   101.914023
Mean          24.568580 2.652090e+02   0.711164   18.788520    96.058060    5.138840   100.147562    98.956064
Median        24.430000 2.672500e+02   0.720000   19.385000    96.830000    5.000000   100.210899    98.984401
Sum        12284.290000 1.326045e+05 355.582000 9394.260000 48029.030000 2569.420000 50073.781022 49478.031833
SE Mean        0.072067 1.257665e+00   0.001133    0.160745     0.198642    0.025689     0.034281     0.149012
LCL Mean      24.426988 2.627380e+02   0.708938   18.472699    95.667782    5.088369   100.080208    98.663296
UCL Mean      24.710172 2.676800e+02   0.713390   19.104341    96.448338    5.189311   100.214916    99.248831
Variance       2.596829 7.908600e+02   0.000642   12.919554    19.729358    0.329956     0.587605    11.102238
Stdev          1.611468 2.812223e+01   0.025339    3.594378     4.441774    0.574418     0.766554     3.332002
Skewness       0.538018 5.449100e-02  -0.885078    0.016802    -0.907299    0.996336    -0.032288    -0.014717
Kurtosis       0.214364 6.738210e-01   0.152394   -1.001263    -0.240351    0.487324     0.404383    -1.018026
                    lp9          lp10
nobs         500.000000    500.000000
NAs            0.000000      0.000000
Minimum       84.468800    246.000000
Maximum      106.437500    461.000000
1. Quartile   89.210975    319.437500
3. Quartile  100.007800    379.250000
Mean          94.812002    347.221000
Median        94.250000    353.625000
Sum        47406.001200 173610.500000
SE Mean        0.261745      2.188219
LCL Mean      94.297744    342.921742
UCL Mean      95.326261    351.520258
Variance      34.255231   2394.150961
Stdev          5.852797     48.930062
Skewness       0.058812     -0.122896
Kurtosis      -1.335466     -0.447620
```

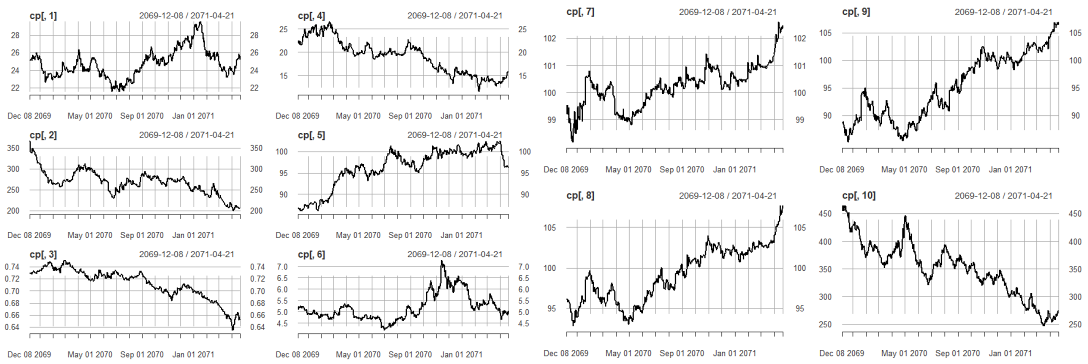
```
> loglp<-log(lp)
> basicStats(loglp)
                    lp1         lp2         lp3         lp4         lp5        lp6         lp7         lp8
nobs         500.000000  500.000000  500.000000  500.000000  500.000000 500.000000  500.000000  500.000000
NAs            0.000000    0.000000    0.000000    0.000000    0.000000   0.000000    0.000000    0.000000
Minimum        3.058707    5.278115   -0.460449    2.433613    4.453649   1.421903    4.582893    4.525519
Maximum        3.378611    5.905362   -0.287682    3.267666    4.627323   1.950187    4.628414    4.677781
1. Quartile    3.157320    5.517202   -0.361436    2.728996    4.548150   1.551809    4.602491    4.563942
3. Quartile    3.234749    5.635682   -0.314711    3.047019    4.600208   1.672413    4.610935    4.624130
Mean           3.199358    5.574814   -0.341500    2.914331    4.563853   1.630939    4.606615    4.594109
Median         3.195812    5.588184   -0.328504    2.964500    4.572957   1.609437    4.607277    4.594962
Sum         1599.679113 2787.406952 -170.750204 1457.165409 2281.926290 815.469640 2303.307738 2297.054688
SE Mean        0.002897    0.004811    0.001621    0.008797    0.002116   0.004793    0.000342    0.001508
LCL Mean       3.193666    5.565362   -0.344686    2.897047    4.559695   1.621522    4.605943    4.591147
UCL Mean       3.205050    5.584265   -0.338315    2.931614    4.568011   1.640357    4.607288    4.597071
Variance       0.004197    0.011571    0.001314    0.038693    0.002239   0.011488    0.000059    0.001136
Stdev          0.064782    0.107568    0.036252    0.196705    0.047322   0.107182    0.007656    0.033710
Skewness       0.353902   -0.350901   -0.960943   -0.263943   -0.973213   0.757665   -0.059809   -0.063697
Kurtosis      -0.003189    0.540811    0.334488   -1.004466   -0.133462   0.062414    0.388528   -1.042356
                    lp9        lp10
nobs         500.000000  500.000000
NAs            0.000000    0.000000
Minimum        4.436382    5.505332
Maximum        4.667558    6.133398
1. Quartile    4.491004    5.766562
3. Quartile    4.605248    5.938196
Mean           4.549993    5.839672
Median         4.545951    5.868237
Sum         2274.996543 2919.836191
SE Mean        0.002762    0.006494
LCL Mean       4.544566    5.826914
UCL Mean       4.555420    5.852430
Variance       0.003815    0.021083
Stdev          0.061768    0.145199
Skewness      -0.002195   -0.442000
Kurtosis      -1.348894   -0.385381
```

```
> scale_lp<-scale(lp)
> basicStats(scale_lp)
                   lp1        lp2        lp3        lp4        lp5        lp6        lp7        lp8        lp9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -2.028325  -2.461006  -3.163633  -2.055577  -2.277932  -1.730168  -3.066535  -1.984471  -1.767224
Maximum       2.954710   3.619592   1.532644   2.075875   1.391773   3.292305   2.875256   2.573568   1.986315
1. Quartile  -0.658456  -0.578599  -0.571801  -0.965680  -0.360342  -0.729155  -0.541532  -0.898885  -0.956983
3. Quartile   0.515940   0.534844   0.743353   0.629867   0.776028   0.324084   0.561657   0.887742   0.887746
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.085996   0.072576   0.348708   0.165948   0.173791  -0.241705   0.082626   0.008505  -0.096023
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.538018   0.054491  -0.885078   0.016802  -0.907299   0.996336  -0.032288  -0.014717   0.058812
Kurtosis      0.214364   0.673821   0.152394  -1.001263  -0.240351   0.487324   0.404383  -1.018026  -1.335466
                  lp10
nobs        500.000000
NAs           0.000000
Minimum      -2.068687
Maximum       2.325339
1. Quartile  -0.567821
3. Quartile   0.654587
Mean          0.000000
Median        0.130881
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.122896
Kurtosis     -0.447620
```

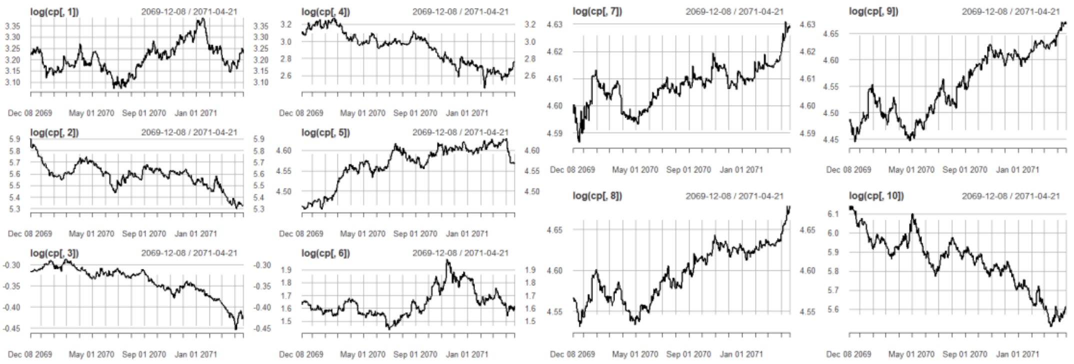
```
> loglp<-log(lp)
> scale_loglp<-scale(loglp)
> basicStats(scale_loglp)
                   lp1        lp2        lp3        lp4        lp5        lp6        lp7        lp8        lp9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -2.171159  -2.758261  -3.281153  -2.443851  -2.328818  -1.950286  -3.098632  -2.034748  -1.839320
Maximum       2.767031   3.072935   1.484554   1.796271   1.341259   2.978541   2.847302   2.482122   1.903334
1. Quartile  -0.648930  -0.535591  -0.549921  -0.942198  -0.331828  -0.738278  -0.538725  -0.894928  -0.955012
3. Quartile   0.546312   0.565860   0.738980   0.674556   0.768262   0.386942   0.564156   0.890549   0.894560
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.054748   0.124296   0.358498   0.255046   0.192392  -0.200610   0.086402   0.025301  -0.065444
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.353902  -0.350901  -0.960943  -0.263943  -0.973213   0.757665  -0.059809  -0.063697  -0.002195
Kurtosis     -0.003189   0.540811   0.334488  -1.004466  -0.133462   0.062414   0.388528  -1.042356  -1.348894
                  lp10
nobs        500.000000
NAs           0.000000
Minimum      -2.302634
Maximum       2.022914
1. Quartile  -0.503520
3. Quartile   0.678538
Mean          0.000000
Median        0.196727
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.442000
Kurtosis     -0.385381
```

Figure A.11: Basic statistical data of low price

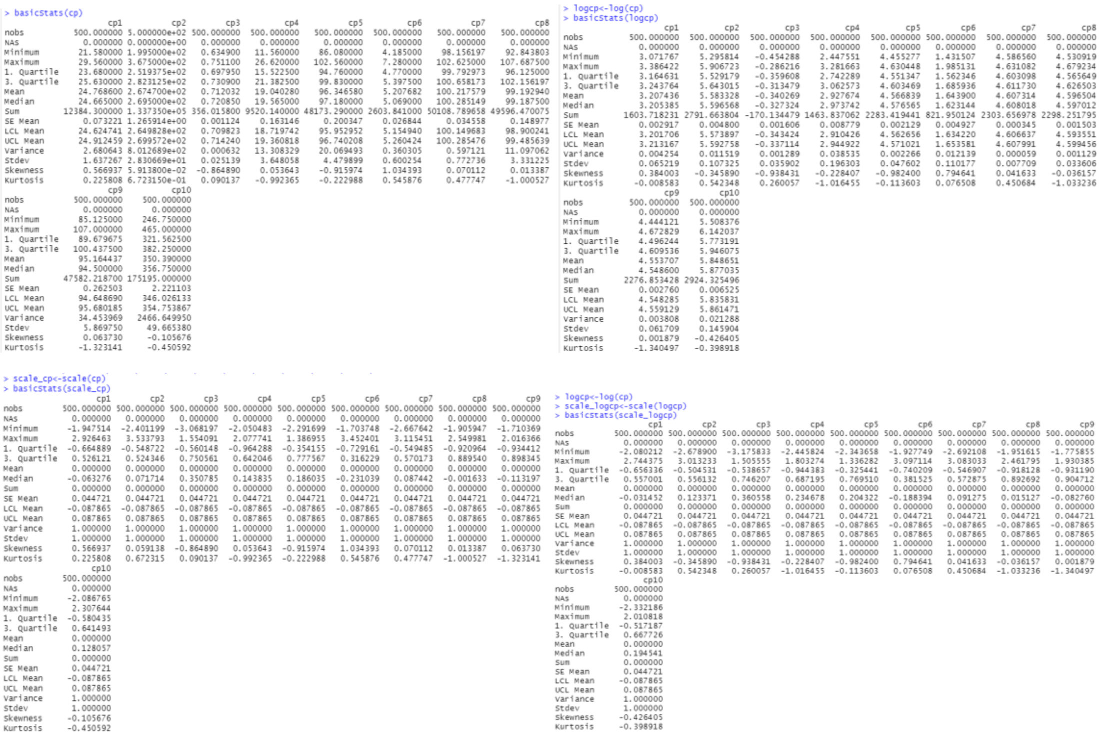
Graph A.12：Correlation graph of low price



Graph A.13: Close price graph



Graph A.14: Log close price graph



```
> basicStats(cp)
                    cp1          cp2        cp3         cp4          cp5         cp6          cp7          cp8
nobs         500.000000 5.000000e+02 500.000000  500.000000   500.000000  500.000000   500.000000   500.000000
NAs            0.000000 0.000000e+00   0.000000    0.000000     0.000000    0.000000     0.000000     0.000000
Minimum       21.580000 1.995000e+02   0.634900   11.560000    86.080000    4.185000    98.156197    92.843803
Maximum       29.560000 3.675000e+02   0.751100   26.620000   102.560000    7.280000   102.625000   107.687500
1. Quartile   23.680000 2.519375e+02   0.697950   15.522500    94.760000    4.770000    99.792973    96.125000
3. Quartile   25.630000 2.823125e+02   0.730900   21.382500    99.830000    5.397500   100.658173   102.156197
Mean          24.768600 2.674700e+02   0.712032   19.040280    96.346580    5.207682   100.217579    99.192940
Median        24.665000 2.695000e+02   0.720850   19.565000    97.180000    5.069000   100.285149    99.187500
Sum        12384.300000 1.337350e+05 356.015800 9520.140000 48173.290000 2603.841000 50108.789658 49596.470075
SE Mean        0.073221 1.265914e+00   0.001124    0.163146     0.200347    0.026844     0.034558     0.148977
LCL Mean      24.624741 2.649828e+02   0.709823   18.719742    95.952952    5.154940   100.149683    98.900241
UCL Mean      24.912459 2.699572e+02   0.714240   19.360818    96.740208    5.260424   100.285476    99.485639
Variance       2.680643 8.012689e+02   0.000632   13.308329    20.069493    0.360305     0.597121    11.097062
Stdev          1.637267 2.830669e+01   0.025139    3.648058     4.479899    0.600254     0.772736     3.331225
Skewness       0.566937 5.913800e-02  -0.864890    0.053643    -0.915974    1.034393     0.070112     0.013387
Kurtosis       0.225808 6.723150e-01   0.090137   -0.992365    -0.222988    0.545876     0.477747    -1.000527
                    cp9         cp10
nobs         500.000000   500.000000
NAs            0.000000     0.000000
Minimum       85.125000   246.750000
Maximum      107.000000   465.000000
1. Quartile   89.679675   321.562500
3. Quartile  100.437500   382.250000
Mean          95.164437   350.390000
Median        94.500000   356.750000
Sum        47582.218700 175195.000000
SE Mean        0.262503     2.221103
LCL Mean      94.648690   346.026133
UCL Mean      95.680185   354.753867
Variance      34.453969  2466.649950
Stdev          5.869750    49.665380
Skewness       0.063730    -0.105676
Kurtosis      -1.323141    -0.450592
```

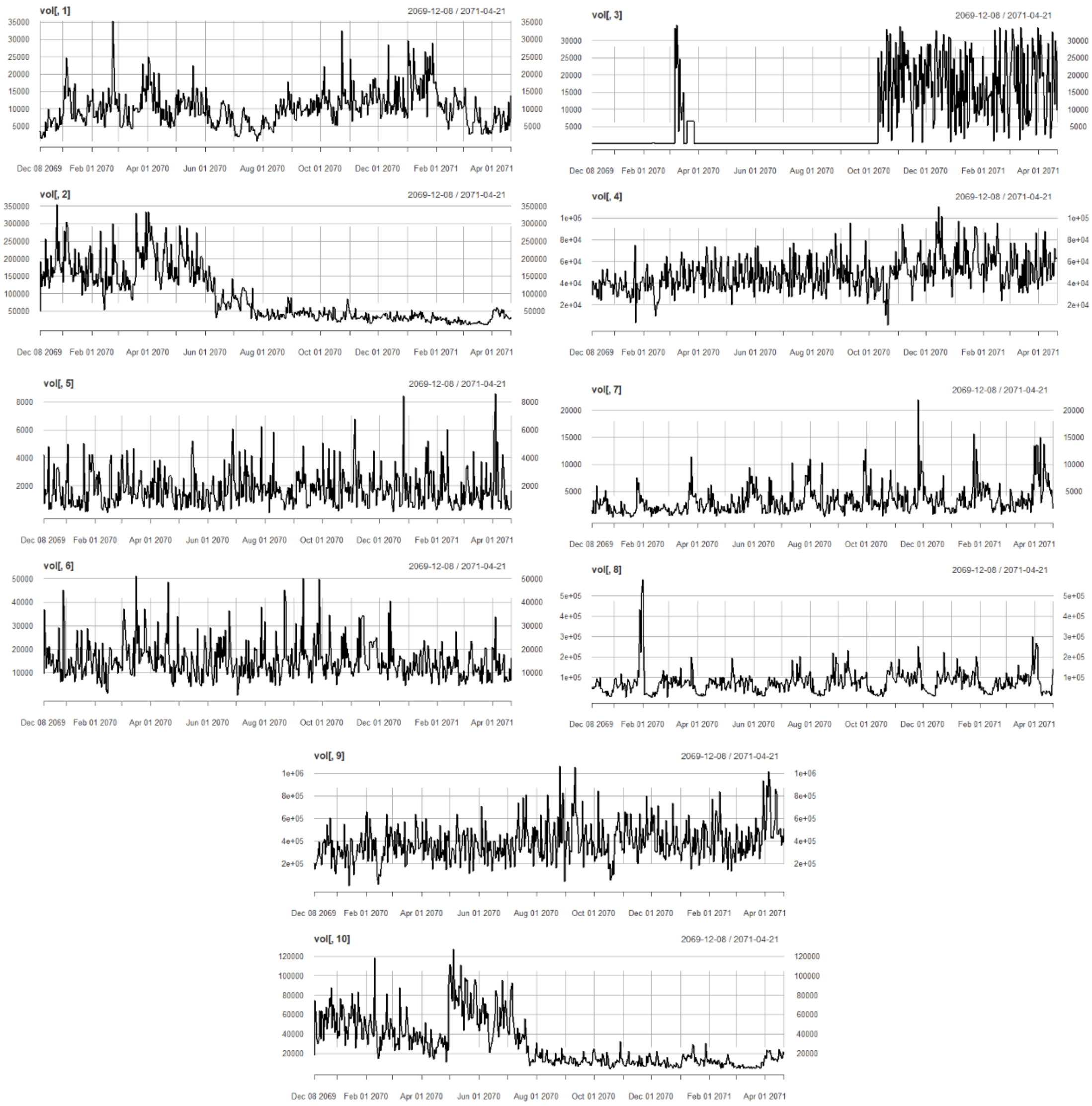
```
> logcp<-log(cp)
> basicStats(logcp)
                    cp1         cp2         cp3         cp4         cp5        cp6         cp7         cp8
nobs         500.000000  500.000000  500.000000  500.000000  500.000000 500.000000  500.000000  500.000000
NAs            0.000000    0.000000    0.000000    0.000000    0.000000   0.000000    0.000000    0.000000
Minimum        3.071767    5.295814   -0.454288    2.447551    4.455277   1.431507    4.586560    4.530919
Maximum        3.386422    5.906723   -0.286216    3.281663    4.630448   1.985131    4.631082    4.679234
1. Quartile    3.164631    5.529179   -0.359608    2.742289    4.551347   1.562346    4.603098    4.565649
3. Quartile    3.243764    5.643015   -0.313479    3.062573    4.603469   1.685936    4.611730    4.626503
Mean           3.207436    5.583328   -0.340269    2.927674    4.566839   1.643900    4.607314    4.596504
Median         3.205385    5.596568   -0.327324    2.973742    4.576565   1.623144    4.608018    4.597012
Sum         1603.718231 2791.663804 -170.134479 1463.837062 2283.419441 821.950124 2303.656978 2298.251795
SE Mean        0.002917    0.004800    0.001606    0.008779    0.002129   0.004927    0.000345    0.001503
LCL Mean       3.201706    5.573897   -0.343424    2.910426    4.562656   1.634220    4.606637    4.593551
UCL Mean       3.213167    5.592758   -0.337114    2.944922    4.571021   1.653581    4.607991    4.599456
Variance       0.004254    0.011519    0.001289    0.038535    0.002266   0.012139    0.000059    0.001129
Stdev          0.065219    0.107325    0.035902    0.196303    0.047602   0.110177    0.007709    0.033606
Skewness       0.384003   -0.345890   -0.938431   -0.228407   -0.982400   0.794641    0.041633   -0.036157
Kurtosis      -0.008583    0.542348    0.260057   -1.016455   -0.113603   0.076508    0.450684   -1.033236
                    cp9        cp10
nobs         500.000000  500.000000
NAs            0.000000    0.000000
Minimum        4.444121    5.508376
Maximum        4.672829    6.142037
1. Quartile    4.496244    5.773191
3. Quartile    4.609536    5.946075
Mean           4.553707    5.848651
Median         4.548600    5.877035
Sum         2276.853428 2924.325496
SE Mean        0.002760    0.006525
LCL Mean       4.548285    5.835831
UCL Mean       4.559129    5.861471
Variance       0.003808    0.021288
Stdev          0.061709    0.145904
Skewness       0.001879   -0.426405
Kurtosis      -1.340497   -0.398918
```

```
> scale_cp<-scale(cp)
> basicStats(scale_cp)
                   cp1        cp2        cp3        cp4        cp5        cp6        cp7        cp8        cp9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -1.947514  -2.401199  -3.068197  -2.050483  -2.291699  -1.703748  -2.667642  -1.905947  -1.710369
Maximum       2.926463   3.533793   1.554091   2.077741   1.386955   3.452401   3.115451   2.549981   2.016366
1. Quartile  -0.664889  -0.548722  -0.560148  -0.964288  -0.354155  -0.729161  -0.549485  -0.920964  -0.934412
3. Quartile   0.526121   0.524346   0.750561   0.642046   0.777567   0.316229   0.570173   0.889540   0.898345
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.063276   0.071714   0.350785   0.143835   0.186035  -0.231039   0.087442  -0.001633  -0.113197
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.566937   0.059138  -0.864890   0.053643  -0.915974   1.034393   0.070112   0.013387   0.063730
Kurtosis      0.225808   0.672315   0.090137  -0.992365  -0.222988   0.545876   0.477747  -1.000527  -1.323141
                  cp10
nobs        500.000000
NAs           0.000000
Minimum      -2.086765
Maximum       2.307644
1. Quartile  -0.580435
3. Quartile   0.641493
Mean          0.000000
Median        0.128057
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.105676
Kurtosis     -0.450592
```

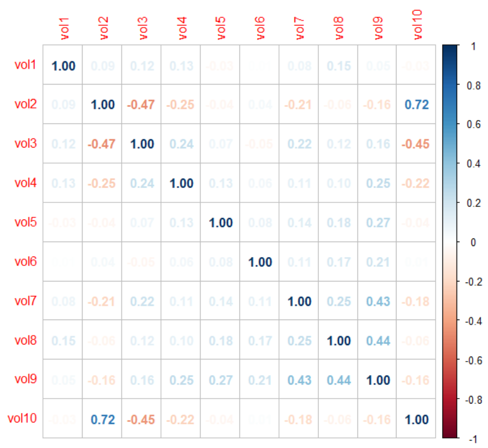
```
> logcp<-log(cp)
> scale_logcp<-scale(logcp)
> basicStats(scale_logcp)
                   cp1        cp2        cp3        cp4        cp5        cp6        cp7        cp8        cp9
nobs        500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000 500.000000
NAs           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Minimum      -2.080212  -2.678900  -3.175833  -2.445824  -2.343658  -1.927749  -2.692108  -1.951615  -1.775855
Maximum       2.744375   3.013233   1.505555   1.803274   1.336282   3.097114   3.083033   2.461795   1.930385
1. Quartile  -0.656336  -0.504531  -0.538657  -0.944383  -0.325441  -0.740209  -0.546907  -0.918128  -0.931190
3. Quartile   0.557001   0.556132   0.746207   0.687195   0.769510   0.381525   0.572875   0.892692   0.904712
Mean          0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
Median       -0.031452   0.123371   0.360558   0.234678   0.204322  -0.188394   0.091275   0.015127  -0.082760
Sum           0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
SE Mean       0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721   0.044721
LCL Mean     -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865  -0.087865
UCL Mean      0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865   0.087865
Variance      1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Stdev         1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000   1.000000
Skewness      0.384003  -0.345890  -0.938431  -0.228407  -0.982400   0.794641   0.041633  -0.036157   0.001879
Kurtosis     -0.008583   0.542348   0.260057  -1.016455  -0.113603   0.076508   0.450684  -1.033236  -1.340497
                  cp10
nobs        500.000000
NAs           0.000000
Minimum      -2.332186
Maximum       2.010818
1. Quartile  -0.517187
3. Quartile   0.667726
Mean          0.000000
Median        0.194541
Sum           0.000000
SE Mean       0.044721
LCL Mean     -0.087865
UCL Mean      0.087865
Variance      1.000000
Stdev         1.000000
Skewness     -0.426405
Kurtosis     -0.398918
```

Figure A.15: Basic statistical data of close price

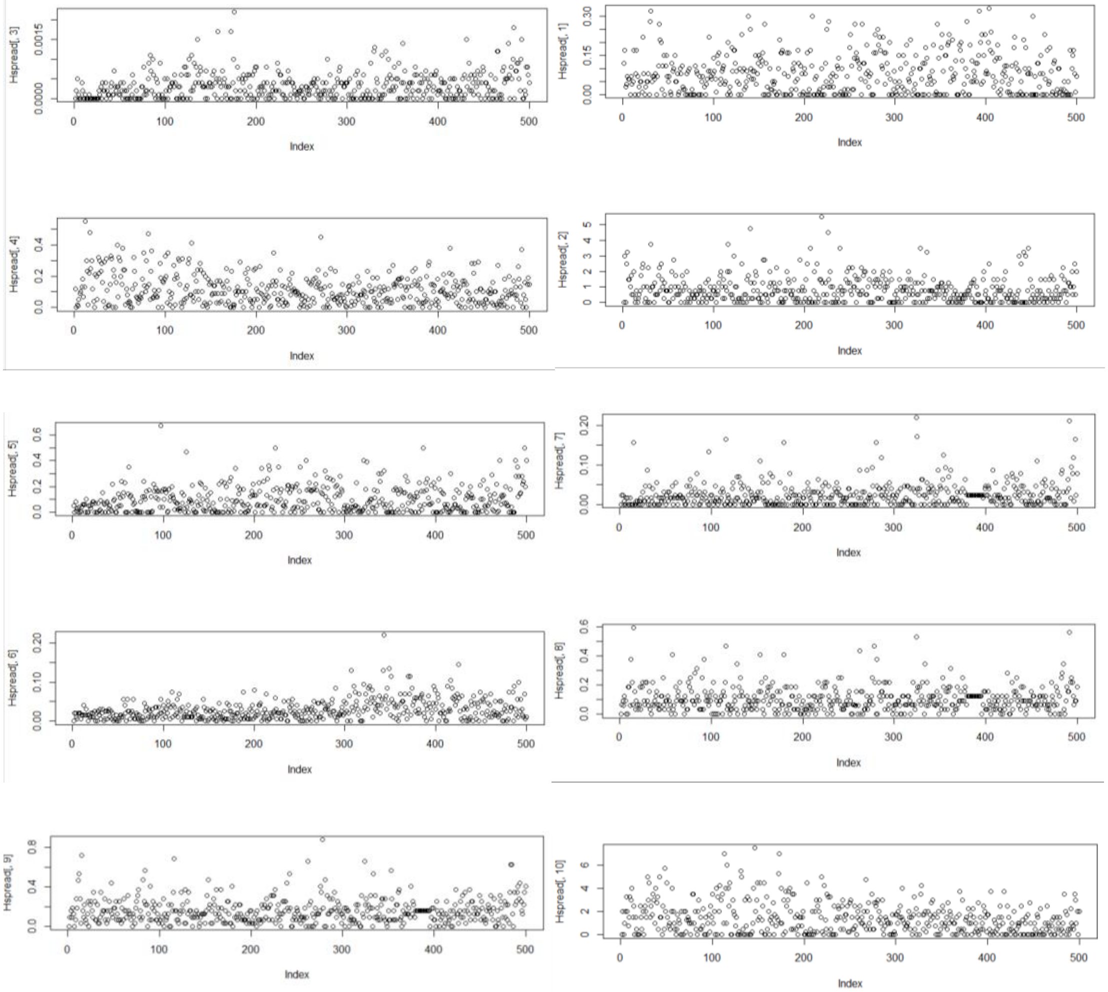
Graph A.16：Correlation graph of close price



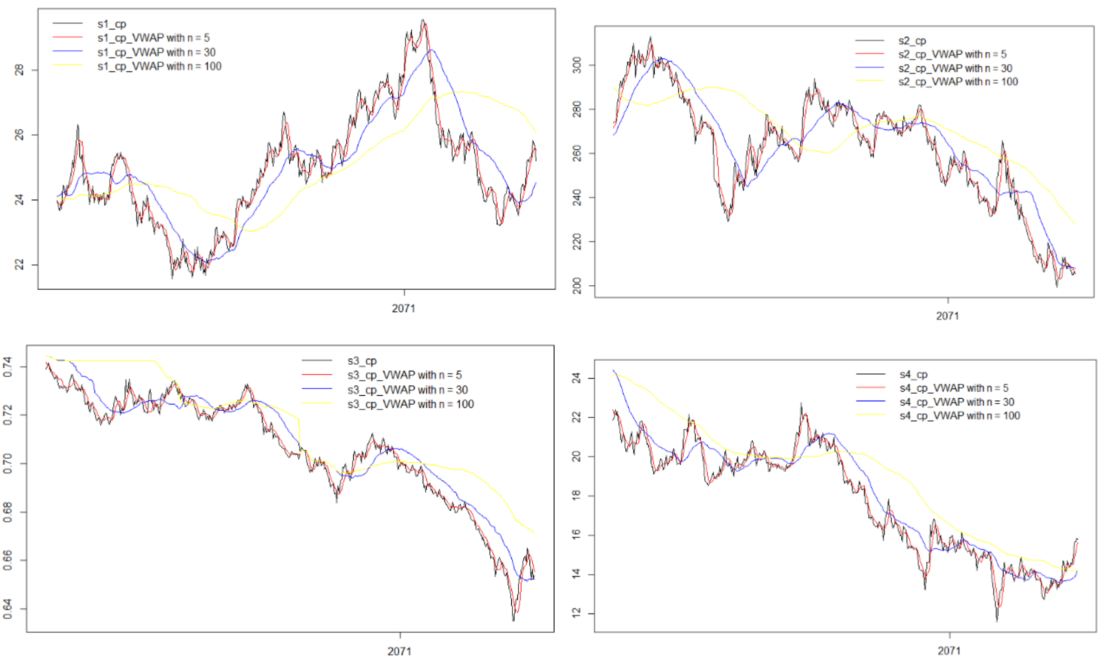
Graph A.17: Volume

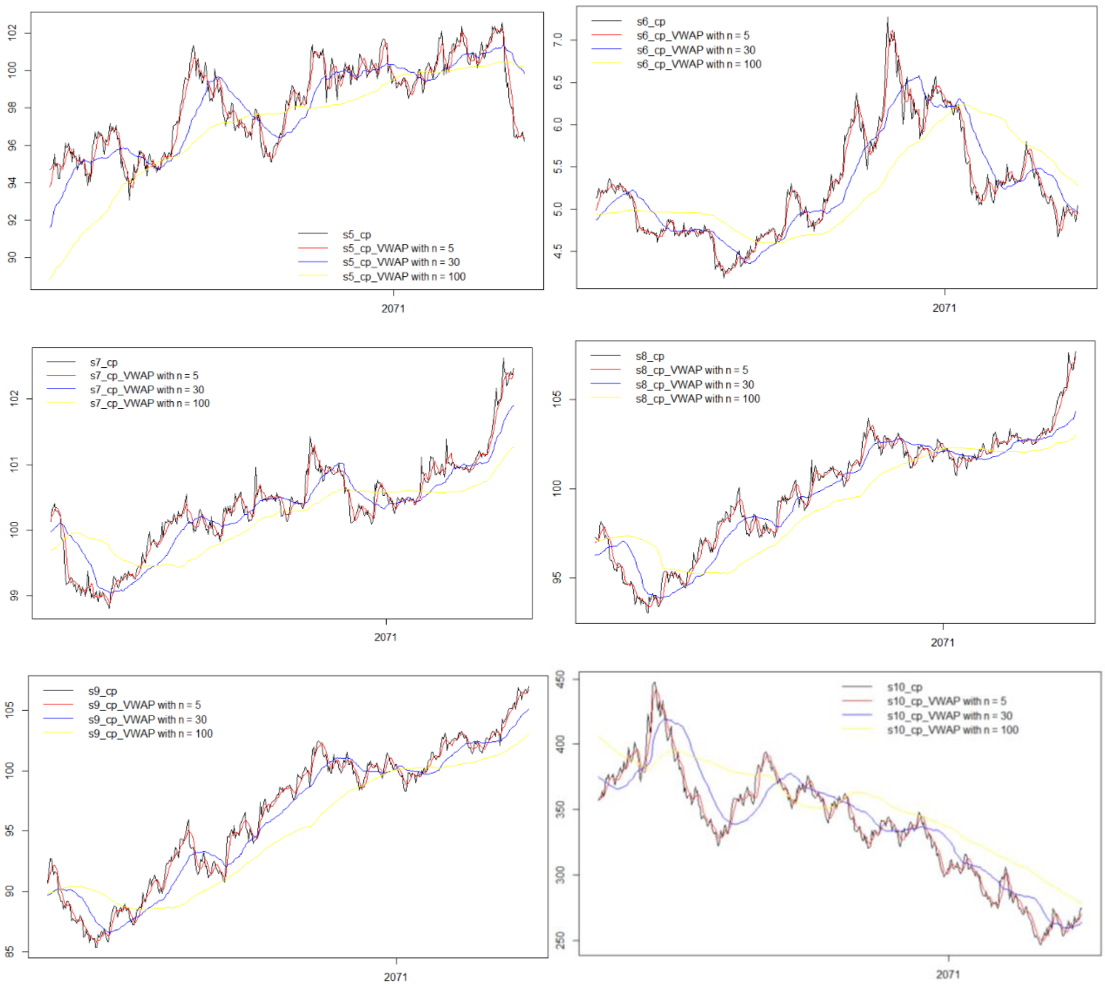


Graph A.18: Correlation graph of volume

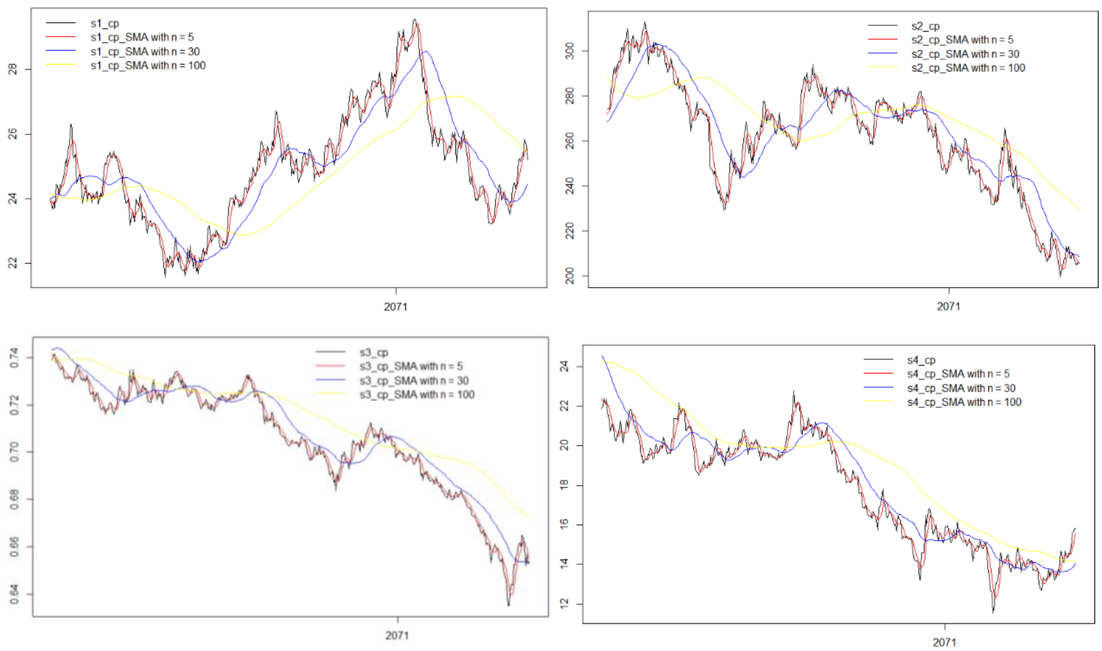


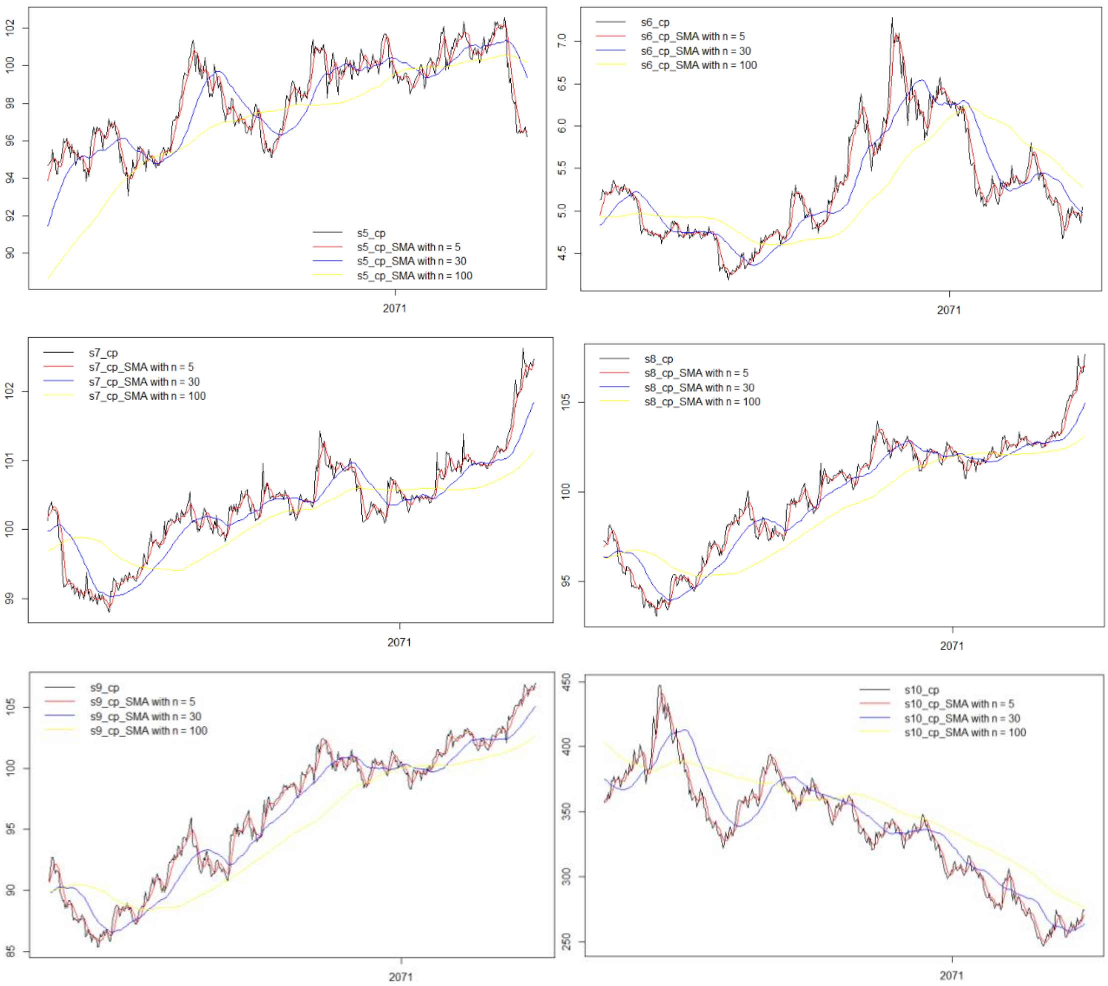
Graph A.19: Daily spread of each series



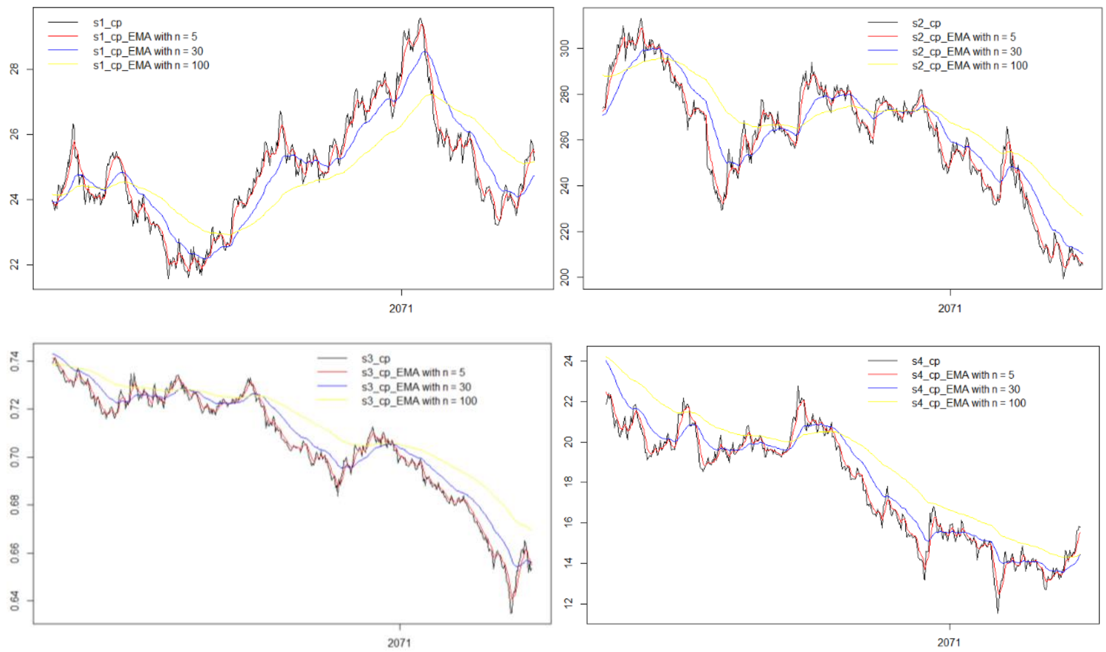


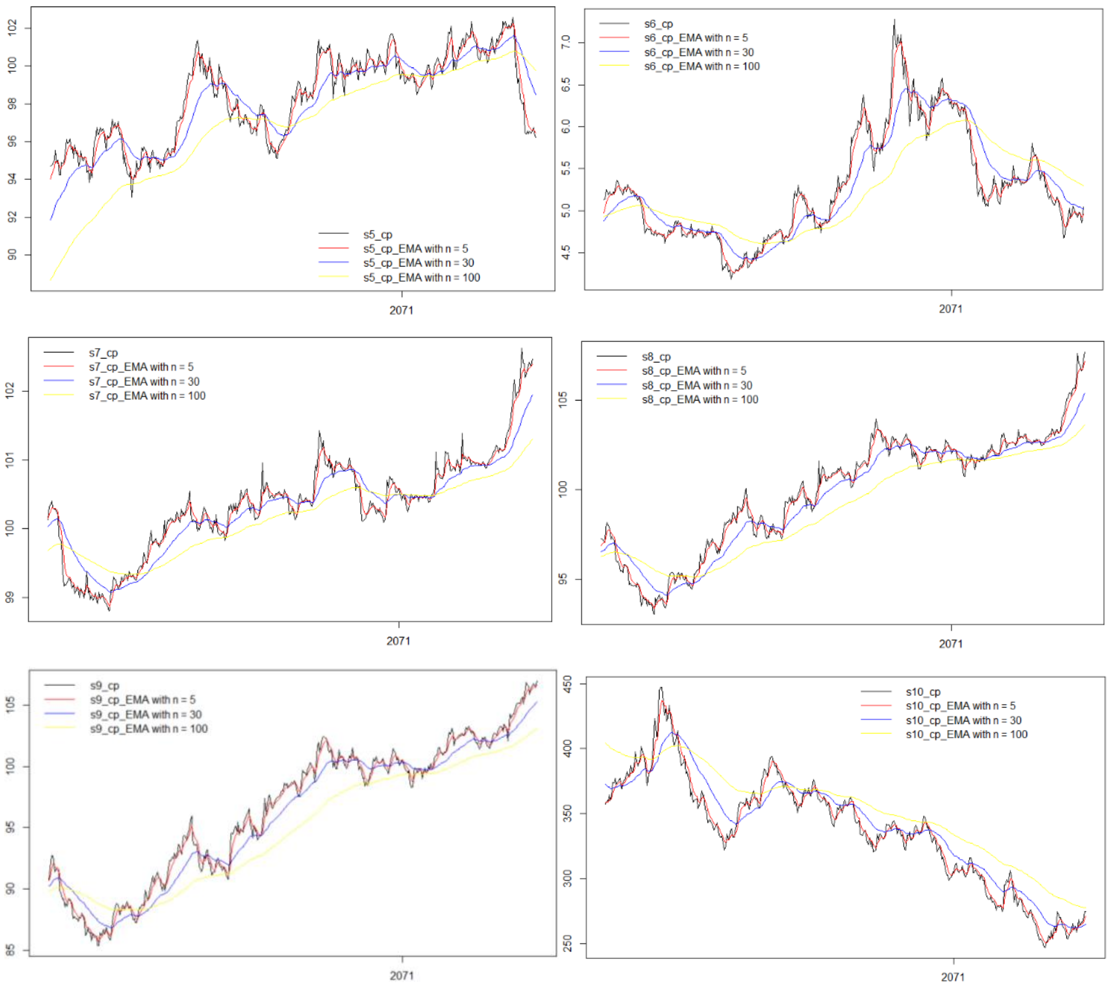
Graph A.20: VWAP of each series



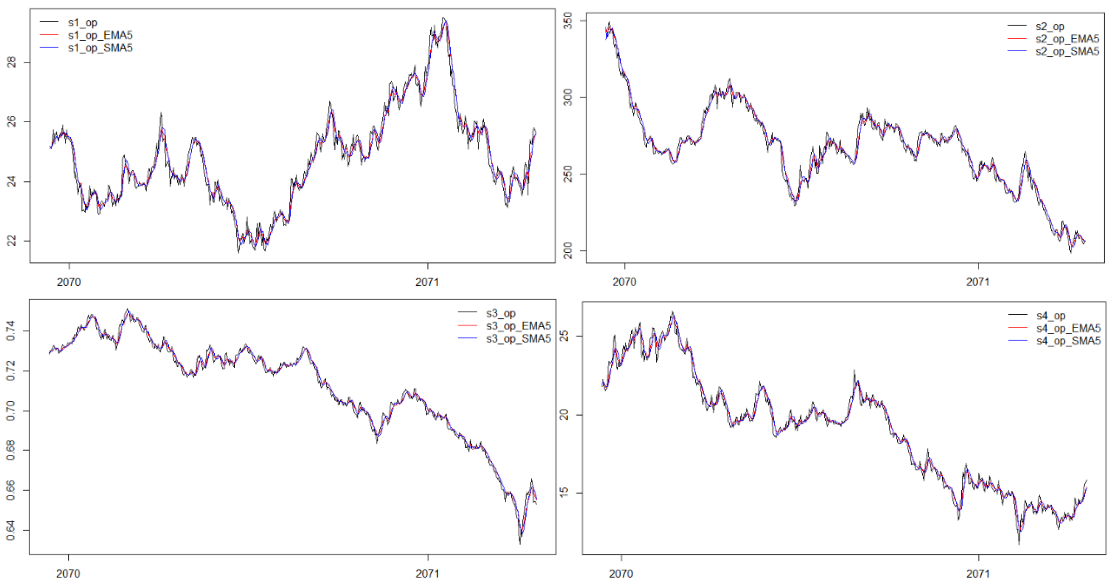


Graph A.21: SMA of close price of each series

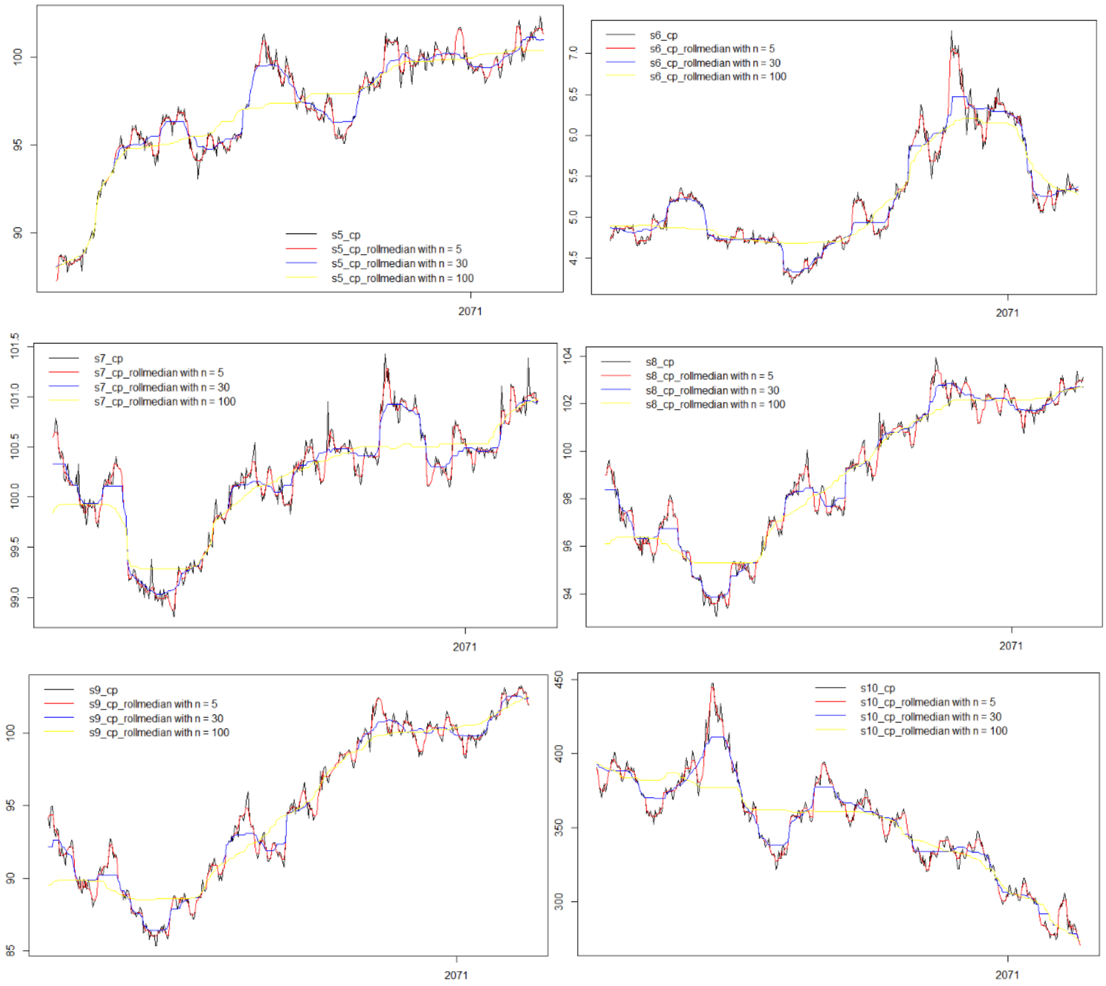




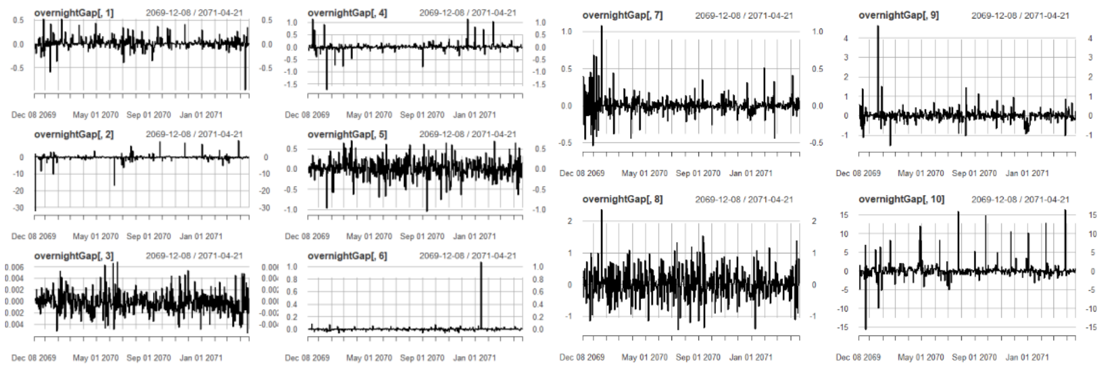
Graph A.22: EMA of close price of each series



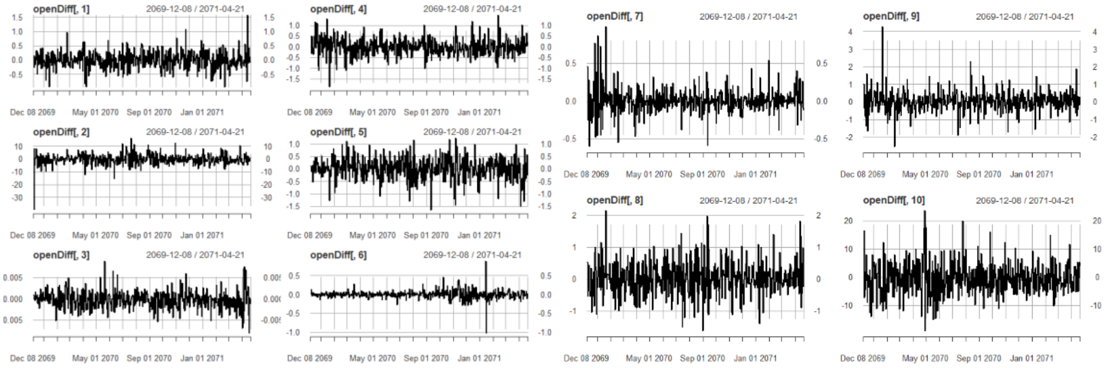
Graph A.23: Compare open price, EMA and SMA of close price of each series



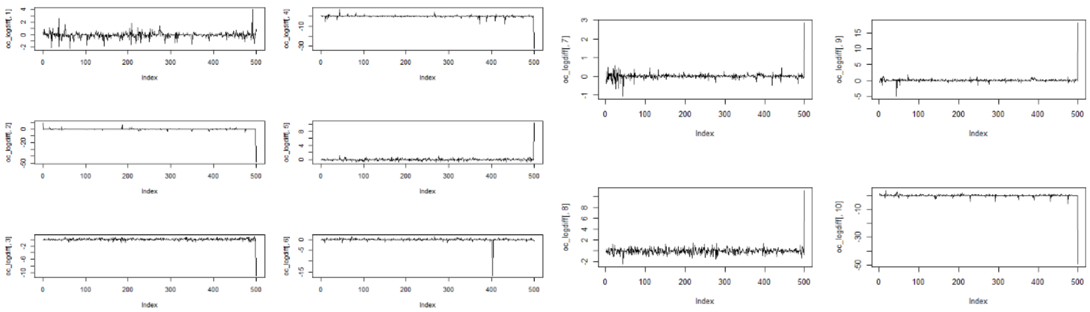
Graph A.24: Rolling Median of each series



Graph A.25: Overnight gap of each series

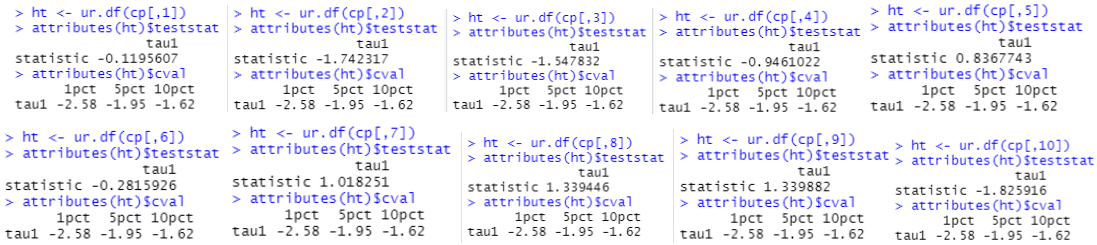


Graph A.26: Open to open difference of each series

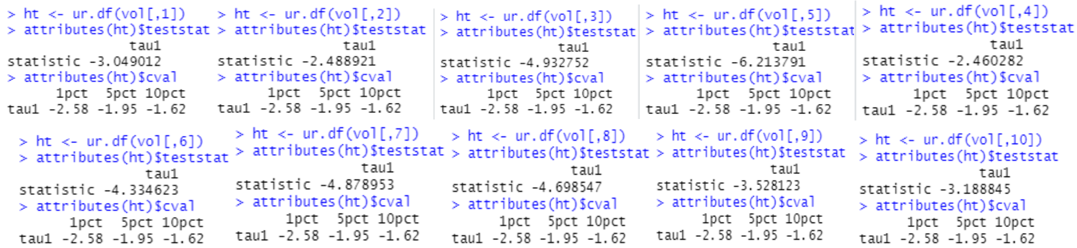


Graph A.27: Log return of each series

Appendix B



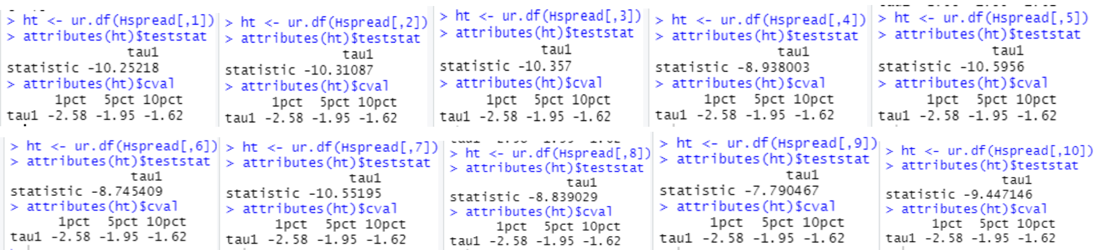
Figures B.1: Dickey-Fuller Test of close price



Figures B.2: Dickey-Fuller Test of volume

Table B.1: Dickey-Fuller Test of volume

series	tau1 statistic	tau1 95% critical value	stationary
1	-3.049012	-1.95	non-stationary
2	-2.488921	-1,95	non-stationary
3	-4.932752	-1,95	non-stationary
4	-2.460282	-1.95	non-stationary
5	-6.213791	-1.95	non-stationary
6	-4.334623	-1.95	non-stationary
7	-4.878953	-1.95	non-stationary
8	-4.698547	-1.95	non-stationary
9	-3.528123	-1.95	non-stationary
10	-3.188845	-1.95	non-stationary



Figures B.3: Dickey-Fuller Test of daily spread

Table B.2: Dickey-Fuller Test of daily spread

series	tau1 statistic	tau1 95% critical value	stationary
1	-10.25218	-1.95	non-stationary
2	-10.31097	-1,95	non-stationary

3	-10.357	-1,95	non-stationary
4	-8.938003	-1.95	non-stationary
5	-10.5956	-1.95	non-stationary
6	-8.745409	-1.95	non-stationary
7	-10.55195	-1.95	non-stationary
8	-8.839029	-1.95	non-stationary
9	-7.790467	-1.95	non-stationary
10	-9.447146	-1.95	non-stationary

```
> ht <- ur.df(overnightGap_S1)
> attributes(ht)$teststat
               tau1
statistic -15.93029
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S2)
> attributes(ht)$teststat
               tau1
statistic -17.85881
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S3)
> attributes(ht)$teststat
               tau1
statistic -15.57334
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S4)
> attributes(ht)$teststat
               tau1
statistic -15.22881
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S5)
> attributes(ht)$teststat
               tau1
statistic -16.13264
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S6)
> attributes(ht)$teststat
               tau1
statistic -15.54861
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S7)
> attributes(ht)$teststat
               tau1
statistic -19.68034
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S8)
> attributes(ht)$teststat
               tau1
statistic -16.33168
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S9)
> attributes(ht)$teststat
               tau1
statistic -16.65716
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(overnightGap_S10)
> attributes(ht)$teststat
               tau1
statistic -14.85384
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62
```

Figures B.4: Dickey-Fuller Test of overnight gap

Table B.3: Dickey-Fuller Test of overnight gap

series	tau1 statistic	tau1 95% critical value	stationary
1	-15.93029	-1.95	non-stationary
2	-17.85881	-1,95	non-stationary
3	-15.57334	-1,95	non-stationary
4	-15.22881	-1.95	non-stationary
5	-16.13264	-1.95	non-stationary
6	-15.54861	-1.95	non-stationary
7	-19.68034	-1.95	non-stationary
8	-16.33168	-1.95	non-stationary
9	-16.65716	-1.95	non-stationary
10	-14.85384	-1.95	non-stationary

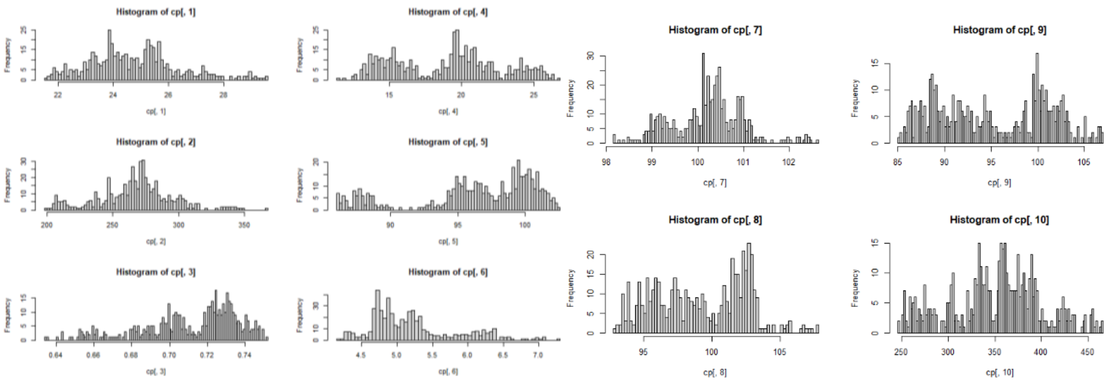
```
> ht <- ur.df(openDiff_S1)
> attributes(ht)$teststat
               tau1
statistic -15.98474
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S2)
> attributes(ht)$teststat
               tau1
statistic -15.21893
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S3)
> attributes(ht)$teststat
               tau1
statistic -15.42344
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S4)
> attributes(ht)$teststat
               tau1
statistic -16.89176
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S5)
> attributes(ht)$teststat
               tau1
statistic -15.29016
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S6)
> attributes(ht)$teststat
               tau1
statistic -16.35839
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S7)
> attributes(ht)$teststat
               tau1
statistic -18.29278
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S8)
> attributes(ht)$teststat
               tau1
statistic -13.80379
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S9)
> attributes(ht)$teststat
               tau1
statistic -16.88328
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62

> ht <- ur.df(openDiff_S10)
> attributes(ht)$teststat
               tau1
statistic -15.94599
> attributes(ht)$cval
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62
```

Figures B.5: Dickey-Fuller Test of open-to-open difference

Table B.4: Dickey-Fuller Test of open-to-open difference

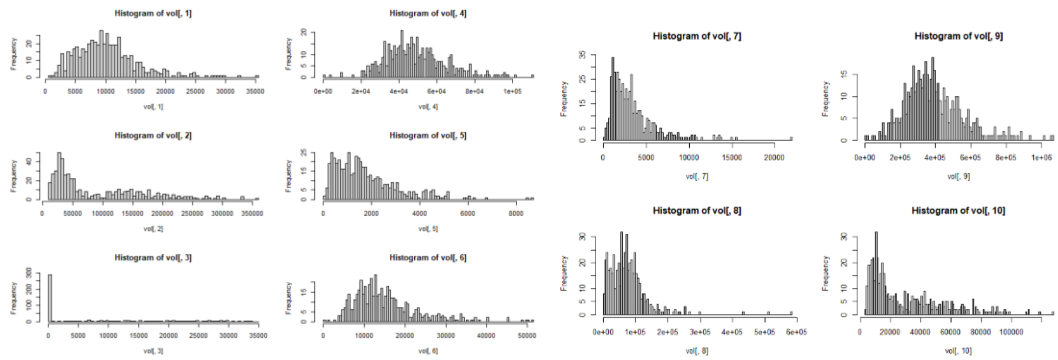
series	tau1 statistic	tau1 95% critical value	stationary
1	-15.98474	-1.95	non-stationary
2	-15.21893	-1,95	non-stationary
3	-15.42344	-1,95	non-stationary

4	-16.89176	-1.95	non-stationary
5	-15.29016	-1.95	non-stationary
6	-16.35839	-1.95	non-stationary
7	-18.29278	-1.95	non-stationary
8	-13.80379	-1.95	non-stationary
9	-16.88328	-1.95	non-stationary
10	-15.94599	-1.95	non-stationary



Graph B.6: Ljung-Box test of close price

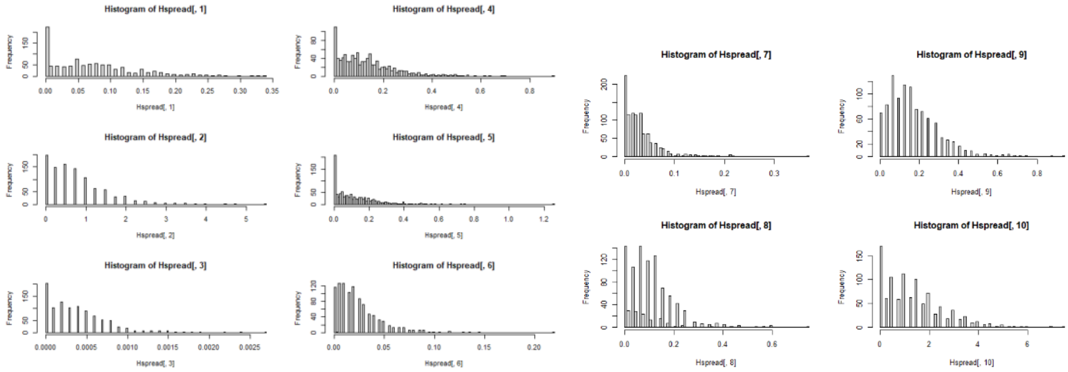
Table B.5: Dickey-Fuller Test of open-to-open difference



Graph B.7: Ljung-Box test of volume

Table B.5: Ljung-Box test of volume

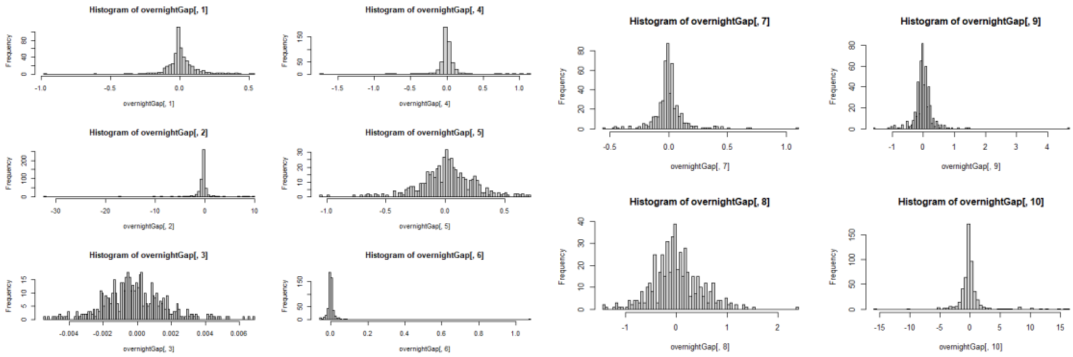
series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	white noise	= 0.05791
6	non-white noise	= 2.745e-07
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16



Graph B.8: Ljung-Box test of daily spread

Table B.6: Ljung-Box test of daily spread

series	OP auto-correlation(p-value)	p-value
1	non-white noise	= 1.532e-09
2	white noise	= 9.616e-05
3	non-white noise	= 4.774e-15
4	non-white noise	< 2.2e-16
5	white noise	= 6.473e-14
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	white noise	= 1.016e-07

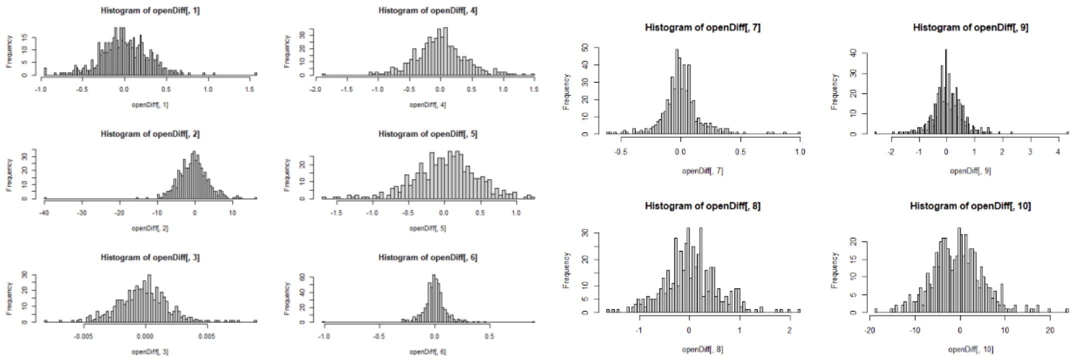


Graph B.9: Ljung-Box test of overnight gap

Table B.7: Ljung-Box test of overnight gap

series	OP auto-correlation(p-value)	p-value
1	white noise	= 0.7677
2	white noise	= 0.8944
3	white noise	= 0.5961
4	white noise	= 0.7158
5	white noise	= 0.4052

6	white noise	= 0.9969
7	non-white noise	= 1.891e-06
8	non-white noise	= 1.221e-15
9	white noise	= 0.3372
10	white noise	= 0.8472



Graph B.10: Ljung-Box test of open-to-open difference

Table B.8: Ljung-Box test of open-to-open difference

series	OP auto-correlation(p-value)	p-value
1	white noise	= 0.5016
2	white noise	= 0.1146
3	white noise	= 0.3992
4	non-white noise	= 0.02723
5	white noise	= 0.5481
6	non-white noise	= 0.000291
7	non-white noise	= 0.002019
8	non-white noise	< 2.2e-16
9	white noise	= 0.7261
10	non-white noise	= 0.04832

```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , with linear trend

Eigenvalues (lambda):
 [1] 0.3721529598 0.0929146426 0.0855103747 0.0606051996 0.0412756301 0.0396997391 0.0315908840 0.0242244536 0.0069764818 0.0001996895

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 9 |   0.10  6.50  8.18 11.65
r <= 8 |   3.49 12.91 14.90 19.19
r <= 7 |  12.21 18.90 21.07 25.75
r <= 6 |  15.99 24.78 27.14 32.14
r <= 5 |  20.17 30.84 33.32 38.78
r <= 4 |  20.99 36.25 39.43 44.59
r <= 3 |  31.13 42.06 44.91 51.30
r <= 2 |  44.52 48.43 51.07 57.07
r <= 1 |  48.56 54.01 57.00 63.37
r = 0  | 231.80 59.00 62.42 68.61

Eigenvectors, normalised to first column:
(These are the cointegration relations)

            a.l2         b.l2        c.l2         d.l2         e.l2         f.l2        g.l2         h.l2         i.l2          j.l2
a.l2   1.00000000    1.0000000   1.0000000     1.000000   1.00000000   1.00000000  1.00000000  1.000000000   1.00000000  1.000000e+00
b.l2  -0.04131573    0.2908269   1.0664889     2.388202   0.09104705  -0.01049434 -0.26150312 -0.043880459  -0.07478396  3.766011e-03
c.l2 366.98535362 -321.8761550 241.4349995 10537.125404 -22.77297134 -71.34151472 83.85257792 53.389300540 188.68139252 -1.192521e+02
d.l2  -2.10631440   14.6602061   0.9814125   -67.075829  -0.56383160   0.19681388 -0.50967021  0.172031685  -1.53399492  8.592145e-01
e.l2  -0.33969687    4.2830188   2.4243507   -26.993416  -0.69115792   0.24710021  0.30644764  0.091946433   1.26388978 -8.712495e-01
f.l2   1.27324770   -8.7419186  -2.7094368  -286.163670   2.26623206  -2.19502460  3.35987788 -0.567718632  11.80000609  2.036341e-02
g.l2  37.74253449  -47.0657096  49.0315047  -202.901382   3.69949523   1.53131976  5.57979096 -0.026770907 -12.81803575  3.213670e+00
h.l2 -30.00541039   -1.6201518   2.2881511    33.848192  -1.36315573   0.05939971  0.45165027  0.001378267  -1.26515939  1.267465e+00
i.l2  14.21716803    5.8645202  -7.0353324    33.762908  -0.99274923  -0.35590655 -1.64809007  0.141350010   3.27672217 -5.889193e-01
j.l2   0.19789308   -0.8371368  -0.5241784    -2.492442  -0.16223992   0.02178916  0.06291508  0.030266933   0.12745798 -4.279355e-02

Weights W:
(This is the loading matrix)

             a.l2          b.l2          c.l2          d.l2          e.l2          f.l2          g.l2          h.l2          i.l2          j.l2
a.d  1.513102e-04 -1.023121e-03  1.186732e-03 -1.782842e-04 -6.464035e-03 -2.285756e-02  2.590636e-03 -1.451913e-02  4.700336e-05 -6.115699e-05
b.d  1.729894e-03  1.329374e-03  2.079831e-02  3.459636e-04 -8.618180e-02 -1.043387e-01  1.312160e-01  1.050889e-02 -4.302486e-03  3.032961e-03
c.d  9.589957e-07 -1.063833e-05 -1.704281e-05 -2.502917e-06  5.638832e-06  1.993381e-05 -1.420302e-06  8.728690e-06 -7.043663e-06  1.555859e-06
d.d -1.423802e-03 -4.485158e-03 -3.182509e-03  4.005977e-04 -4.170203e-03  6.510740e-04  2.133033e-03 -5.992552e-03 -1.045906e-04  1.303023e-04
e.d -7.730412e-04  7.723812e-04 -6.925601e-04  2.288711e-04  8.213636e-03 -4.697756e-02 -4.121759e-04  1.459899e-02 -9.237127e-04 -3.308723e-04
f.d  1.740495e-04  9.038573e-05  4.976602e-04  2.711819e-05 -3.607412e-03  4.181241e-03 -1.421101e-03  3.877799e-04 -1.932959e-04 -2.793264e-05
g.d -1.183024e-03  1.323363e-03 -1.848979e-03 -8.651534e-06 -9.269852e-04  1.717479e-03  6.341427e-04 -5.081390e-03  5.584059e-06 -9.582272e-05
h.d  1.325696e-02  5.738812e-04 -1.383268e-03 -2.117336e-05  3.254386e-04  5.154927e-03  9.086909e-04 -3.945963e-03 -3.217727e-05 -1.568900e-04
i.d -4.234682e-03  1.998524e-03 -3.237798e-03 -8.490236e-05  5.863858e-03  2.159282e-02  7.092534e-03 -1.630812e-02 -5.608793e-04 -1.190437e-03
j.d  6.255898e-03  1.005277e-02  4.148212e-02  2.225365e-03  9.902399e-03 -6.234911e-03  7.369435e-02 -2.822541e-01 -1.011754e-02  6.620518e-03

> slotNames(cotest)
 [1] "x"          "Z0"         "Z1"         "ZK"         "type"       "model"      "ecdet"      "lag"        "P"          "season"     "dumvar"     "cval"
[13] "teststat"   "lambda"     "Vorg"       "V"          "W"          "PI"         "DELTA"      "GAMMA"      "R0"         "RK"         "bp"         "spec"
[25] "call"       "test.name"
```

Figures B.11: Cointegration Test of close price

```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , with linear trend

Eigenvalues (lambda):
 [1] 0.33031521 0.29298378 0.27510502 0.23436517 0.16492879 0.13682509 0.12638641 0.10864854 0.06573928 0.02191363

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 9 |  11.03  6.50  8.18 11.65
r <= 8 |  33.86 12.91 14.90 19.19
r <= 7 |  57.28 18.90 21.07 25.75
r <= 6 |  67.29 24.78 27.14 32.14
r <= 5 |  73.27 30.84 33.32 38.78
r <= 4 |  89.76 36.25 39.43 44.59
r <= 3 | 132.99 42.06 44.91 51.30
r <= 2 | 160.22 48.43 51.07 57.07
r <= 1 | 172.66 54.01 57.00 63.37
r = 0  | 199.67 59.00 62.42 68.61

Eigenvectors, normalised to first column:
(These are the cointegration relations)

            a.l2        b.l2        c.l2        d.l2         e.l2          f.l2       g.l2        h.l2         i.l2         j.l2
a.l2   1.00000000  1.00000000  1.00000000   1.0000000  1.000000000  1.0000000000  1.0000000  1.00000000  1.000000000  1.000000000
b.l2   0.32945884 -0.03364035 -0.04898897   0.3084233  0.001699518 -0.0546357191  0.2594476  0.01496194  0.202098384 -0.471282495
c.l2  -3.05613651  0.32762904  1.09562351  -2.5820121 -0.688886273 -0.2636156735 12.5500891  1.17361311  0.288508106  1.013092362
d.l2   2.69573920 -0.74295009 -1.79974650  -1.5969653  0.301587615  0.0014536990  3.2387606  0.03616814  0.067656156  0.223896765
e.l2 162.67601775 13.46351317 -4.21656790 -30.3417378 -0.026366379 -0.1296739256 -7.3897069 -0.50317824 -0.635261172 -0.966446242
f.l2 -13.33808891  0.21739871  0.22193720 -18.3060278 -0.221899052  0.0210059324 -3.3440788 -0.39177912  0.249350599 -0.050592489
g.l2  28.64346766 -2.68815476  3.55723640  -5.1668805 10.931640249 -0.5081546323  5.0017187 -3.86925048  0.098143739  0.199614013
h.l2   0.04204508 -0.07107876 -0.05728710   0.1782645  0.084809833 -0.0264583771 -1.1873432  0.49312905 -0.035207437  0.040511694
i.l2  -1.46899616  0.10461474 -0.03480152   0.5092800 -0.024754359  0.0004909957  0.1095783 -0.06584176  0.003377406 -0.006694807
j.l2  -2.27523993  0.15118258  0.09870333  -1.5444501  0.235828471  0.1048225069  4.3513039  0.36385867 -0.611519941 -0.316431728

Weights W:
(This is the loading matrix)

             a.l2         b.l2         c.l2          d.l2         e.l2        f.l2          g.l2          h.l2         i.l2          j.l2
a.d  0.0000512307 -0.020324980 -0.004901640 -0.0028160080 -0.017610449 -0.25278775 -1.741428e-03 -0.0121251938 -0.037701542 -0.0004996450
b.d -0.0024832230  0.006632471  0.029266476 -0.0225052493 -0.018436955  0.19157353 -1.938659e-02 -0.0924268519 -0.289023246  0.0907975630
c.d  0.0011377250 -0.042050258 -0.046196519  0.0055995240  0.001797306  0.19892468 -1.414841e-02 -0.0304498325 -0.023794082 -0.0080804143
d.d  0.0050939399  0.120500204  0.311526870  0.0074547163 -0.068362335 -0.03496704 -1.120368e-02  0.0044085127  0.002543972 -0.0039886331
e.d -0.0020568111 -0.029492919  0.011967621  0.0012359358 -0.003759018  0.01116565 -1.003341e-05  0.0007146988  0.001349372  0.0002958129
f.d  0.0111810734 -0.047115906  0.004805639  0.0263131269 -0.013380694 -0.02131231  3.878380e-03  0.0084345040 -0.028028449  0.0035112921
g.d  0.0001798506 -0.006994209 -0.014932919 -0.0003524983 -0.034878333  0.04077728 -4.901461e-04  0.0086544045 -0.004997335 -0.0003967371
h.d  0.0427082502 -0.455889717  0.188254356 -0.0249360137 -0.371944830  0.79945289  3.820438e-02 -0.3346393194  0.041354097 -0.0024780896
i.d  0.2869562096 -3.008587178  1.010309404 -0.1635293407 -0.632932257  2.55242655 -1.718610e-02  0.3860981328 -0.065346738 -0.0145589213
j.d  0.0044410805 -0.022553800 -0.026387581  0.0021739268 -0.037658362 -0.32219571 -1.579085e-02 -0.0308702382  0.109500877  0.0266548800

> slotNames(cotest)
 [1] "x"          "Z0"         "Z1"         "ZK"         "type"       "model"      "ecdet"      "lag"        "P"          "season"     "dumvar"     "cval"
[13] "teststat"   "lambda"     "Vorg"       "V"          "W"          "PI"         "DELTA"      "GAMMA"      "R0"         "RK"         "bp"         "spec"
[25] "call"       "test.name"
```

Figures B.12: Cointegration Test of volume

```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , with linear trend

Eigenvalues (lambda):
 [1] 0.3490770 0.3428321 0.3163549 0.3021869 0.2894548 0.2759976 0.2452845 0.2389289 0.1921782 0.1596325

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 9 | 173.57  6.50  8.18 11.65
r <= 8 | 212.99 12.91 14.90 19.19
r <= 7 | 272.48 18.90 21.07 25.75
r <= 6 | 280.85 24.78 27.14 32.14
r <= 5 | 322.31 30.84 33.32 38.78
r <= 4 | 341.04 36.25 39.43 44.59
r <= 3 | 359.08 42.06 44.91 51.30
r <= 2 | 379.56 48.43 51.07 57.07
r <= 1 | 418.98 54.01 57.00 63.37
r = 0  | 428.51 59.00 62.42 68.61

Eigenvectors, normalised to first column:
(These are the cointegration relations)

              x.1.l2      x.2.l2       x.3.l2       x.4.l2     x.5.l2      x.6.l2       x.7.l2        x.8.l2        x.9.l2     x.10.l2
x.1.l2    1.00000000   1.0000000   1.00000000   1.00000000    1.00000  1.00000000   1.00000000    1.00000000    1.00000000   1.0000000
x.2.l2   -0.21301510   0.1421064  -0.15211606  -0.04755728   -6.46948  0.09535486  -0.06882517    0.03690174    0.03579234  -0.6519527
x.3.l2 -494.19323852 227.0558518 389.97373066 -26.26847404 6685.26513  8.21734745 160.91789702 -146.32168387 -424.35690888 581.9243657
x.4.l2    0.07445092   1.0656688  -0.65570278  -0.03826097   70.32168 -0.23219843   0.57426222    0.91186706   -0.49344987 -18.9894392
x.5.l2    1.39535056  -0.2726888   0.41025571  -0.43848813  -11.14466  0.53958799   0.51918487   -0.37854268   -1.04390387  -9.5294655
x.6.l2    0.19555010   0.7644961  -2.85035558  -1.03033406  316.02214  0.62513392   4.90538451   -1.32720361    4.55147132 171.5142032
x.7.l2   -3.21252873  -5.5065534  -2.28387263   0.74626326  -79.83045  0.24993257   3.47834088    3.02653414   -5.89766447  15.0310849
x.8.l2    0.88458879   1.5112774   1.55518855  -0.68869758  -71.20042 -0.60312302  -0.53335805    2.57530240    1.42894968  16.1030733
x.9.l2    0.53124635   0.2122629  -1.00867735   0.46642347   46.51987  0.23143968  -1.41742743   -1.47804450   -2.28225090   4.9740519
x.10.l2  -0.02125033  -0.1548611   0.07539882  -0.01057633    7.66979  0.01098037  -0.10772058    0.04814550    0.03224826  -0.2501639

Weights W:
(This is the loading matrix)

            x.1.l2        x.2.l2        x.3.l2        x.4.l2        x.5.l2        x.6.l2        x.7.l2        x.8.l2        x.9.l2       x.10.l2
x.1.d  -0.0334219816 -0.0526390207 -0.0690147429 -0.3445831736 -1.720752e-05 -0.2585526740 -0.0198157902 -0.0486294944 -0.0116488804 -2.020150e-05
x.2.d   1.0890627771 -0.5162210293  0.9596516991  1.7498398938  4.982735e-03 -2.9404408517  0.5825257404 -0.3094595754 -0.1448134768  7.117566e-03
x.3.d   0.0006291174 -0.0004597656 -0.0007634329  0.0002482753 -3.383179e-06  0.0000778315 -0.0001263888  0.0001722531  0.0002020227 -3.836615e-06
x.4.d  -0.0158390912 -0.1310432806  0.1352511831  0.0449761983 -3.329939e-03  0.1148341117 -0.0713171148 -0.1284005670  0.0278133280  5.126290e-03
x.5.d  -0.1858688891  0.0253776266 -0.0717586086  0.5341274639  2.227800e-05 -0.3002636152 -0.0726324342  0.0326916358  0.0657625607  2.606364e-03
x.6.d  -0.0048944139 -0.0060124238  0.0181656486  0.0403201399 -4.647343e-04 -0.0261720500 -0.0216063983  0.0034524585 -0.0048581920 -1.430757e-03
x.7.d   0.0151714020  0.0431932190  0.0238131178 -0.0208445073  3.249746e-04 -0.0164886469 -0.0154926130 -0.0405670944  0.0315480800 -8.105770e-04
x.8.d  -0.0630701326 -0.0764778319 -0.0301324858  0.1132447303  8.946404e-04  0.0449412406  0.0784043677 -0.1418068353  0.0485979469 -3.995176e-03
x.9.d  -0.0951474857 -0.1091675368  0.0739663619 -0.1517476716 -3.646854e-04 -0.0360025396  0.1585568472 -0.0283904891  0.1033633437 -4.313998e-03
x.10.d  0.5553995777  1.5333090345 -0.9620838202  0.9543262674 -3.913681e-02 -2.6524834567  1.3935057109 -0.9455618264 -0.2190072622  3.421974e-03

> slotNames(cotest)
 [1] "x"          "Z0"          "Z1"          "ZK"          "type"        "model"       "ecdet"       "lag"         "P"           "season"      "dumvar"      "cval"
[13] "teststat"   "lambda"      "Vorg"        "V"           "W"           "PI"          "DELTA"       "GAMMA"       "R0"          "RK"          "bp"          "spec"
[25] "call"       "test.name"
```

Figures B.13: Cointegration Test of daily spread

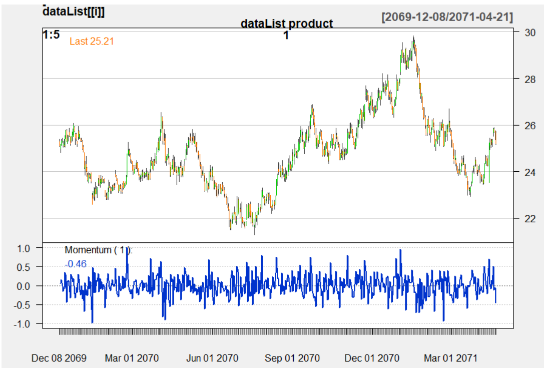
```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , with linear trend

Eigenvalues (lambda):
 [1] 0.4942965 0.4368537 0.4166531 0.4021867 0.3836231 0.3671906 0.3353352 0.3106309 0.2923250 0.2692312

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 9 | 155.89  6.50  8.18 11.65
r <= 8 | 171.85 12.91 14.90 19.19
r <= 7 | 184.87 18.90 21.07 25.75
r <= 6 | 203.01 24.78 27.14 32.14
r <= 5 | 227.42 30.84 33.32 38.78
r <= 4 | 240.50 36.25 39.43 44.59
r <= 3 | 255.69 42.06 44.91 51.30
r <= 2 | 267.87 48.43 51.07 57.07
r <= 1 | 285.39 54.01 57.00 63.37
r = 0  | 338.86 59.00 62.42 68.61

Eigenvectors, normalised to first column:
(These are the cointegration relations)

                 Open.l2     Open.1.l2    Open.2.l2     Open.3.l2    Open.4.l2    Open.5.l2   Open.6.l2    Open.7.l2    Open.8.l2    Open.9.l2
Open.l2       1.00000000    1.00000000  1.000000000   1.000000000   1.00000000   1.00000000  1.00000000   1.00000000   1.00000000    1.0000000
Open.1.l2     0.15589096    0.12610725  0.022284141  -0.068415744  -0.13263414  -0.06607633 -0.04092435   0.03206611  -0.01346732   -0.3287758
Open.2.l2  -104.96197939  -13.08170197 76.406148774 -11.211410547 337.94270589 -56.64820753 20.36846147 146.14776002 -29.63442773 -822.5896307
Open.3.l2     0.55018307    0.40409289  1.120550729   0.590277004   2.61706681   0.47871886 -0.35292282  -0.70465186  -0.60521521    9.2448567
Open.4.l2    -0.14940174    0.06360737 -0.002866303   0.439824828   0.14257478  -1.23794646 -0.16526570  -0.83800730   0.35598161    0.8558133
Open.5.l2    -0.79832830    0.15943017  3.209218823  -1.387879726   1.56352979   0.19404054  2.01517628  -7.60838595  -0.24270692  -21.0765325
Open.6.l2    -7.61648703    1.17218619 -0.015563082   0.095372410  -1.42297061   0.29697375 -0.12769290   0.08777035  -0.06402503    0.3341480
Open.7.l2     0.30280761    0.15130696 -0.618284673   0.190008561   0.08363934  -0.11593299  0.09051025  -0.20599096  -0.25257400   -2.1939023
Open.8.l2     1.64252614   -0.13243500  1.030972897   0.335451866  -1.32144025  -0.07307757 -0.12254476  -0.10145610  -0.18218631   -2.4734247
Open.9.l2    -0.08115186   -0.05476917  0.024176424   0.004920374  -0.15213321  -0.05168103  0.05612921   0.01166335  -0.04004343    1.0263470

Weights W:
(This is the loading matrix)

                Open.l2     Open.1.l2   Open.2.l2     Open.3.l2     Open.4.l2    Open.5.l2    Open.6.l2    Open.7.l2   Open.8.l2     Open.9.l2
Open.d    -0.0341416929 -0.2209232012 -0.06918842 -0.1242025596 -0.0094181901 -0.054446703 -0.293588687 -0.065045677 -0.198695485 -0.0035850506
Open.1.d  -0.7684752323 -4.5879746107 -0.37767638  3.7411965048  0.2561156777  1.775562587 -0.878265379 -0.434559011  0.756043003 -0.0825776932
Open.2.d   0.0005477022  0.0008388788 -0.00107730  0.0006251192 -0.0009557876  0.001797229 -0.001173025 -0.001607505  0.001626045  0.0001910457
Open.3.d  -0.0123679033 -0.1791109479 -0.10948991 -0.1220484758 -0.1182865555 -0.048677072  0.187246421  0.046392863  0.226965090 -0.0183285575
Open.4.d   0.0478220605 -0.0311041536 -0.04040582 -0.2980224902 -0.0414949728  0.531394476  0.122065816  0.099535364 -0.399348686 -0.0058495242
Open.5.d   0.0063615826 -0.0111353105 -0.03710132  0.0732925159 -0.0083393917 -0.011709495 -0.094630395  0.063842854  0.012900605  0.0032583334
Open.6.d   0.1592914077 -0.1917006312 -0.03241237 -0.1373015127  0.0557680658 -0.054341358  0.081072300 -0.008561914  0.047889220  0.0070183553
Open.7.d  -0.0881341526 -0.5640400084  0.65412867 -0.9844665576 -0.0208577003  0.002971761 -0.654093852  0.076905639  0.710154138  0.0310619823
Open.8.d  -0.0484802928  0.1146157790 -0.34056872 -0.7774286512  0.2092532848 -0.047753393  0.281374206 -0.043628063  0.218068922  0.0392298008
Open.9.d   0.1402663943  0.4377809473 -0.86511469  0.7443490083  0.7795813335  2.333133940 -5.875603263 -0.942537607  2.242840002 -0.2235839598

> slotNames(cotest)
 [1] "x"          "Z0"          "Z1"          "ZK"          "type"        "model"       "ecdet"       "lag"         "P"           "season"      "dumvar"      "cval"
[13] "teststat"   "lambda"      "Vorg"        "V"           "W"           "PI"          "DELTA"       "GAMMA"       "R0"          "RK"          "bp"          "spec"
[25] "call"       "test.name"
```

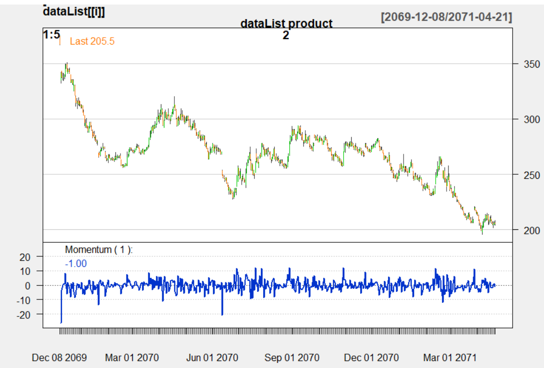
Figures B.14: Cointegration Test of overnight gap

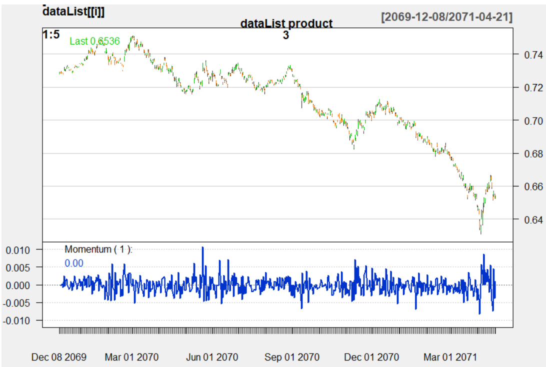
```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , with linear trend

Eigenvalues (lambda):
 [1] 0.5650357 0.4942614 0.4046332 0.3878619 0.3685255 0.3632730 0.3498701 0.3050718 0.2910761 0.2796544

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 9 | 163.03  6.50  8.18 11.65
r <= 8 | 170.97 12.91 14.90 19.19
r <= 7 | 180.88 18.90 21.07 25.75
r <= 6 | 214.00 24.78 27.14 32.14
r <= 5 | 224.35 30.84 33.32 38.78
r <= 4 | 228.47 36.25 39.43 44.59
r <= 3 | 243.93 42.06 44.91 51.30
r <= 2 | 257.73 48.43 51.07 57.07
r <= 1 | 338.82 54.01 57.00 63.37
r = 0  | 413.75 59.00 62.42 68.61

Eigenvectors, normalised to first column:
(These are the cointegration relations)

             a.l2        b.l2          c.l2          d.l2          e.l2         f.l2         g.l2        h.l2          i.l2          j.l2
a.l2   1.00000000  1.00000000  1.000000e+00   1.000000000  1.000000e+00    1.0000000  1.000000000  1.00000000   1.000000000     1.0000000
b.l2   0.01946188 -0.02457334 -9.855656e-04   0.005113033 -9.343768e-03    0.5428331 -0.007380430 -0.21919926  -0.041441570    -0.4887589
c.l2  -2.48195360  9.23578807 -2.114396e+02 653.782882656 -1.656209e+02 -561.0736257 36.694607975 15.82131592 -56.932747874 -1183.1039137
d.l2   0.50733709  0.06842422  2.040909e+00   0.465093474 -1.928199e+00    1.5106537 -0.146386773  0.52676283   0.354891111    -1.3288380
e.l2   0.41990032  0.79386681  1.166874e+00   2.660507396  3.919688e-01    0.4660911  0.169657590  0.61055166  -1.019771555     2.4383721
f.l2  -1.29531068  2.99528249 -1.439990e+00 -20.822360200 -1.199151e+00    2.7340151  0.984533237  4.51576988  -2.766847750    -7.1262106
g.l2 -14.78017172 20.72479684 -2.075519e-01   1.349874807  9.035071e-01   -0.9200810 -0.163133862 -0.75746118  -0.157773820    -2.3093533
h.l2  10.95930423  0.02282558  1.668218e+00  -0.483510396  1.031401e+00   -0.3268789 -0.244085543  0.25820948  -0.097010584    -5.2631225
i.l2 -12.14811244 -4.29195498  6.749708e-01  -0.925826892  1.168354e-01    0.1960775  0.029813676  0.13842672   0.073888672    -1.2930373
j.l2  -0.15194229  0.02346488  1.017462e-01  -0.131921043 -1.891183e-02   -0.4962106  0.009719346 -0.04867372  -0.006718696     0.2913732

Weights W:
(This is the loading matrix)

             a.l2          b.l2          c.l2          d.l2          e.l2          f.l2         g.l2          h.l2          i.l2          j.l2
a.d -4.095217e-03 -1.245042e-02 -0.0571675078 -0.0109277090 -0.0706695953 -0.0149230324 -0.744993671  0.0171610283 -0.1593797429  0.0006877764
b.d -1.973848e-02 -1.150781e-02 -0.4665555735  0.1295515812  0.3724606556 -0.5583245608 -4.567292540  2.5826971214  0.9739189584  0.1444592976
c.d -1.184002e-06  5.437983e-05  0.0003989189 -0.0003380928  0.0005943992  0.0002737106 -0.002043858 -0.0001042301  0.0005516567  0.0002576846
d.d -1.403723e-03 -3.115434e-02 -0.1818986993 -0.0111254295  0.2790864364 -0.0365131184  0.034337775 -0.0566881578 -0.1190167035  0.0038339596
e.d  4.999376e-03  1.090688e-02 -0.1342580311 -0.0742110885 -0.0950387744 -0.0311300059 -0.087686968 -0.0356473812  0.4474798582 -0.0235016076
f.d -1.247415e-04 -1.025543e-02  0.0146726740  0.0278165194  0.0209428091 -0.0066175328 -0.121901839 -0.0309557389  0.0548135149  0.0041062505
g.d  8.208830e-03 -6.137266e-02 -0.0219785753 -0.0001742115 -0.0490765537  0.0058720645  0.136871074 -0.0086661089 -0.0076281096  0.0126600017
h.d -5.571232e-02 -1.134289e-02 -0.1019466344  0.0191986981 -0.1551979128  0.0333441904  0.289722687 -0.0455054922  0.0056910275  0.0339456307
i.d  3.610445e-02  6.466451e-02 -0.1745339374  0.0188016729 -0.2210742291  0.0270397006  0.335405648 -0.0814840826 -0.0083544084  0.0571092005
j.d  8.439973e-03 -2.402972e-01 -1.6848025447  0.5478252852  0.8730275644  0.9928329841 -5.964023923  2.8277989155  1.3656636949 -0.1234682719

> slotNames(cotest)
 [1] "x"          "Z0"          "Z1"          "ZK"          "type"        "model"       "ecdet"       "lag"         "P"           "season"      "dumvar"      "cval"
[13] "teststat"   "lambda"      "Vorg"        "V"           "W"           "PI"          "DELTA"       "GAMMA"       "R0"          "RK"          "bp"          "spec"
[25] "call"       "test.name"
```

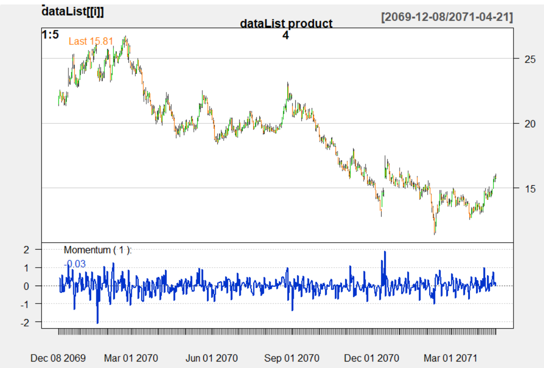
Graph B.15: Cointegration Test of open-to-open difference

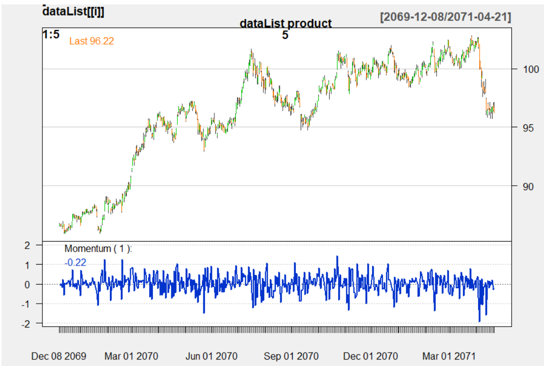
Appendix C

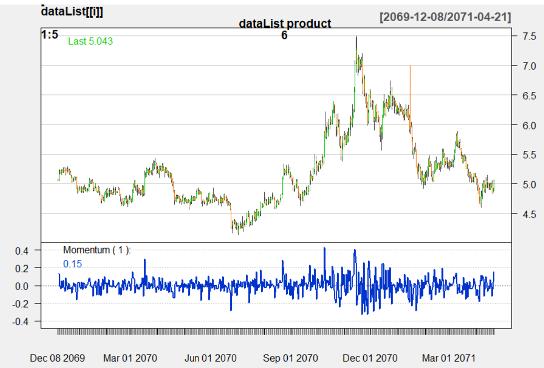

dataList[[i]]
dataList product
1
[2069-12-08/2071-04-21]
1:5
Last 25.21
Momentum (1):
-0.46
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071

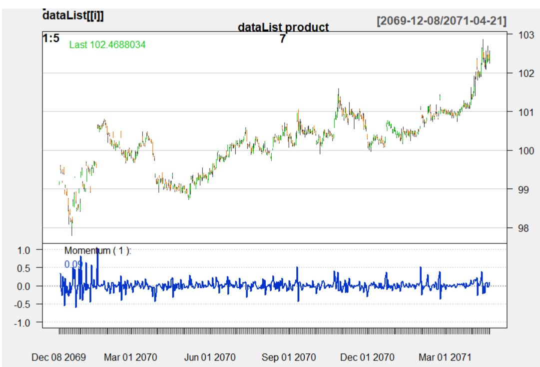

dataList[[i]]
dataList product
2
[2069-12-08/2071-04-21]
1:5
Last 205.5
Momentum (1):
-1.00
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071

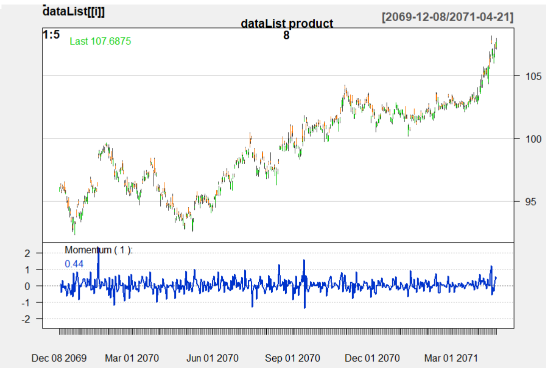

dataList[[i]]
dataList product
3
[2069-12-08/2071-04-21]
1:5
Last 0.6536
Momentum (1):
0.00
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071

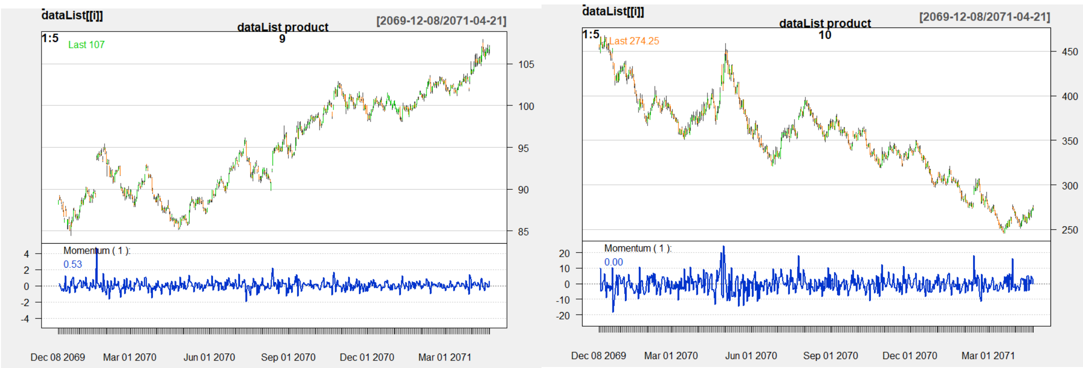

dataList[[i]]
dataList product
4
[2069-12-08/2071-04-21]
1:5
Last 15.81
Momentum (1):
0.03
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071


dataList[[i]]
dataList product
5
[2069-12-08/2071-04-21]
1:5
Last 96.22
Momentum (1):
-0.22
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071

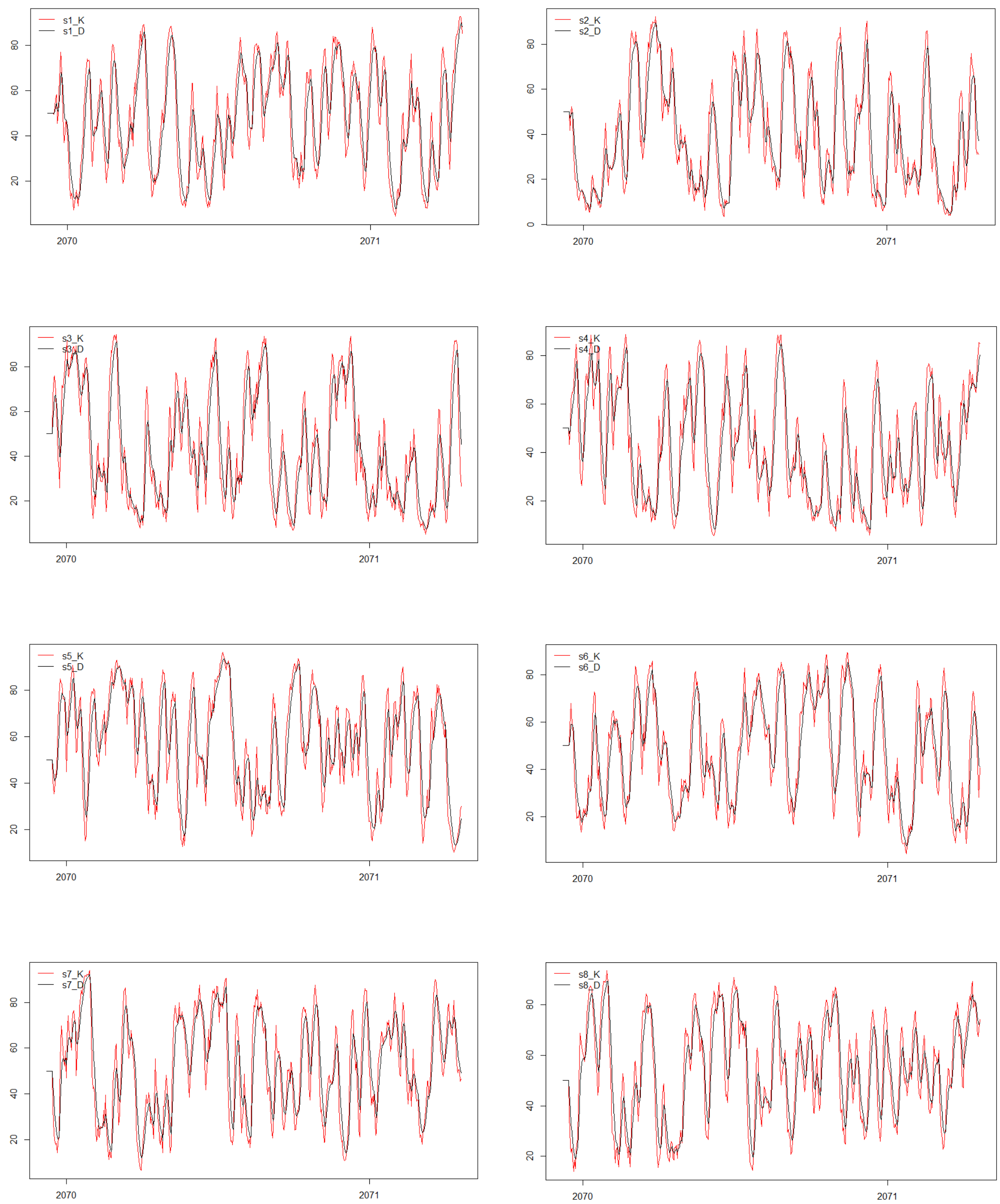

dataList[[i]]
dataList product
6
[2069-12-08/2071-04-21]
1:5
Last 5.043
Momentum (1):
0.15
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071

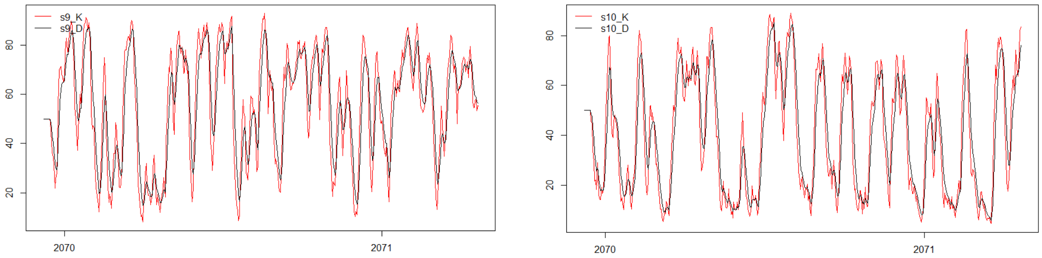

dataList[[i]]
dataList product
7
[2069-12-08/2071-04-21]
1:5
Last 102.4688034
Momentum (1):
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071


dataList[[i]]
dataList product
8
[2069-12-08/2071-04-21]
1:5
Last 107.6875
Momentum (1):
0.44
Dec 08 2069
Mar 01 2070
Jun 01 2070
Sep 01 2070
Dec 01 2070
Mar 01 2071

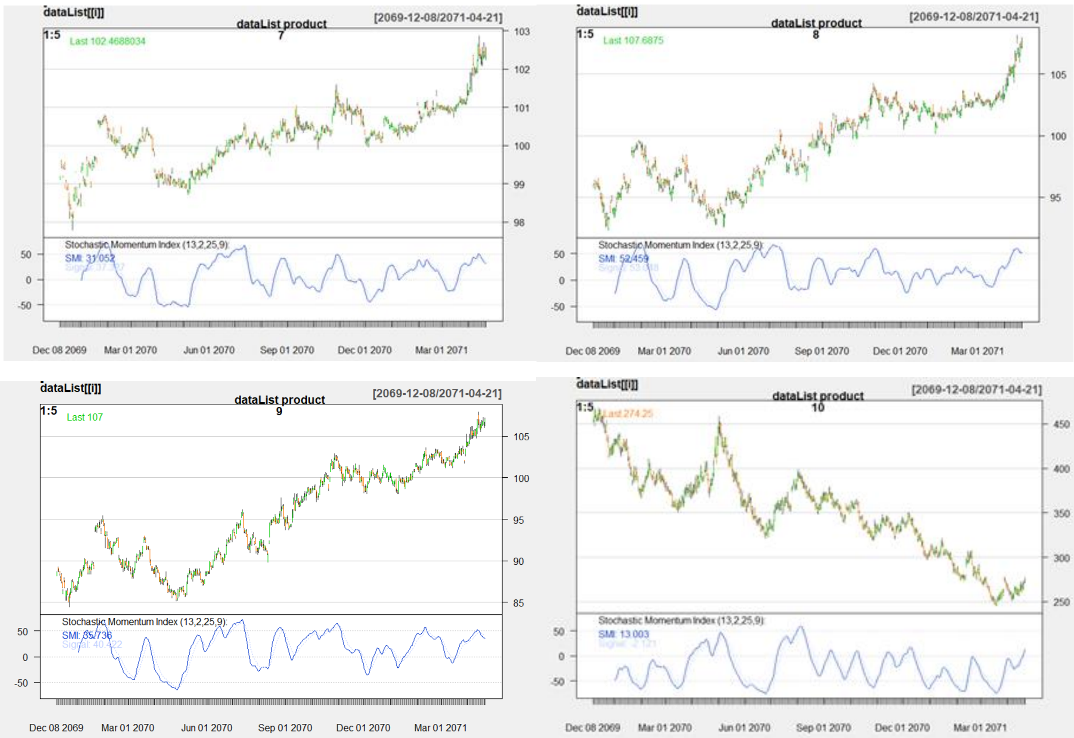


Graph C.1: Momentum graph





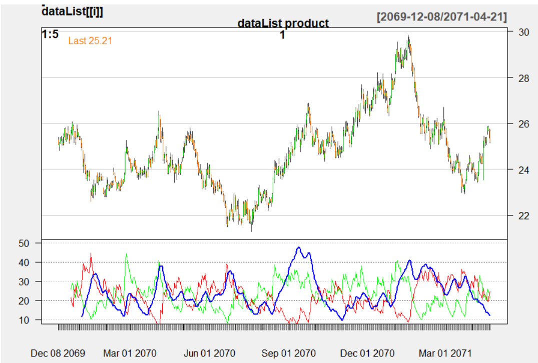
Graph C.2: Stochastic Oscillator graph

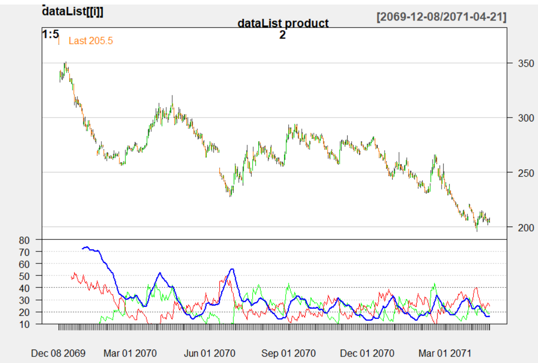


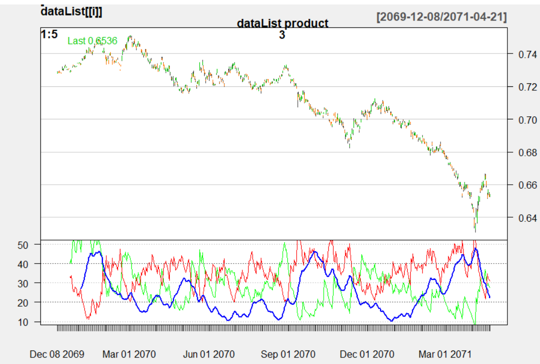
Graph C.3: SMI graph

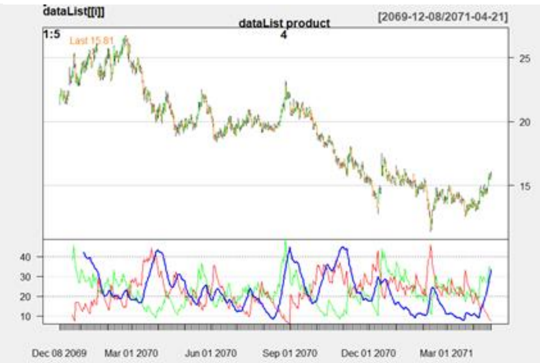
HLC							
Stochastic Momentum Index							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	56.769223	-70.266305	-6.488703	-10.719545	34.499569	1190.220277
	0-250days	49.260895	-70.266305	-17.212666	-21.048261	28.454829	809.677307
	251-500days	51.345764	-62.49471	-1.901548	-2.30886	35.595466	1267.037169
time series 02	0-500days	65.235129	-81.604312	-20.815218	-22.891716	38.152281	1455.596577
	0-250days	65.235129	-81.604312	-20.713646	-27.74959	44.415805	1972.763719
	251-500days	65.59565	-72.754634	-23.672187	-27.233779	31.646113	1001.476467
time series 03	0-500days	69.284428	-76.271838	-15.11183	-27.555434	39.842806	1587.449226
	0-250days	69.284428	-66.153134	-5.771574	-13.116586	37.874729	1434.495086
	251-500days	58.856062	-76.271841	-30.046994	-41.819466	36.486724	1331.281048
time series 04	0-500days	47.482858	-76.755342	-16.923431	-17.682481	30.533033	932.266128
	0-250days	47.482858	-65.683137	-10.346624	-13.258508	30.004109	900.246563
	251-500days	46.639832	-76.97	-26.745645	-26.893949	28.048384	786.711842
time series 05	0-500days	78.512684	-62.543672	17.904573	19.757079	32.766714	1073.657544
	0-250days	78.512684	-32.571677	33.327846	36.104463	28.814371	830.26797
	251-500days	55.602555	-62.543672	8.157503	15.547545	28.965043	838.973724
time series 06	0-500days	60.7277	-77.816135	-7.357658	-10.213559	33.062096	1093.102194
	0-250days	55.039821	-54.809278	-12.216972	-16.050524	30.07176	904.31075
	251-500days	61.073111	-77.816253	-7.045622	-7.977853	34.536758	1192.787629
time series 07	0-500days	73.239113	-54.511705	8.492149	11.125374	31.32959	981.543181
	0-250days	73.239113	-54.511705	7.728216	11.125374	38.402417	1474.745656
	251-500days	49.948104	-44.238172	7.368745	7.589069	23.795251	566.213982
time series 08	0-500days	70.666151	-56.020302	13.707006	15.213821	28.989227	840.375301
	0-250days	70.666151	-56.020302	10.232831	15.831642	37.029155	1371.15835
	251-500days	25	-27.966466	15.660203	13.889235	19.300569	372.511969
time series 09	0-500days	71.968918	-63.909969	17.017605	21.641924	32.736687	1071.690676
	0-250days	71.968918	-63.909969	8.900345	13.028506	39.546526	1563.927703
	251-500days	64.324575	-34.775109	22.942159	25.913143	23.488895	551.728194
time series 10	0-500days	59.03804	-75.110661	-23.222335	-24.653004	32.498641	1056.161642
	0-250days	59.03804	-75.110661	-16.971914	-22.017204	38.691115	1497.002399
	251-500days	27.874564	-73.858659	-30.048816	-28.751134	25.394208	644.865798

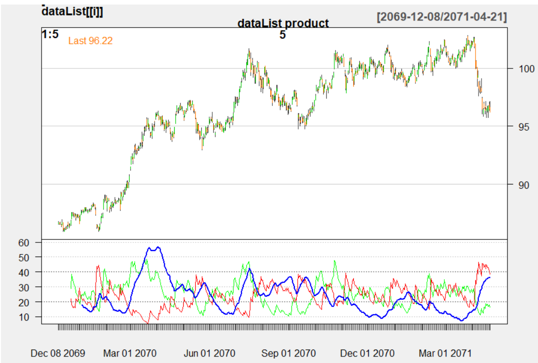
Figures C.3: SMI figures


dataList[[i]]
dataList product
1
[2069-12-08/2071-04-21]
1:5
Last 25.21
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071

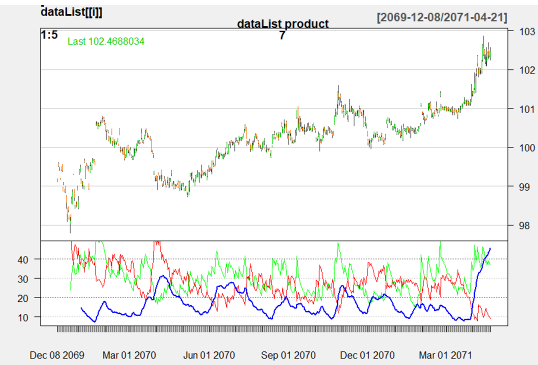

dataList[[i]]
dataList product
2
[2069-12-08/2071-04-21]
1:5
Last 205.5
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071

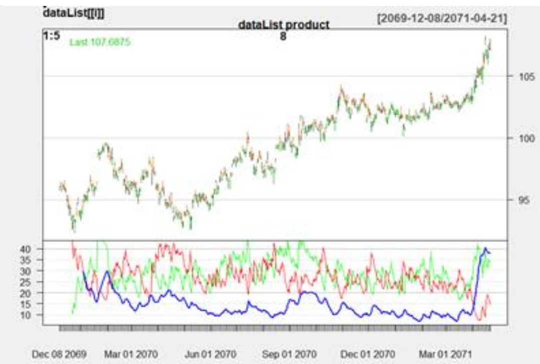

dataList[[i]]
dataList product
3
[2069-12-08/2071-04-21]
1:5
Last 0.6536
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071

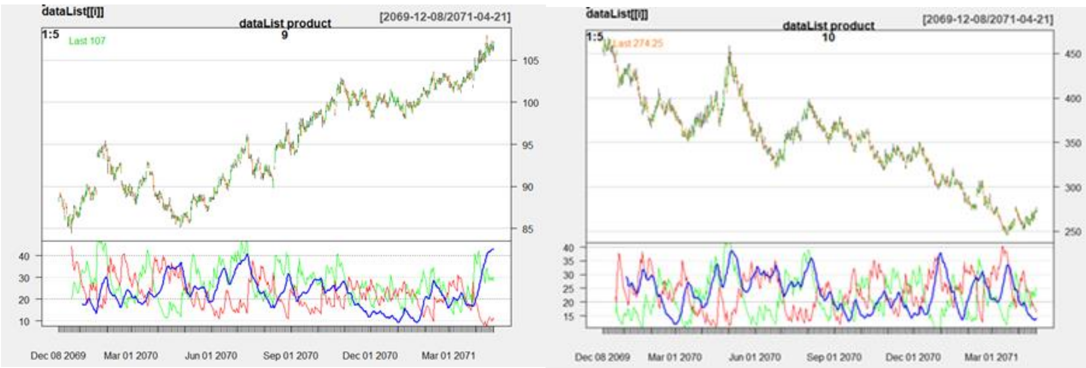

dataList[[i]]
dataList product
4
[2069-12-08/2071-04-21]
1:5
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList[[i]]
dataList product
5
[2069-12-08/2071-04-21]
1:5
Last 96.22
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList[[i]]
dataList product
6
[2069-12-08/2071-04-21]
1:5
Last 5.043
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList[[i]]
dataList product
7
[2069-12-08/2071-04-21]
1:5
Last 102.4688034
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList[[i]]
dataList product
8
[2069-12-08/2071-04-21]
1:5
Last 107.6875
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071



Graph C.4: ADX graph

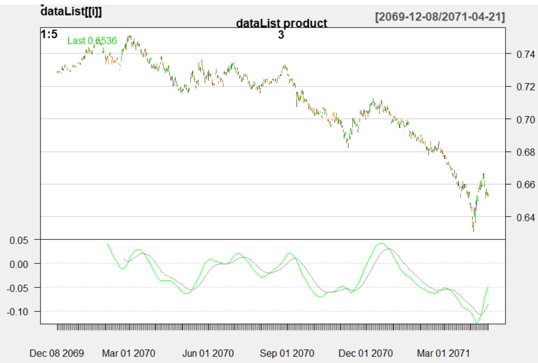
HLC							
Average Directional Movement Index							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	47.756967	9.578371	24.164865	22.599124	8.299317	68.878656
	0-250days	37.931331	11.571381	21.628866	20.839455	6.114643	37.388856
	251-500days	53.881044	9.713286	26.108409	23.857289	9.680404	93.710224
time series 02	0-500days	73.928305	12.603509	29.313846	25.716249	14.025609	196.717697
	0-250days	73.928305	13.943189	37.42976	31.809978	16.056358	257.806626
	251-500days	38.448343	12.615596	22.364028	22.548993	5.712354	32.630992
time series 03	0-500days	48.231995	10.113305	24.957956	22.806045	10.070696	101.418914
	0-250days	46.186076	10.616153	22.689276	20.951368	8.861826	78.531964
	251-500days	48.231986	10.109816	28.070832	28.376837	10.366048	107.454955
time series 04	0-500days	44.905427	7.673263	22.359747	20.17762	88.626831	9.414182
	0-250days	43.147671	8.340935	23.124375	20.73531	8.346998	69.672376
	251-500days	44.546191	7.673236	21.176464	19.435554	10.030395	100.608827
time series 05	0-500days	56.977861	7.323334	23.718561	22.576848	10.90169	118.846839
	0-250days	56.977861	11.650936	27.401753	25.4188	12.164919	147.985265
	251-500days	36.540608	7.32334	18.774234	18.217524	7.322729	53.622357
time series 06	0-500days	52.349481	8.733928	30.081919	23.354502	9.78913	95.827064
	0-250days	43.427194	10.216243	22.338438	19.720448	8.658894	74.976439
	251-500days	53.160018	8.733974	23.111681	20.97021	10.356266	107.252237
time series 07	0-500days	45.671275	7.159019	16.863306	15.215158	6.741443	45.447057
	0-250days	31.390343	7.159019	17.194462	15.466155	6.267426	39.280629
	251-500days	45.671275	7.998874	16.381084	14.33377	7.612348	57.947841
time series 08	0-500days	40.292275	6.845857	14.526978	12.482412	5.995004	35.94007
	0-250days	29.746055	8.474975	15.484462	14.528794	4.687421	21.971916
	251-500days	40.292282	6.845922	14.840616	11.281477	8.303221	68.943472
time series 09	0-500days	43.191316	9.142372	22.86607	22.476153	7.264081	52.766879
	0-250days	40.984433	13.51076	25.14133	23.453605	6.440974	41.486141
	251-500days	43.191318	9.14283	20.169055	19.294681	7.515421	56.48156
time series 10	0-500days	38.548807	11.99224	23.592909	23.380351	6.288581	39.546252
	0-250days	38.548807	11.99224	26.319369	26.78338	5.851978	34.245644
	251-500days	37.884065	9.987011	21.037853	20.100512	6.189553	38.310562

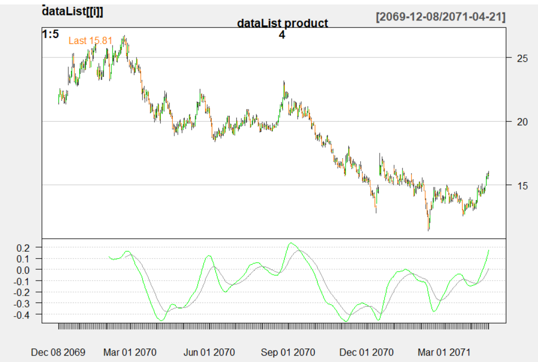
Figures C.4: ADX figures

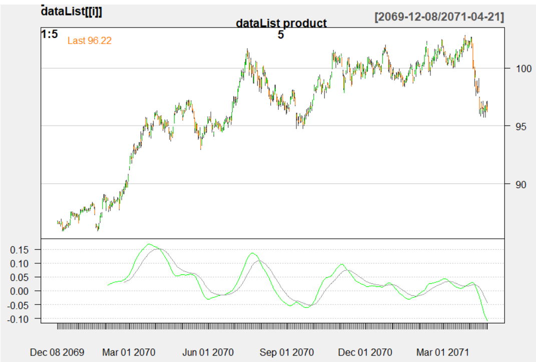
Table C.1: Up/Down times of ADX in the beginning 1-500 days

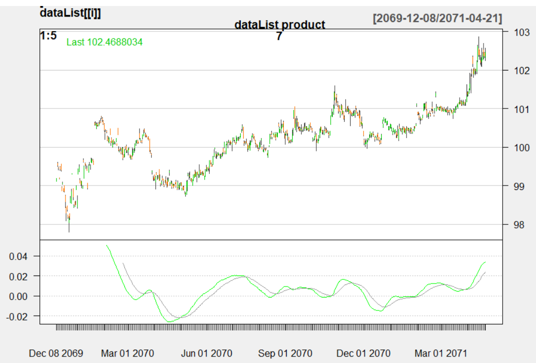
Times	ADX 0-25	ADX 25-50	ADX 50-75	ADX 75-100
Trend Strength	Absent or Weak Trend	Strong Trend	Very Strong Trend	Extremely Strong Trend
1	304	169	0	0
2	216	257	40	0
3	277	196	0	0
4	323	150	0	0
5	284	189	20	0
6	290	183	4	0
7	413	60	0	0

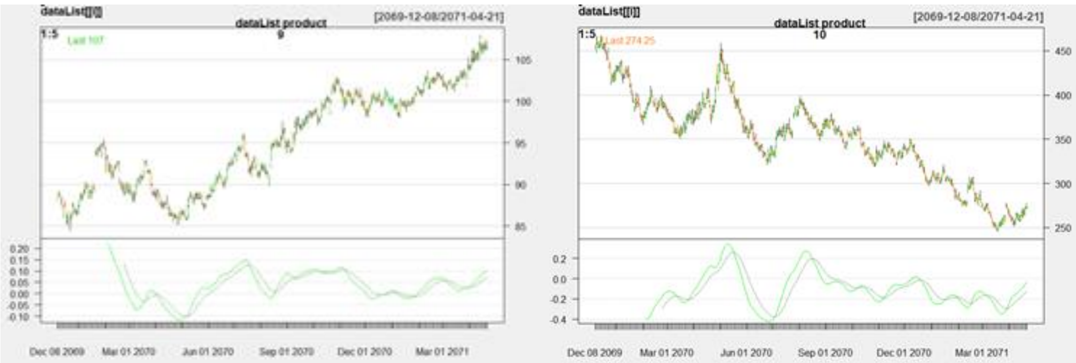
8	445	28	0	0
9	315	158	0	0
10	276	197	0	0



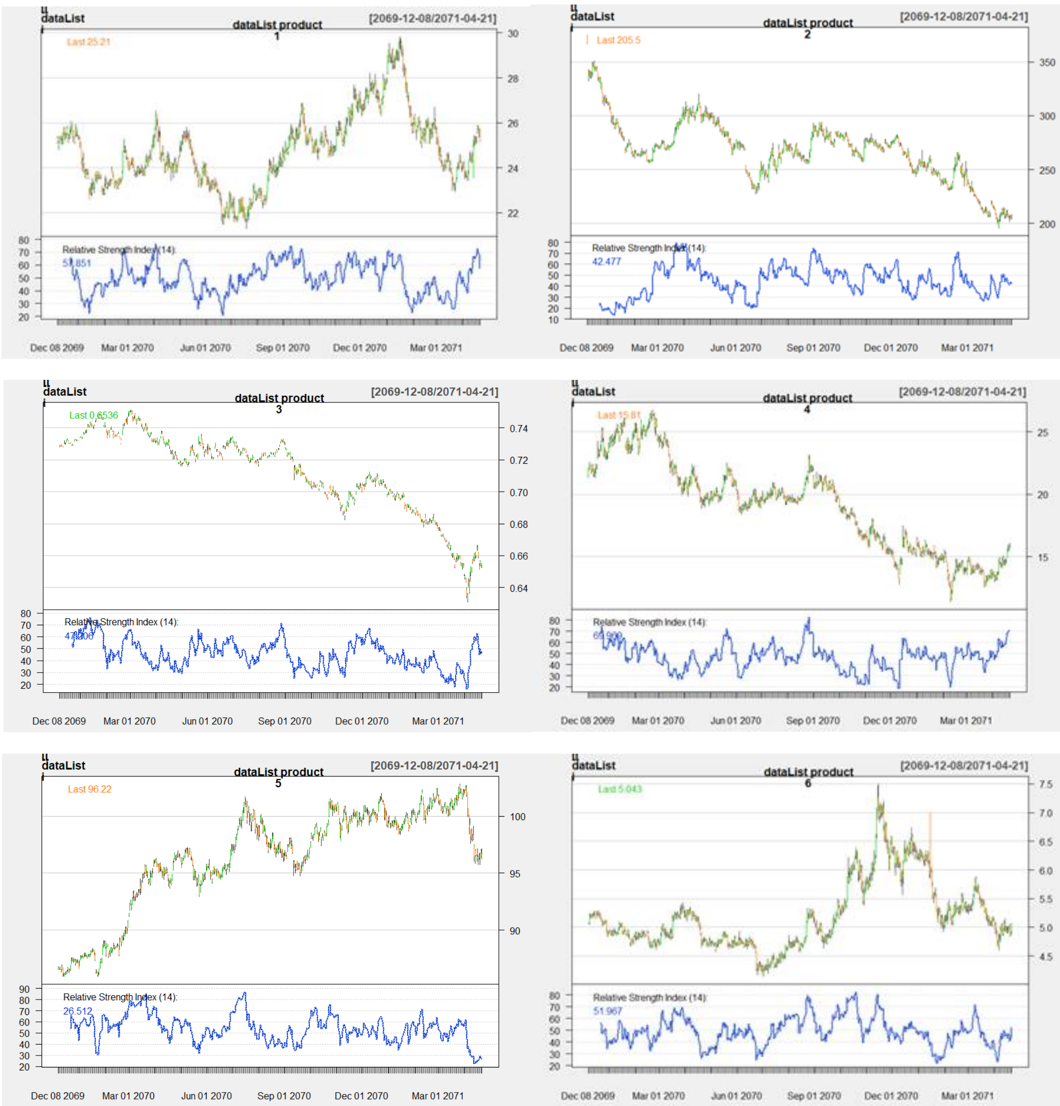


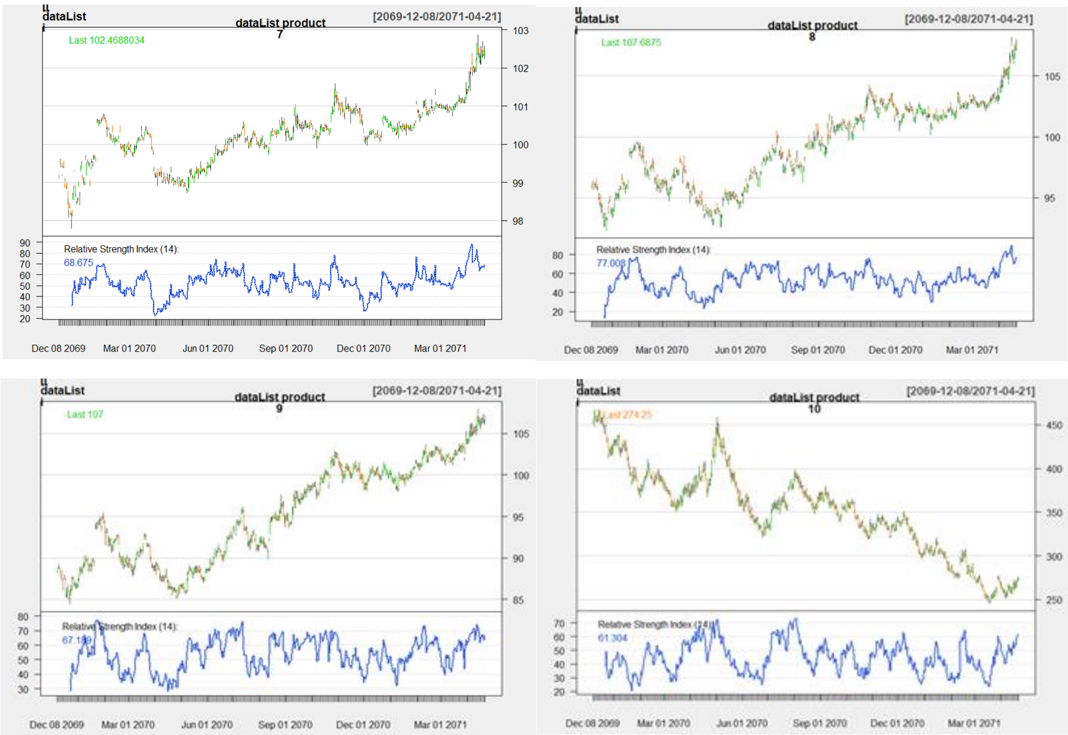






Graph C.5: Triple Exponential Moving Average graph





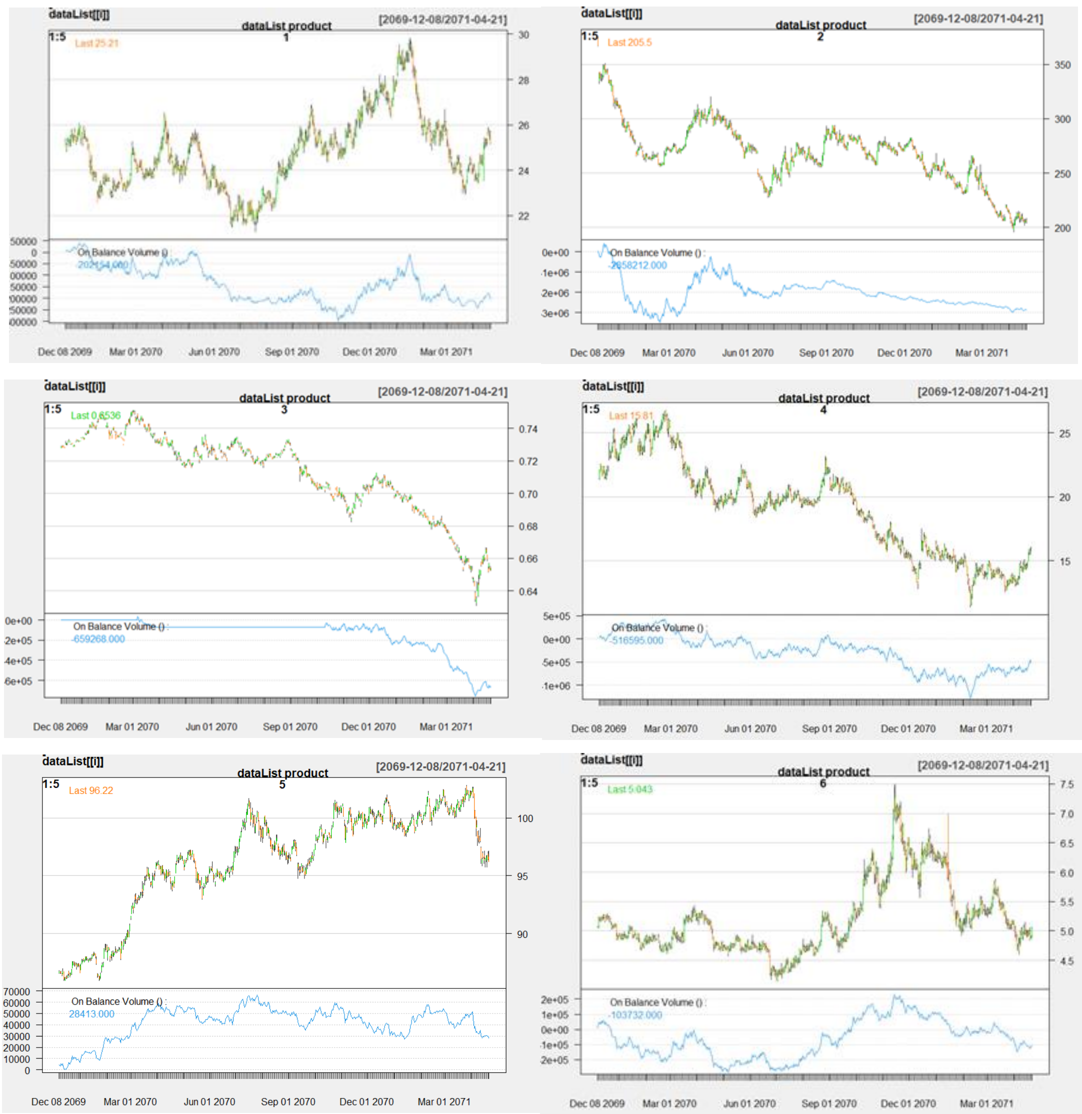
Graph C.6：RSI graph

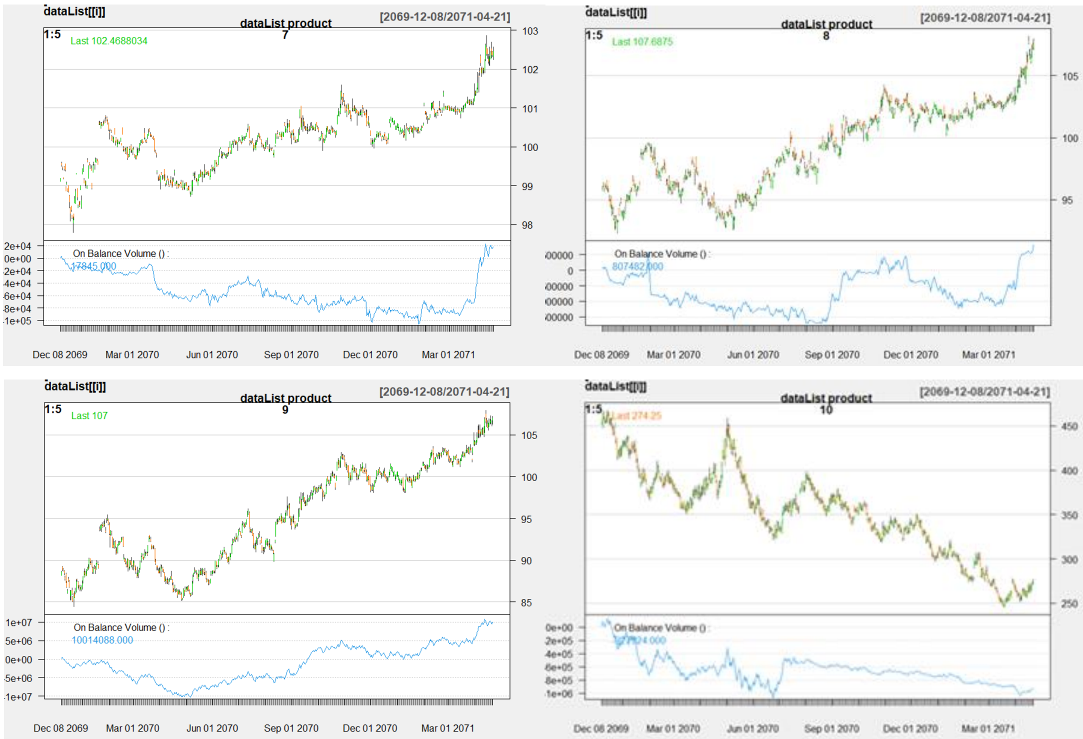
OP							
Relative Strength Index							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	76.035136	23.025437	49.903846	48.95684	11.671867	136.232474
	0-250days	76.035136	23.328234	47.537181	47.226632	10.183882	103.711461
	251-500days	74.406393	23.025344	50.90712	51.707461	12.104279	146.513566
time series 02	0-500days	79.96574	17.621724	44.542455	44.937707	13.586088	184.581796
	0-250days	79.96574	17.621724	43.745057	44.062245	15.965392	254.893756
	251-500days	77.781448	21.948573	45.273398	44.936661	11.303477	127.768587
time series 03	0-500days	80.554097	11.774571	45.351242	43.916056	13.601058	184.988772
	0-250days	80.554097	28.519803	50.087513	48.784482	12.165727	148.004904
	251-500days	72.121212	11.774572	40.075288	38.204274	12.93397	167.287572
time series 04	0-500days	83.811288	18.717914	46.825795	46.979302	11.435661	130.774336
	0-250days	78.535539	24.503794	48.356141	48.057677	10.895833	118.719182
	251-500days	75.721227	18.725501	44.869741	46.240874	11.215596	125.789589
time series 05	0-500days	83.577095	20.984461	54.308183	54.25562	11.833074	140.021651
	0-250days	83.577095	29.053584	58.267104	58.026138	11.84466	140.295976
	251-500days	76.587963	20.984461	51.315754	51.90474	10.525782	110.792095
time series 06	0-500days	80.267313	23.478936	49.825919	48.605709	11.458633	131.300281
	0-250days	71.806663	24.602033	47.955969	47.444853	10.405504	108.274512
	251-500days	80.421997	23.478937	51.619566	49.196027	12.192079	148.646796
time series 07	0-500days	85.670924	24.546292	52.546505	52.527609	9.708241	94.249939
	0-250days	74.364766	24.546292	51.470946	52.387141	9.810285	96.241682
	251-500days	85.670924	26.121042	53.034616	52.079509	9.740921	94.885544
time series 08	0-500days	77.493293	26.599047	52.551353	53.143074	8.670759	75.182069
	0-250days	73.683724	26.599047	51.221035	51.38727	9.85214	97.064664
	251-500days	77.493293	34.971113	53.87829	53.533216	7.401132	54.77676
time series 09	0-500days	81.655324	25.029542	54.390034	55.276681	11.812712	139.540174
	0-250days	81.655324	25.029542	52.013656	52.725207	13.904053	193.322693
	251-500days	76.929525	34.287703	56.06763	56.454098	8.960243	80.285955
time series 10	0-500days	74.751731	23.627246	45.103241	44.583606	10.493757	110.118931
	0-250days	74.751731	23.627246	46.633962	45.461209	11.8322	140.000949
	251-500days	62.756199	25.028596	43.388591	43.726105	8.835673	78.069123

Figures C.6: RSI figures

Table C.2: Up/Down times of RSI in the beginning 1-500 days

TIMES/CP	RSI 80-100	RSI 50-80	RSI 20-50	RSI 0-20
1	0	231	255	0
2	0	176	290	20
3	0	172	311	3
4	1	184	298	3
5	12	303	171	0
6	3	205	278	0
7	5	310	171	0
8	9	304	171	2
9	0	312	174	0
10	0	154	332	0





Graph C.7：OBV graph

OP							
On Balance Volume							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	145994	-162938	-56762.16	-64810	59697.74	3563820000
	0-250days	64311	-152000	-53552.71	-64075	56732.67	3218595000
	251-500days	189667	-140429	-18387.66	-23198	70881.68	5024212000
time series 02	0-500days	704775	-3420570	-1316725	-1286430	785782	6.17453E+11
	0-250days	704775	-3420570	-1237264	-1179312	1067458	1.13947E+12
	251-500days	421382	-1022382	-298448.9	-278368.5	356689.8	1.27228E+11
time series 03	0-500days	34150	-589955	-123278.8	-75787	130182.2	16947420000
	0-250days	34150	-81998	-45964.2	-75562	36808.43	1354860000
	251-500days	135068	-418667	-66153.61	-263.5	129318.3	16723220000
time series 04	0-500days	438524	-1476866	-563534.3	-592606	476285.3	2.26848E+11
	0-250days	438524	-921044	-252657.8	-285328.5	381568.9	1.45595E+11
	251-500days	476177	-788567	-240550.5	-305416.5	290551.8	84420370000
time series 05	0-500days	108992	1784	71293.04	77309.5	24105.58	581079000
	0-250days	101425	1784	57445.86	65598	26603.91	707768000
	251-500days	26192	-5347	11982.41	12679	7451.158	55519750
time series 06	0-500days	417573	-163958	134572.5	131858.5	164079	26921930000
	0-250days	130393	-163958	-17749.98	-23068	58736.28	3449950000
	251-500days	371714	-7461	178149.4	178416	84028.4	7060772000
time series 07	0-500days	28010	-66307	-13641.89	-11345.5	19869.63	394802200
	0-250days	9814	-66307	-24417.34	-25605	18718.73	350390700
	251-500days	31429	-59844	-12521.35	-17815.5	21468.5	460896400
time series 08	0-500days	767312	-1384128	-407382.7	-638888	598482.5	3.58181E+11
	0-250days	711982	-1314378	-763300.6	-905487.5	429897.6	1.84812E+11
	251-500days	1686450	-53829	730284.2	756501	428626.4	1.83721E+11
time series 09	0-500days	13765080	-7823699	1896458	-227042	5794974	3.35817E+13
	0-250days	636986	-7823699	-3079359	-2827839	2267560	5.14183E+12
	251-500days	10617530	-1139559	4937631	5117789	2323175	5.39714E+12
time series 10	0-500days	67370	-836466	-536040.9	-555914.5	160171	25654740000
	0-250days	67370	823715	-469773.5	-468740	188410.4	35498490000
	251-500days	28315	-398678	-146788.5	-124434	106393.5	11319580000

Figures C.7: OBV figures


dataList
dataList product
1
[2069-12-08/2071-04-21]
Last 25.21
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList
dataList product
2
[2069-12-08/2071-04-21]
Last 205.5
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList
dataList product
3
[2069-12-08/2071-04-21]
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071

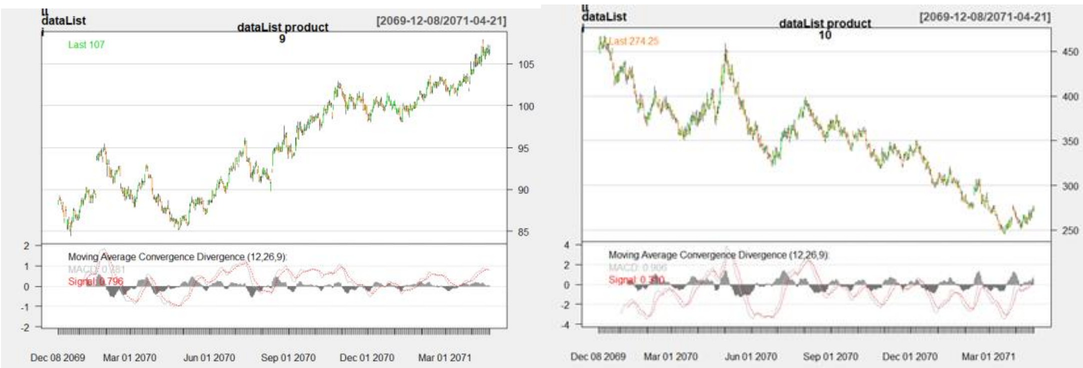

dataList
dataList product
4
[2069-12-08/2071-04-21]
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList
dataList product
5
[2069-12-08/2071-04-21]
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList
dataList product
6
[2069-12-08/2071-04-21]
Last 5.043
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList
dataList product
7
[2069-12-08/2071-04-21]
Last 102.4688034
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071


dataList
dataList product
8
[2069-12-08/2071-04-21]
Last 107.6875
Moving Average Convergence Divergence (12,26,9)
Dec 08 2069 Mar 01 2070 Jun 01 2070 Sep 01 2070 Dec 01 2070 Mar 01 2071



Graph C.8：MACD graph

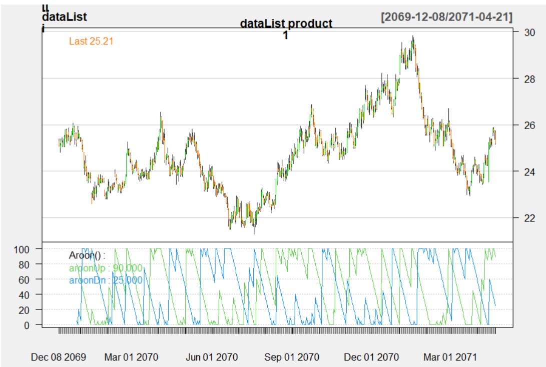
OP							
MACD Oscillator							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	2.172842	-2.628603	-0.069625	-0.040772	1.246156	1.552904
	0-250days	2.034943	-2.440741	-0.375335	-0.389251	1.006781	1.013607
	251-500days	2.148708	-2.628604	0.053481	0.172111	1.364022	1.860557
time series 02	0-500days	2.935757	-4.548208	-0.7504	-0.683055	1.790873	3.207225
	0-250days	2.935757	-4.548208	-0.870995	-0.837188	2.192394	4.80659
	251-500days	4.06295	-3.530566	-0.687492	-0.913112	1.428193	2.039736
time series 03	0-500days	0.478033	-1.208599	-0.159063	-0.195646	0.335904	0.112832
	0-250days	0.478033	-0.549318	-0.031696	-0.041056	0.264821	0.07013
	251-500days	0.465385	-1.208599	-0.326012	-0.373699	0.343553	0.118029
time series 04	0-500days	3.262832	-5.230133	-0.71883	-0.56189	1.794571	3.220483
	0-250days	2.773061	-4.365689	-0.426093	-0.348893	1.777409	3.159184
	251-500days	3.262832	-5.230134	-1.25173	-1.036149	1.622799	2.633476
time series 05	0-500days	1.392993	-1.346887	0.202255	0.198642	0.500419	0.250419
	0-250days	1.392993	-0.59913	0.416412	0.362223	0.489116	0.239234
	251-500days	0.891598	-1.346887	0.069758	0.101413	0.416581	0.173539
time series 06	0-500days	5.394207	-5.30666	-0.082963	-0.25946	1.939051	3.75992
	0-250days	2.258007	-2.95864	-0.419361	-0.50666	1.281529	1.642316
	251-500days	5.393075	-5.306663	0.005861	-0.143502	2.371363	5.623361
time series 07	0-500days	0.418373	-0.256199	0.04159	0.041231	0.121809	0.014837
	0-250days	0.418373	-0.256199	0.03487	0.041532	0.14417	0.020785
	251-500days	0.326345	-0.196862	0.042025	0.028855	0.102058	0.010416
time series 08	0-500days	1.124194	-0.698047	0.13885	0.139775	0.37118	0.137775
	0-250days	1.124194	-0.698047	0.085064	0.06855	0.460994	0.212516
	251-500days	0.911837	-0.35008	0.153227	0.130487	0.253067	0.064043
time series 09	0-500days	1.847281	-1.006794	0.266432	0.286405	0.574725	0.330309
	0-250days	1.847281	-1.006794	0.166349	0.161729	0.721533	0.52061
	251-500days	1.045864	-0.48327	0.29598	0.269753	0.357647	0.127911
time series 10	0-500days	3.953251	-3.531508	-0.840229	-0.78123	1.555448	2.419419
	0-250days	3.953251	-3.529098	-0.663554	-0.740689	1.997221	3.98889
	251-500days	0.903274	-3.531508	-1.009114	-0.794778	1.03422	1.069611

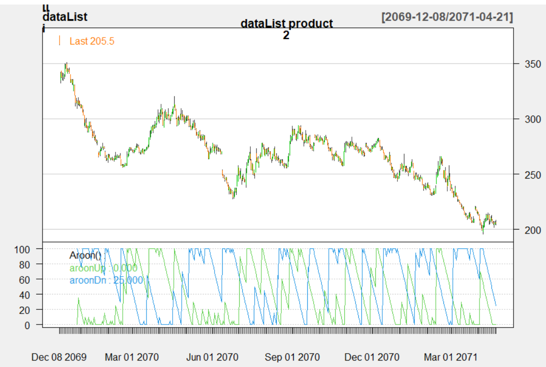
Figures C.8: MACD figures

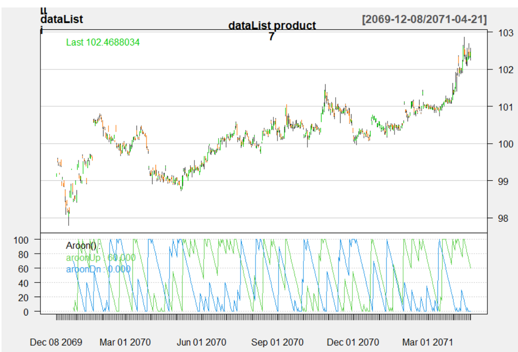
Table C.3: Up/Down times of MACD in the beginning 1-500 days

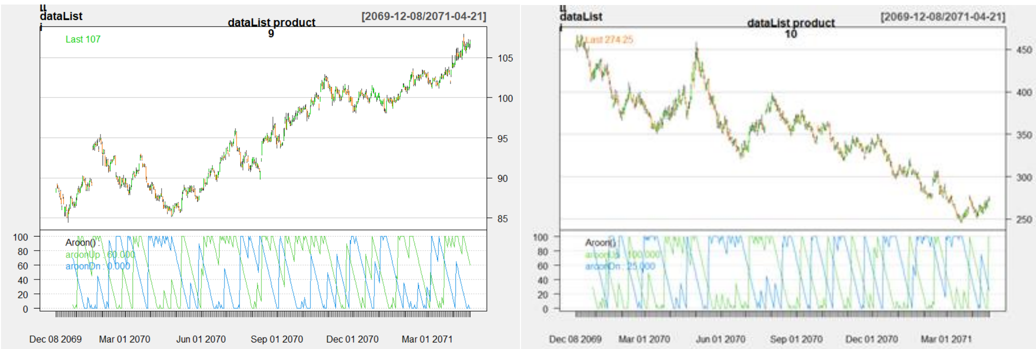
Times	MACD>Signal,MACD,Signal>0	MACD<Signal,MACD,Signal<0
1	129	102
2	85	141
3	80	184
4	82	160
5	173	80
6	107	115
7	164	63
8	180	76

9	191	77
10	62	180









Graph C.9：Aroon graph

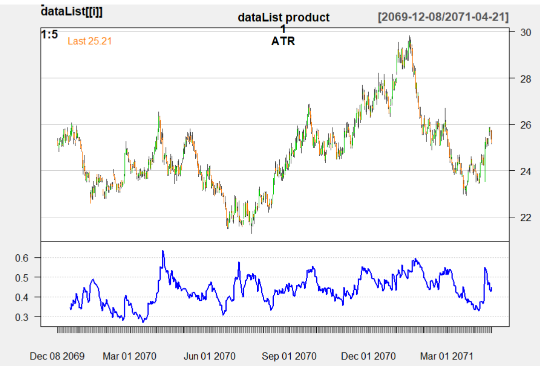
HL							
Aroon							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	100	-100	3.635417	35	63.590075	4043.697699
	0-250days	100	-100	-8.326087	-25	60.497593	3659.958705
	251-500days	100	-100	9.782609	40	64.680577	4183.576989
time series 02	0-500days	100	-100	-21.895833	-45	63.861064	4078.235473
	0-250days	100	-100	-14.413043	-30	69.428288	4820.287165
	251-500days	100	-100	-28.456522	-45	58.454516	3416.930416
time series 03	0-500days	100	-100	-22.541667	-47.5	67.148127	4508.870912
	0-250days	100	-100	-9.413043	-30	67.093292	4501.509873
	251-500days	95	-100	-44.695652	-65	57.535965	3310.387317
time series 04	0-500days	100	-100	-15.697917	-30	61.0322	3724.929432
	0-250days	100	-100	-2.26087	-15	61.11498	3735.04082
	251-500days	100	-100	-35.456522	-47.5	54.349149	2953.829979
time series 05	0-500days	100	-100	16.322917	35	62.173321	3865.521812
	0-250days	100	-85	33.978261	52.5	59.010579	3482.248434
	251-500days	100	-100	6.282609	25	59.096052	3492.343364
time series 06	0-500days	100	-100	-1.4375	-15	61.627342	3797.92928
	0-250days	100	-100	-4.23913	-25	59.252691	3510.881432
	251-500days	100	-100	-0.456522	17.5	65.000069	4225.009018
time series 07	0-500days	100	-100	14.333333	30	59.070509	3489.324983
	0-250days	100	-100	12.673913	35	61.629281	3798.168312
	251-500days	100	-100	13.717391	25	57.839434	3345.400133
time series 08	0-500days	100	-100	10.927083	20	57.953304	3358.585486
	0-250days	100	-100	2.369565	25	65.568844	4299.273305
	251-500days	100	-100	16.608696	20	49.005604	2401.549269
time series 09	0-500days	100	-100	14.46875	35	63.911956	4084.738061
	0-250days	100	-100	3.869565	25	69.053365	4768.367192
	251-500days	100	-100	21.978261	35	58.627865	3437.2266
time series 10	0-500days	100	-100	-18.489583	-45	65.516734	4292.44248
	0-250days	100	-100	-9.217391	-20	69.678273	4855.061705
	251-500days	100	85	-22.630435	-45	60.749812	3690.539681

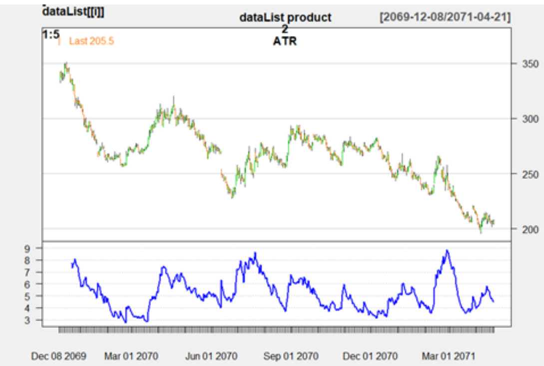
Figures C.9: Aroon figures

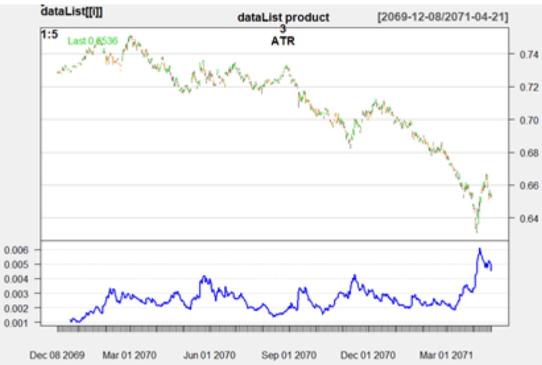
Table C.4: Up/Down times of Aroon in the beginning 1-500 days

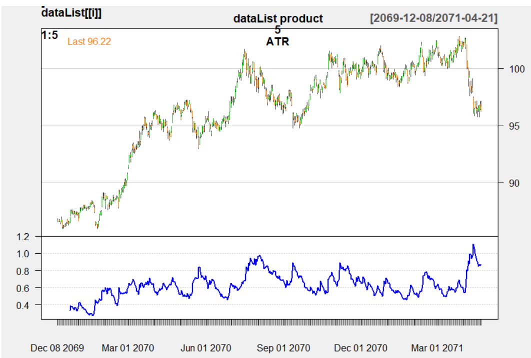
Times	Aroon_UP	Aroon_DOWN	Aroon_UP	Aroon_DOWN
Trend Strength	Buy	Buy	Sell	Sell
1	163	238	203	0
2	117	154	270	7
3	138	146	280	5
4	111	158	268	4
5	204	268	162	1
6	132	218	226	0
7	197	268	156	9
8	206	235	156	15

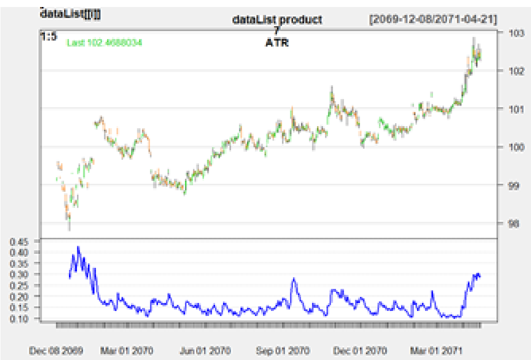
9	226	251	164	7
10	135	168	266	3

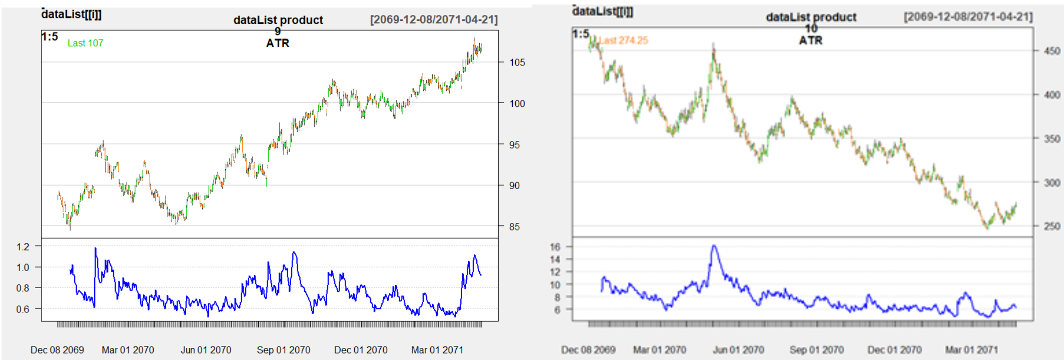












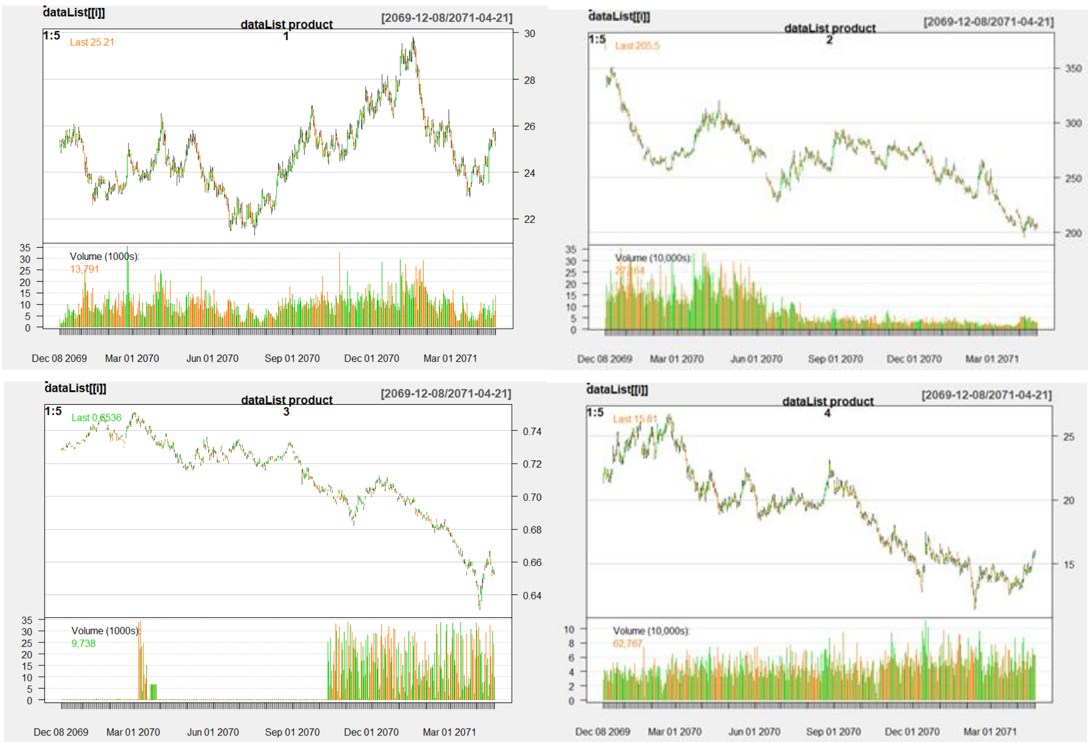
Graph C.10：ATR graph

HLC							
Average True Range							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	29.33	21.3	24.557094	24.41	1.614494	2.606591
	0-250days	25.85	21.3	23.579157	23.6	1.101929	1.214246
	251-500days	29.33	22.93	25.537912	25.3	1.446299	2.091782
time series 02	0-500days	345.5	196	264.903808	267	27.812089	773.512315
	0-250days	345.5	227.5	277.75	271.25	24.84264	617.156754
	251-500days	287.5	196	252.064257	257.5	24.59443	604.885975
time series 03	0-500days	0.7495	0.631	0.710734	0.7196	0.025344	0.000642
	0-250days	0.7495	0.716	0.729961	0.7294	0.008521	0.000073
	251-500days	0.7309	0.631	0.691456	0.6966	0.021731	0.000472
time series 04	0-500days	26.25	11.4	18.773146	19.38	3.599087	12.953428
	0-250days	26.25	18.4	21.462731	20.74	2.183654	4.768345
	251-500days	21.88	11.4	16.080964	15.3	2.588664	6.701181
time series 05	0-500days	102.17	85.94	96.042565	96.82	4.427763	19.605089
	0-250days	100.99	85.94	93.071165	94.45	4.287769	18.384967
	251-500days	102.17	94.74	99.009759	99.4	1.809511	3.27433
time series 06	0-500days	7.03	4.145	5.138411	4.995	0.575131	0.330776
	0-250days	5.31	4.145	4.774606	4.735	0.261611	0.06844
	251-500days	7.03	4.605	5.504357	5.325	0.572091	0.327288
time series 07	0-500days	102.351601	97.796898	100.128508	100.195297	-0.057388	0.773909
	0-250days	100.656197	97.796898	99.576058	99.718803	0.583836	0.340865
	251-500days	102.351601	99.898399	100.680344	100.523399	0.499557	0.249558
time series 08	0-500days	107.093803	92.343803	98.883832	98.968803	3.33451	11.118959
	0-250days	99.781197	92.343803	95.983182	95.8125	1.701772	2.896027
	251-500days	98.031197	107.093803	101.790666	101.875	1.578146	2.490544
time series 09	0-500days	106.4375	84.4688	94.784071	94.2188	5.860023	34.339867
	0-250days	95.4688	84.4688	89.551585	89.1875	2.484092	6.170712
	251-500days	106.4375	93.7188	100.018325	100	2.790694	7.787975
time series 10	0-500days	461	246	346.792585	353.5	48.759682	2377.506591
	0-250days	461	321	382.03012	379.25	31.230052	975.316125
	251-500days	371.5	246	311.46988	319.25	36.022795	1297.64173

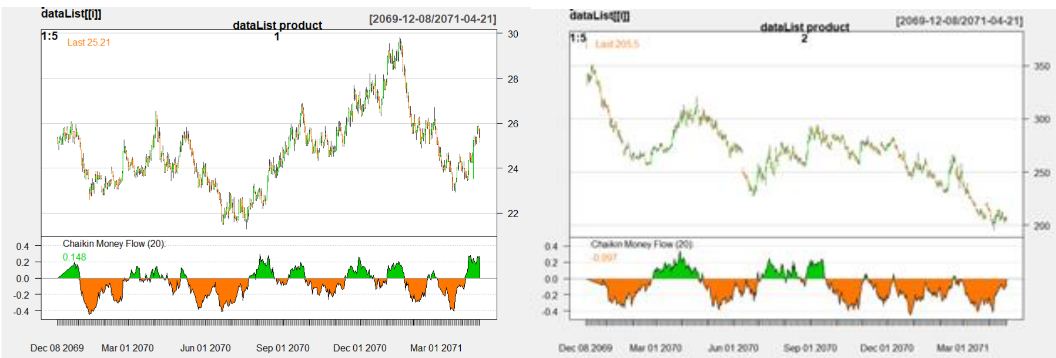
Figures C.10: ATR figures

HLC							
True Range							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	1.69	0.15	0.434329	0.4	0.185866	0.034546
	0-250days	1.22	0.15	0.404859	0.37	0.18316	0.033548
	251-500days	1.69	0.17	0.463293	0.43	0.184514	0.034046
time series 02	0-500days	35.5	1.25	5.196393	4.5	3.056859	9.344385
	0-250days	35.5	1.25	5.521084	4.75	3.441959	11.847084
	251-500days	14.75	1.75	4.880522	4.25	2.586806	6.691565
time series 03	0-500days	0.0113	0.0003	0.002588	0.0022	0.001621	0.000003
	0-250days	0.0107	0.0003	0.002367	0.0021	0.001477	0.000002
	251-500days	0.0113	0.0004	0.002816	0.0024	0.001725	0.000003
time series 04	0-500days	2.89	0.09	0.577715	0.5	0.296205	0.087737
	0-250days	2.11	0.2	0.615904	0.56	0.292787	0.085724
	251-500days	2.89	0.09	0.540602	0.48	0.295503	0.087322
time series 05	0-500days	2.18	0.12	0.625671	0.56	0.318469	0.101423
	0-250days	1.94	0.12	0.591165	0.54	0.309264	0.095644
	251-500days	2.18	0.19	0.659076	0.57	0.324653	0.1054
time series 06	0-500days	1.145	0.02	0.139381	0.115	0.096826	0.009375
	0-250days	0.41	0.02	0.097474	0.085	0.04962	0.002462
	251-500days	1.145	0.05	0.181386	0.16	0.113256	0.012827
time series 07	0-500days	1.101501	0.031197	0.172001	0.132805	0.12622	0.015932
	0-250days	1.101501	0.031197	0.176767	0.132797	0.140092	0.019626
	251-500days	0.546906	0.031296	0.167391	0.132805	0.110976	0.012316
time series 08	0-500days	2.5	0.156197	0.590804	0.5	0.323958	0.104949
	0-250days	2.5	0.156197	0.603788	0.5	0.320217	0.102539
	251-500days	2	0.1875	0.576178	0.468803	0.327331	0.107146
time series 09	0-500days	28.75	2	7.676854	7	3.644522	13.28254
	0-250days	28.75	3.25	9.039157	8.25	3.865	14.938229
	251-500days	22	2	6.307229	5.75	2.823788	7.973778
time series 10	0-500days	4.9374	0.1875	0.748934	0.6563	0.403039	0.16244
	0-250days	4.9374	0.1875	0.752257	0.6563	0.446371	0.199247
	251-500days	2.2188	0.25	0.746109	0.6563	0.356178	0.126862

Figures C.11: TR figures



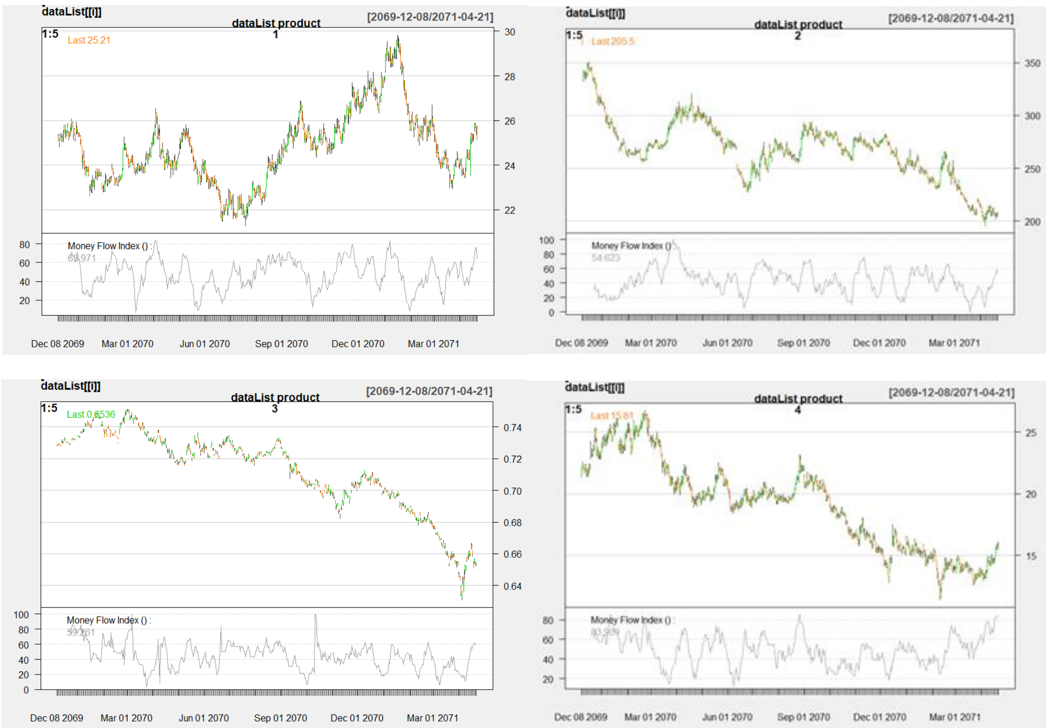
Graph C.11：Volume graph

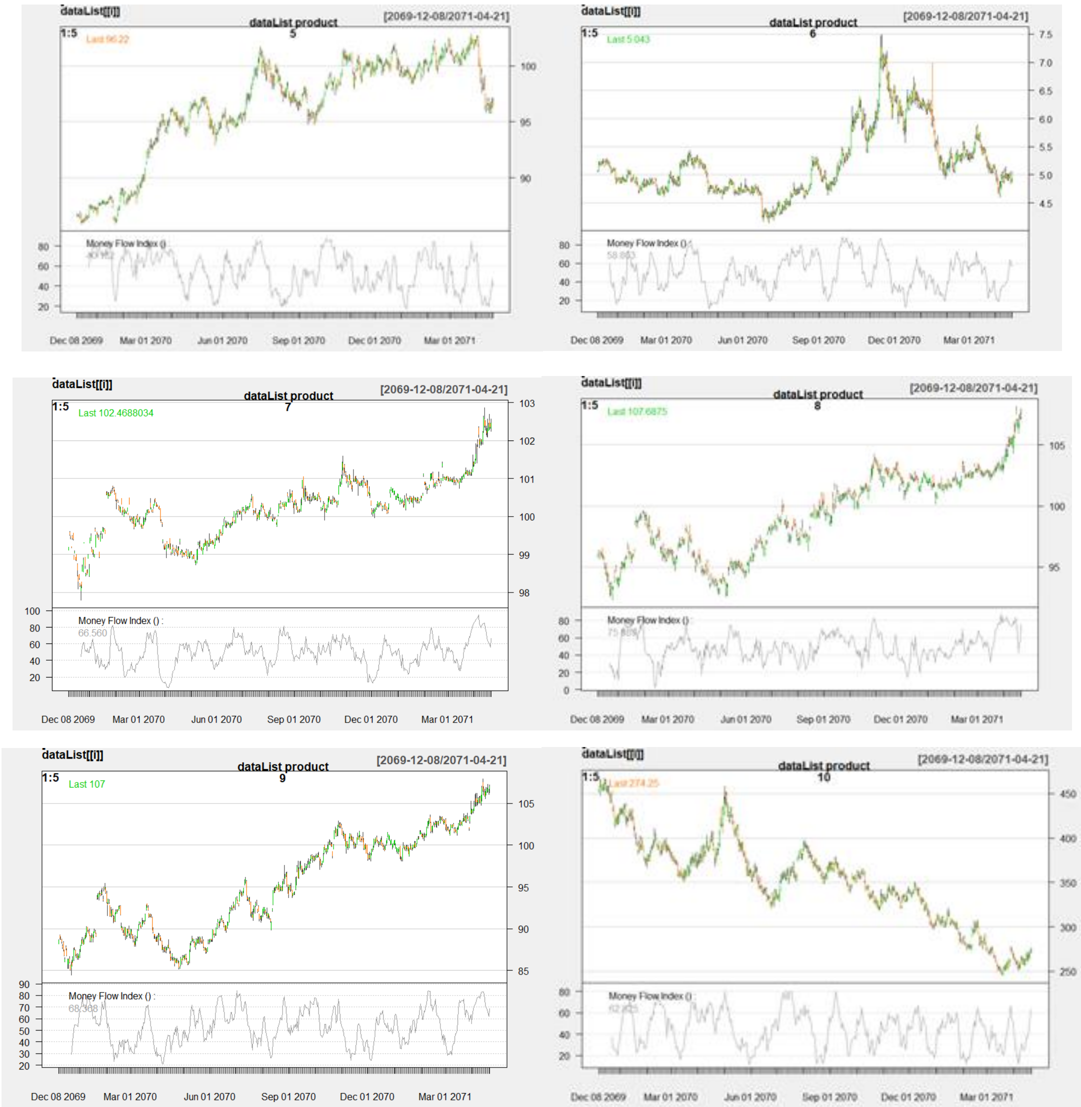


Graph C.12：CMF graph

HLC							
Chaikin Money Flow							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	0.290819	-0.449265	-0.065445	-0.068648	0.165979	0.027549
	0-250days	0.290819	-0.449265	-0.106867	-0.108892	0.171469	0.029402
	251-500days	0.274723	-0.405087	-0.029561	-0.043382	0.155376	0.024142
time series 02	0-500days	0.239329	-0.448762	-0.171545	-0.193686	0.142154	0.020208
	0-250days	0.352352	-0.379003	-0.051939	-0.07028	0.177079	0.031357
	251-500days	0.239329	-0.448762	-0.171545	-0.193686	0.142154	0.020208
time series 03	0-500days	0.797258	-0.896828	0.013936	-0.008863	0.197125	0.038858
	0-250days	0.464513	-0.896828	0.032167	0.018744	0.206815	0.042773
	251-500days	0.797258	-0.359374	-0.021343	-0.060746	0.180349	0.032526
time series 04	0-500days	0.319345	-0.505968	-0.120342	-0.150728	0.177499	0.031506
	0-250days	0.319345	-0.42497	-0.046457	-0.029061	0.18893	0.035694
	251-500days	0.162133	-0.505968	-0.194959	-0.209675	0.130948	0.017147
time series 05	0-500days	0.419459	-0.476551	-0.002024	0.007794	0.179517	0.032226
	0-250days	0.444669	-0.258342	0.070529	0.067721	0.148146	0.021947
	251-500days	0.419459	-0.476551	-0.002024	0.007794	0.179517	0.032226
time series 06	0-500days	0.34505	-0.487434	-0.006414	0.006388	0.171263	0.029331
	0-250days	0.34505	-0.348373	-0.040898	-0.060831	0.154869	0.023984
	251-500days	0.338245	-0.487434	0.021458	0.057932	0.18386	0.033804
time series 07	0-500days	0.52751	-0.521256	0.044472	0.055335	0.172933	0.029906
	0-250days	0.429917	-0.3162	0.002301	-0.006382	0.173732	0.030183
	251-500days	0.52751	-0.521256	0.081753	0.096926	0.168867	0.028516
time series 08	0-500days	0.644731	-0.447912	0.017766	0.003838	0.158276	0.025051
	0-250days	0.24492	-0.447912	-0.021709	-0.003401	0.13448	0.018085
	251-500days	0.644731	-0.232789	0.058303	0.017246	0.174004	0.030277
time series 09	0-500days	0.688019	-0.321276	0.073398	0.042556	0.181305	0.032871
	0-250days	0.299947	-0.271155	0.014339	0.01228	0.138339	0.019138
	251-500days	0.688019	-0.321276	0.073398	0.042556	0.181305	0.032871
time series 10	0-500days	0.275449	-0.540997	-0.153972	-0.153466	0.135155	0.018267
	0-250days	0.275449	-0.44034	-0.114881	-0.119194	0.147562	0.021775
	251-500days	0.022765	-0.540997	-0.198738	-0.180917	0.109347	0.011957

Figures C.12: CMF figures





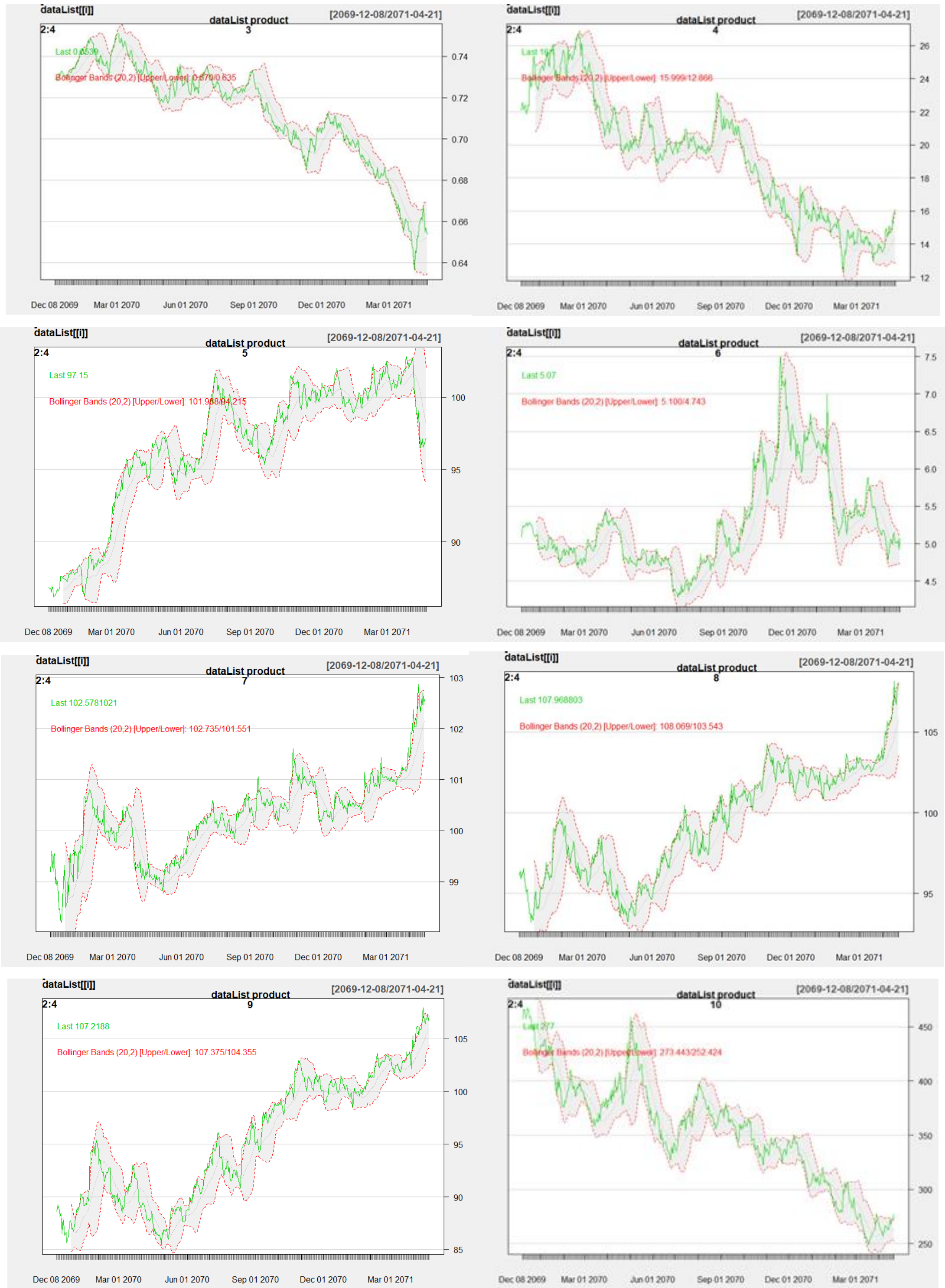
Graph C.13：MFI graph

HLC							
Money Flow Index							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	84.012318	6.906951	48.096486	48.760695	15.842462	250.983617
	0-250days	84.012318	6.906951	46.142918	46.481293	15.683823	245.982296
	251-500days	83.416123	8.891077	49.114643	50.147905	15.853422	251.330982
time series 02	0-500days	100	0	43.568408	43.681473	18.010299	324.370872
	0-250days	100	5.747526	47.002104	47.671839	19.017999	361.684303
	251-500days	75.991973	0	40.415983	39.813531	16.787848	281.831832
time series 03	0-500days	99.913855	3.768834	44.501558	44.889903	17.109908	292.748952
	0-250days	99.797144	3.768834	49.716237	50.056611	17.297358	299.198587
	251-500days	99.913855	6.190189	38.601848	38.837139	15.271014	233.203854
time series 04	0-500days	85.480452	12.771079	49.145905	49.241689	15.314112	234.522016
	0-250days	85.244176	12.771079	51.083822	54.204155	15.427171	237.997611
	251-500days	83.908849	18.640948	46.321023	46.408156	14.445778	208.680511
time series 05	0-500days	87.721944	16.952799	54.808535	57.043569	17.591111	309.447194
	0-250days	86.585902	19.447475	58.254028	62.799832	17.189069	295.464088
	251-500days	87.721944	16.952799	52.33607	53.074241	17.297201	299.193163
time series 06	0-500days	87.969	10.697652	49.032859	48.720299	17.94809	322.133942
	0-250days	85.484546	10.697652	47.758394	47.54176	17.351458	301.073094
	251-500days	87.969	12.47459	49.375508	48.720299	18.543226	343.851218
time series 07	0-500days	95.087949	7.056043	50.179931	51.034198	16.41214	269.358351
	0-250days	82.136634	7.056043	47.338479	49.305125	16.096773	259.106097
	251-500days	95.087949	12.737895	51.80645	52.079199	16.104123	259.342768
time series 08	0-500days	87.576088	2.216344	49.491809	47.93488	15.424577	237.917573
	0-250days	85.867418	2.216344	46.038214	45.750412	15.322786	234.787765
	251-500days	87.576088	13.680597	52.960435	52.728912	15.072153	227.169791
time series 09	0-500days	83.982193	21.124838	53.759793	54.241336	15.102659	228.090299
	0-250days	83.982193	21.124838	51.425004	51.341409	15.149572	229.509543
	251-500days	83.826682	24.244186	55.753018	55.628392	14.90458	222.146504
time series 10	0-500days	81.122503	11.580189	44.400131	46.074167	16.482126	271.660478
	0-250days	81.122503	11.931957	48.522408	49.777523	17.090826	292.096325
	251-500days	80.971896	11.580189	41.776214	43.877712	14.292136	204.265147

Figures C.13: MFI figures

Table C.5: Up/Down times of MFI in the beginning 1-500 days

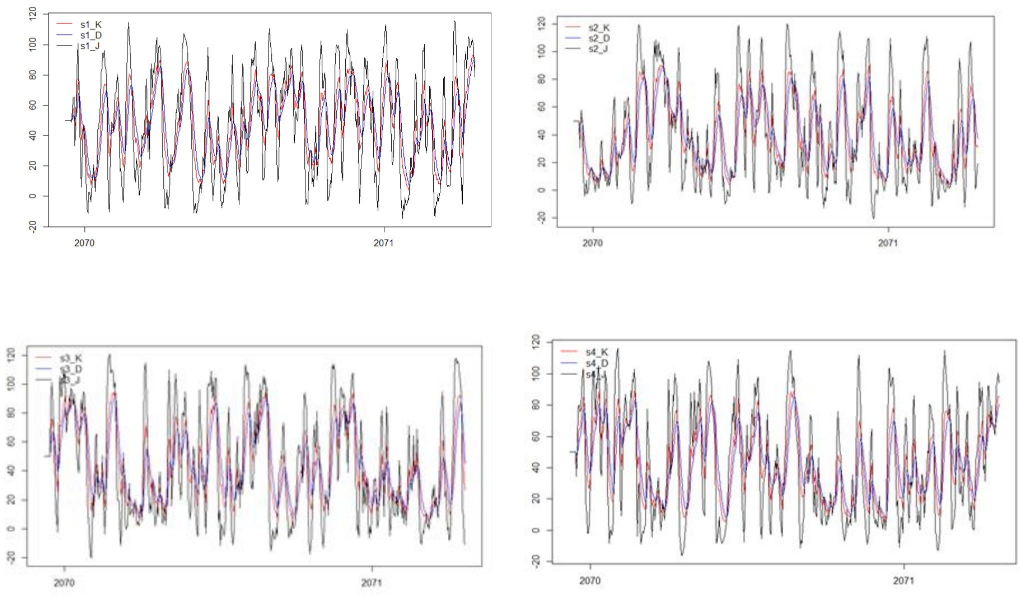
Times	MFI<50	MFI>80	MFI 50—80
1	253	4	229
2	311	14	161
3	293	12	181
4	251	8	227
5	186	32	268
6	250	19	217
7	227	17	242
8	266	10	210
9	202	12	272
10	291	4	191

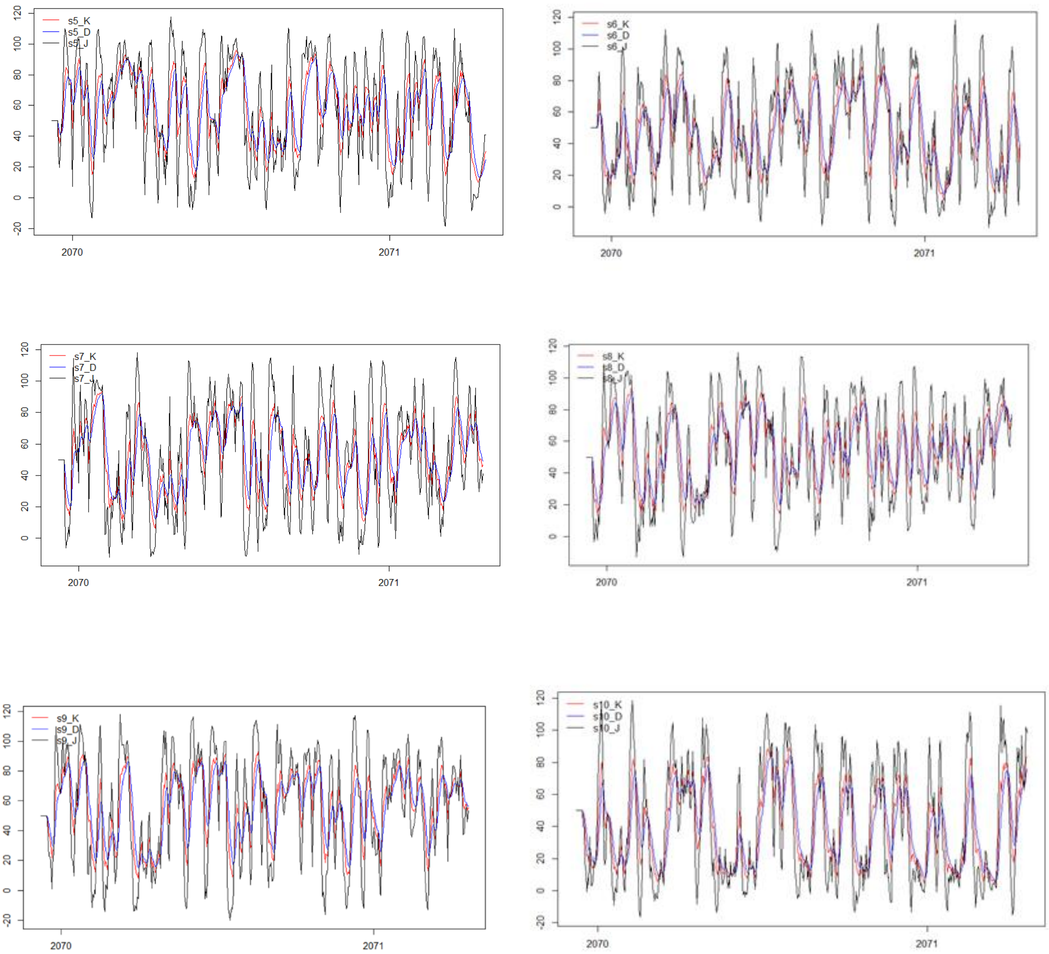


Graph C.14：BBands graph

B%							
Bollinger Bands							
time series	period	the highest data	the lowest data	mean	medium	standart deviation	variance
time series 01	0-500days	1.346801	-0.29494	0.520386	0.510336	0.340621	0.340621
	0-250days	1.346801	-0.29494	0.464973	0.398314	0.337484	0.113895
	251-500days	1.169977	-0.141812	0.549428	0.617942	0.337473	0.113888
time series 02	0-500days	1.286224	-0.457566	0.410442	0.355887	0.330437	0.109189
	0-250days	1.286224	-0.457566	0.429091	0.369366	0.340973	0.116262
	251-500days	1.159294	-0.114506	0.385675	0.352556	0.305296	0.093206
time series 03	0-500days	1.1629	-0.253462	0.403503	0.318494	0.341207	0.116422
	0-250days	1.1629	-0.124893	0.48368	0.447682	0.341297	0.116484
	251-500days	1.044128	-0.253462	0.28583	0.209801	0.291378	0.084901
time series 04	0-500days	1.327299	-0.260663	0.44297	0.408062	0.328141	0.107676
	0-250days	1.292332	-0.152366	0.482681	0.458897	0.317479	0.100793
	251-500days	1.201817	-0.260663	0.363178	0.335919	0.300911	0.090548
time series 05	0-500days	1.311123	-0.360912	0.578822	0.64175	0.330283	0.109087
	0-250days	1.273671	-0.360912	0.630668	0.711221	0.326754	0.106768
	251-500days	1.311123	-0.213368	0.555824	0.574802	0.326396	0.106534
time series 06	0-500days	1.374196	-0.45824	0.494535	0.470922	0.345057	0.119064
	0-250days	1.221182	-0.45824	0.470032	0.454485	0.343079	0.117703
	251-500days	1.265049	-0.284496	0.49255	0.465574	0.339193	0.115052
time series 07	0-500days	1.542856	-0.330913	0.575882	0.586803	0.328987	0.108233
	0-250days	1.320414	-0.330913	0.559095	0.638133	0.336915	0.113512
	251-500days	1.542856	-0.328323	0.578035	0.561075	0.325647	0.106046
time series 08	0-500days	1.301789	-0.191969	0.580042	0.615069	0.31924	0.101914
	0-250days	1.251329	-0.141545	0.537496	0.528816	0.339381	0.115179
	251-500days	1.301789	-0.191969	0.601194	0.627836	0.295526	0.087336
time series 09	0-500days	1.460383	-0.150643	0.597199	0.664627	0.325378	0.105871
	0-250days	1.460383	-0.043537	0.549479	0.554921	0.3493	0.122011
	251-500days	1.196487	-0.150643	0.631998	0.71793	0.2999	0.08994
time series 10	0-500days	1.285094	-0.172261	0.42409	0.386517	0.332732	0.110711
	0-250days	1.285094	-0.172261	0.460362	0.40219	0.354432	0.125622
	251-500days	1.19807	-0.117873	0.40043	0.351249	0.311226	0.096861

Figures C.14: BBands figures





Graph C.15：KDJ graph

Appendix D

Table D.1: Dickey-Fuller Test of RSI

series	tau1 statistic	tau1 95% critical value	stationary
1	-0.8346541	-1.95	stationary
2	-0.9467928	-1.95	stationary
3	-1.210595	-1.95	stationary
4	-1.069005	-1.95	stationary
5	-1.098799	-1.95	stationary
6	-1.010973	-1.95	stationary
7	-0.6065455	-1.95	stationary
8	-0.3626032	-1.95	stationary
9	-0.7760943	-1.95	stationary
10	-0.7856672	-1.95	stationary

Table D.2: Dickey-Fuller Test of SMI

series	tau1 statistic	tau1 95% critical value	stationary
1	-5.616651	-1.95	non-stationary
2	-4.891298	-1.95	non-stationary
3	-4.665977	-1.95	non-stationary
4	-5.038486	-1.95	non-stationary
5	-5.059755	-1.95	non-stationary
6	-5.348861	-1.95	non-stationary
7	-4.860597	-1.95	non-stationary
8	-5.222044	-1.95	non-stationary
9	-5.235759	-1.95	non-stationary
10	-5.063762	-1.95	non-stationary

Table D.3: Dickey-Fuller Test of OBV

series	tau1 statistic	tau1 95% critical value	stationary
1	-1.063469	-1.95	stationary
2	-0.4817806	-1.95	stationary
3	1.449609	-1.95	stationary
4	-0.5133212	-1.95	stationary
5	0.5576344	-1.95	stationary
6	-0.6468439	-1.95	stationary
7	-1.968156	-1.95	non-stationary
8	-1.309318	-1.95	stationary
9	0.754348	-1.95	stationary
10	-0.3046065	-1.95	stationary

Table D.4: Dickey-Fuller Test of MACD

series	tau1 statistic	tau1 95% critical value	stationary
1	-3.413449	-1.95	non-stationary
2	-3.293864	-1.95	non-stationary
3	-3.58127	-1.95	non-stationary
4	-3.868722	-1.95	non-stationary
5	-3.291692	-1.95	non-stationary
6	-3.679439	-1.95	non-stationary
7	-2.768136	-1.95	non-stationary
8	-3.213734	-1.95	non-stationary
9	-3.645938	-1.95	non-stationary
10	-3.594306	-1.95	non-stationary

Table D.5: Dickey-Fuller Test of ATR

series	tau1 statistic	tau1 95% critical value	stationary
1	-0.2099946	-1.95	stationary
2	-1.718366	-1.95	stationary
3	0.08505053	-1.95	stationary
4	-1.056743	-1.95	stationary
5	-0.1209102	-1.95	stationary
6	-0.7025465	-1.95	stationary
7	-1.410355	-1.95	stationary
8	-0.4552171	-1.95	stationary
9	-0.9588831	-1.95	stationary
10	-1.021279	-1.95	stationary

Table D.6: Dickey-Fuller Test of TR

series	tau1 statistic	tau1 95% critical value	stationary
1	-6.904579	-1.95	non-stationary
2	-9.259689	-1.95	non-stationary
3	-7.729136	-1.95	non-stationary
4	-7.342634	-1.95	non-stationary
5	-6.366633	-1.95	non-stationary
6	-7.771892	-1.95	non-stationary
7	-8.763373	-1.95	non-stationary
8	-7.554388	-1.95	non-stationary
9	-8.408749	-1.95	non-stationary
10	-7.82363	-1.95	non-stationary

Table D.7: Dickey-Fuller Test of ADX

series	tau1 statistic	tau1 95% critical value	stationary
1	-1.573687	-1.95	stationary
2	-2.331366	-1.95	non-stationary
3	-1.403337	-1.95	stationary
4	-1.59778	-1.95	stationary
5	-1.09641	-1.95	stationary
6	-1.827408	-1.95	stationary
7	-0.06967325	-1.95	stationary
8	-0.4263232	-1.95	stationary
9	-0.547444	-1.95	stationary
10	-1.36128	-1.95	stationary

Table D.8: Dickey-Fuller Test of MFI

series	tau1 statistic	tau1 95% critical value	stationary
1	-1.558745	-1.95	stationary
2	-1.405721	-1.95	stationary
3	-1.938031	-1.95	stationary
4	-1.031745	-1.95	Stationary
5	-1.572803	-1.95	stationary
6	-1.44776	-1.95	stationary
7	-1.187686	-1.95	stationary
8	-1.01485	-1.95	stationary
9	-0.9324695	-1.95	stationary
10	-1.471979	-1.95	stationary

Table D.9: Dickey-Fuller Test of Aroon

series	tau1 statistic	tau1 95% critical value	stationary
1	-4.046609	-1.95	non-stationary
2	-3.682566	-1.95	non-stationary
3	-3.179995	-1.95	non-stationary
4	-4.20912	-1.95	non-stationary
5	-4.059053	-1.95	non-stationary
6	-4.424858	-1.95	non-stationary
7	-4.380719	-1.95	non-stationary
8	-4.523486	-1.95	non-stationary
9	-3.944631	-1.95	non-stationary
10	-4.120582	-1.95	non-stationary

Table D.10: Dickey-Fuller Test of BBands

series	tau1 statistic	tau1 95% critical value	stationary
1	-0.1231814	-1.95	stationary
2	-0.7768517	-1.95	stationary
3	-1.142671	-1.95	stationary
4	-1.102971	-1.95	stationary
5	-0.07341521	-1.95	stationary
6	-0.4314873	-1.95	stationary
7	1.450815	-1.95	stationary
8	1.424895	-1.95	stationary
9	1.345562	-1.95	stationary
10	-0.9321105	-1.95	stationary

Table D.11: Ljung-Box test of SMI

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

Table D.12: Ljung-Box test of ADX

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white nois	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

Table D.13: Ljung-Box test of RSI

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-1
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

Table D.14: Ljung-Box test of OBV

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

Table D.15: Ljung-Box test of MACD

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

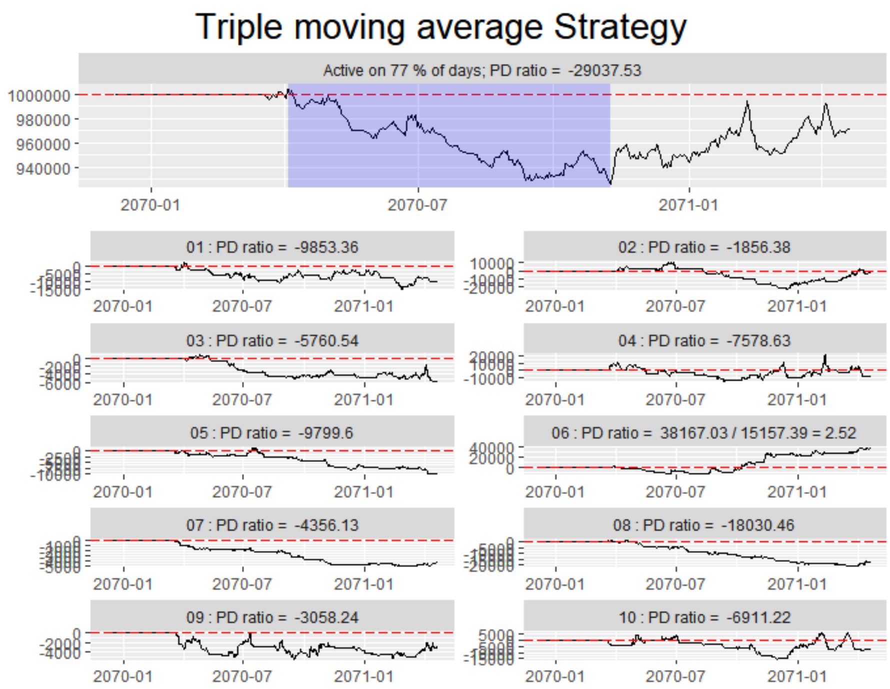
Table D.16: Ljung-Box test of Aroon

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-1
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

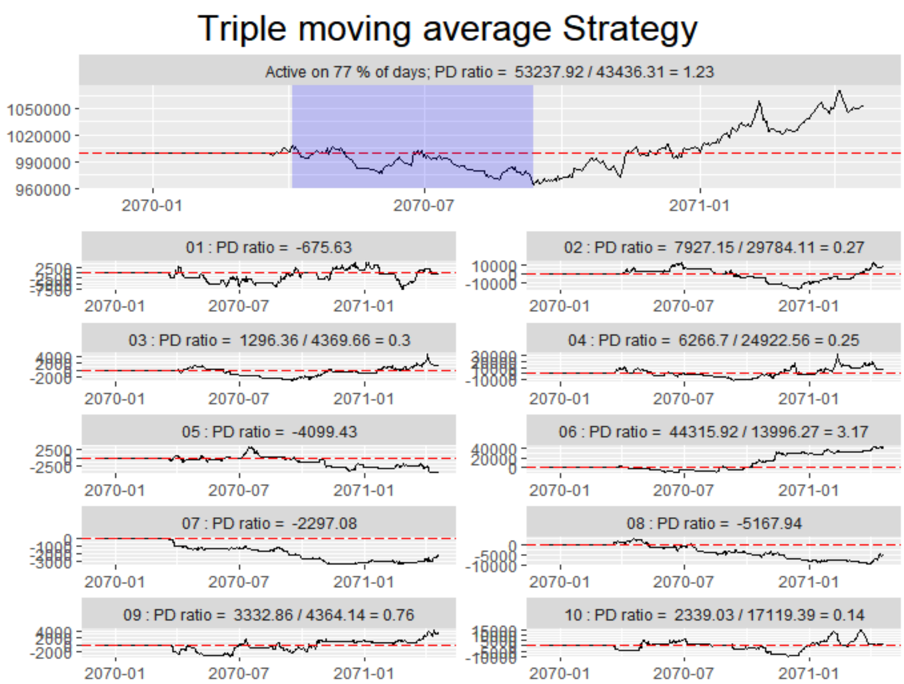
Table D.17: Ljung-Box test of BBands

series	OP auto-correlation(p-value)	p-value
1	non-white noise	< 2.2e-16
2	non-white noise	< 2.2e-16
3	non-white noise	< 2.2e-16
4	non-white noise	< 2.2e-16
5	non-white noise	< 2.2e-16
6	non-white noise	< 2.2e-16
7	non-white noise	< 2.2e-16
8	non-white noise	< 2.2e-16
9	non-white noise	< 2.2e-16
10	non-white noise	< 2.2e-16

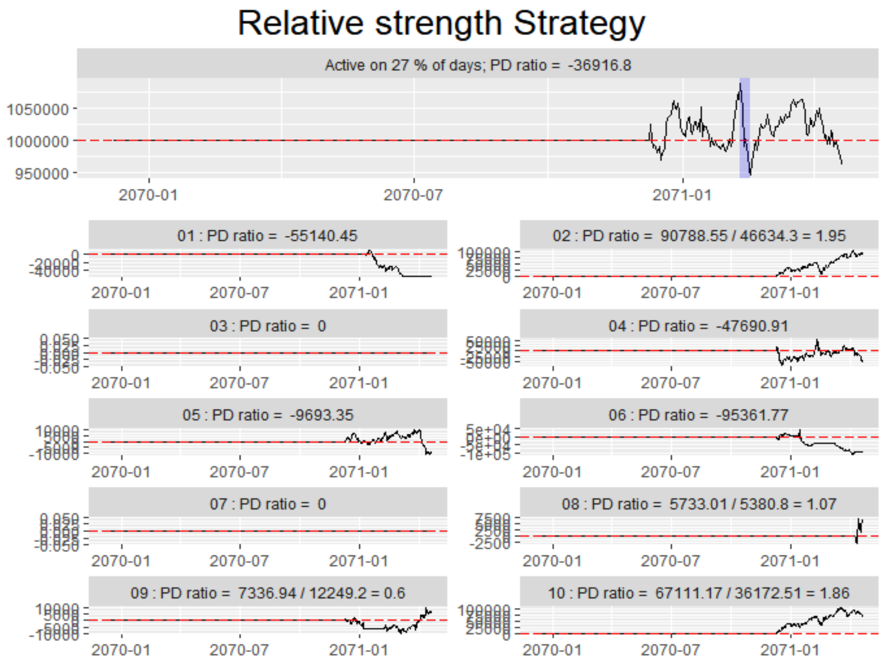
Appendix E



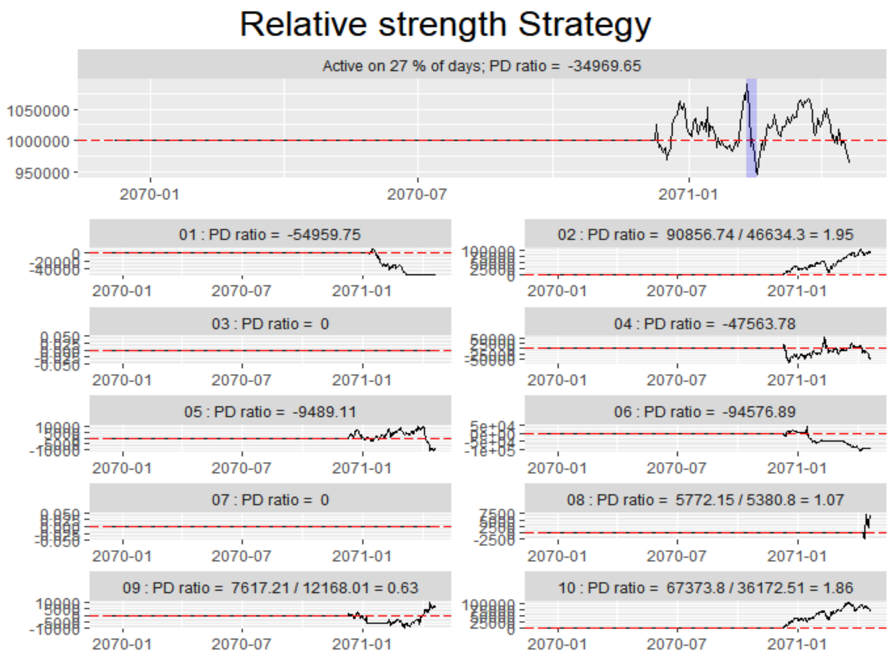
Graph E.1: Triple Moving Average Strategy (day 1-500 with 0.2 slippage and $100,000 wager per time per series)



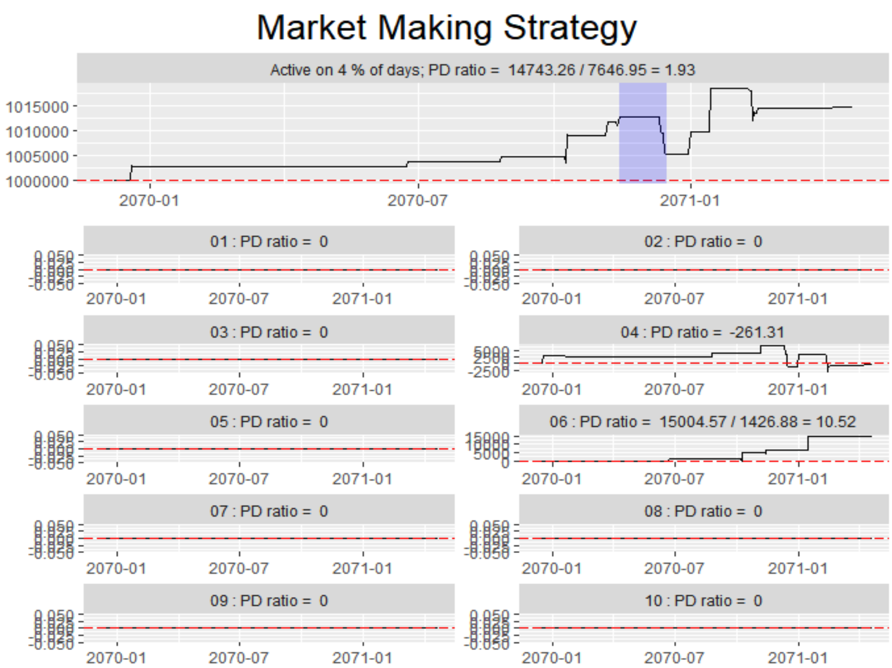
Graph E.2: Triple Moving Average Strategy (day 1-500 without slippage and $100,000 wager per time per series)



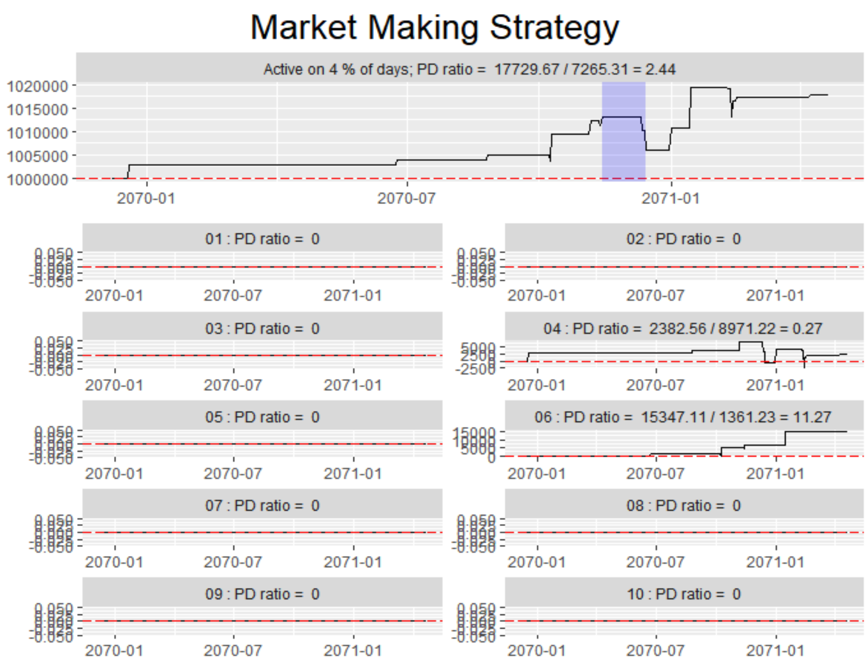
Graph E.3: Relative Strength Strategy (day 1-500 with 0.2 slippage and $100,000 wager per time per series)



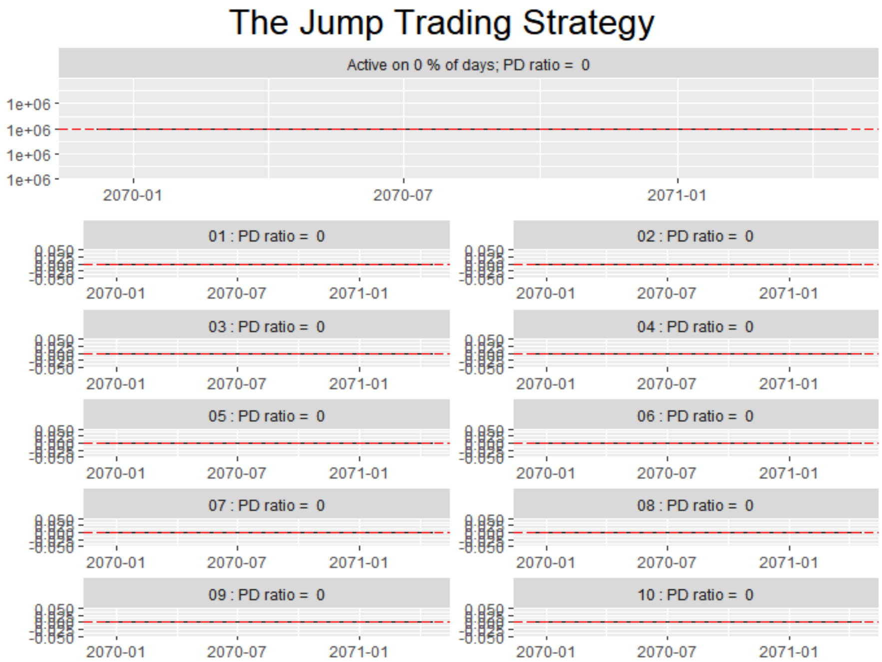
Graph E.4: Relative Strength Strategy (day 1-500 without 0.2 slippage and $100,000 wager per time per series)



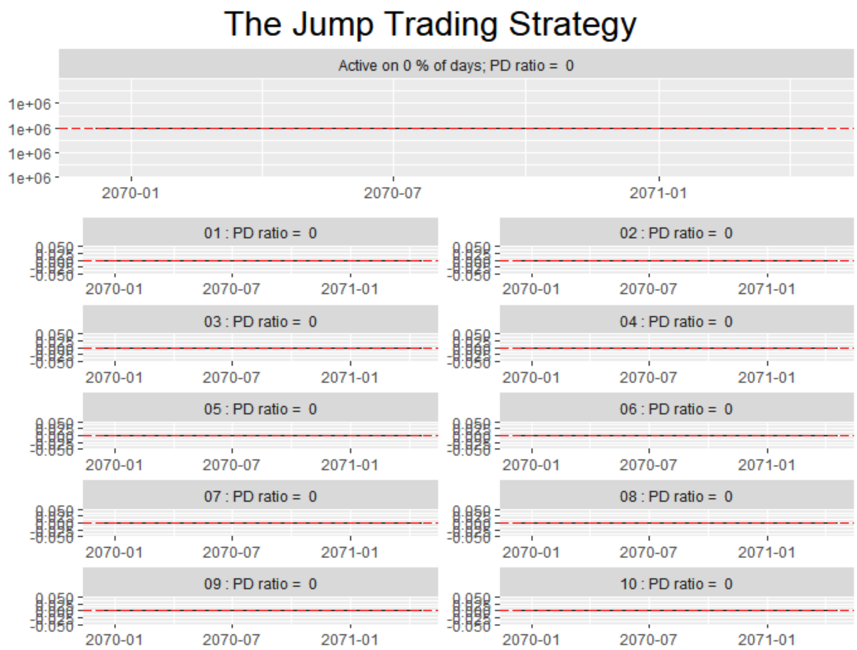
Graph E.5: Market Making Strategy (day 1-500 with 0.2 slippage and $100,000 wager per time per series)



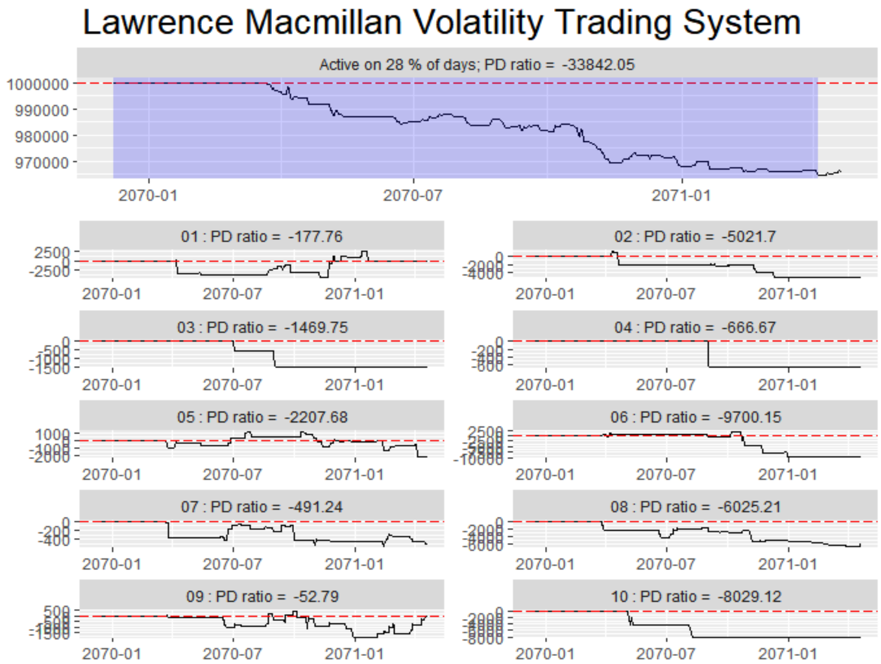
Graph E.6: Market Making Strategy (day 1-500 without 0.2 slippage and $100,000 wager per time per series)



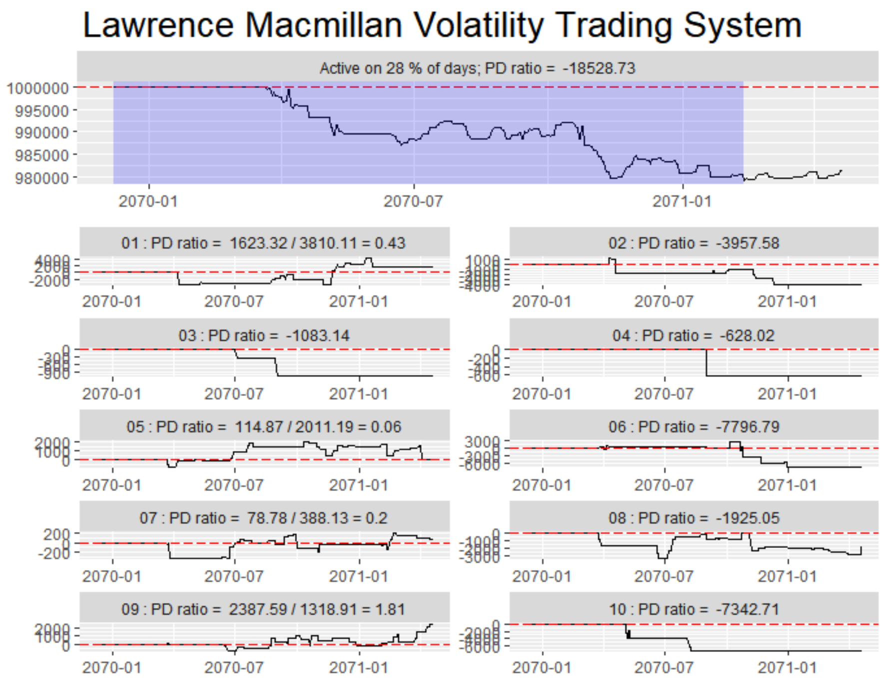
Graph E.7: The Jump Trading Strategy (day 1-500 with 0.2 slippage and $100,000 wager per time per series)



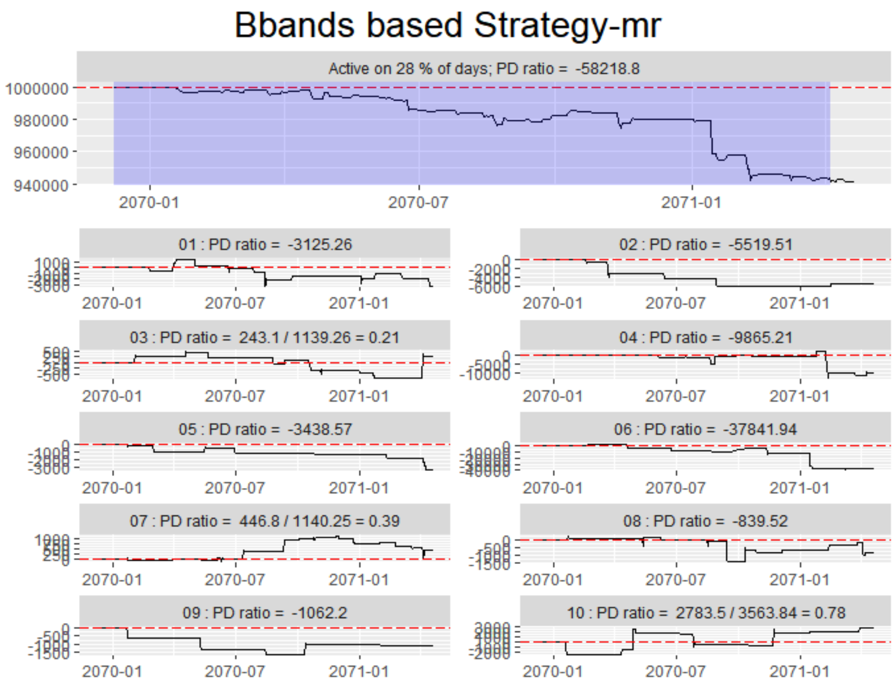
Graph E.8: The Jump Trading Strategy (day 1-500 without 0.2 slippage and $100,000 wager per time per series)



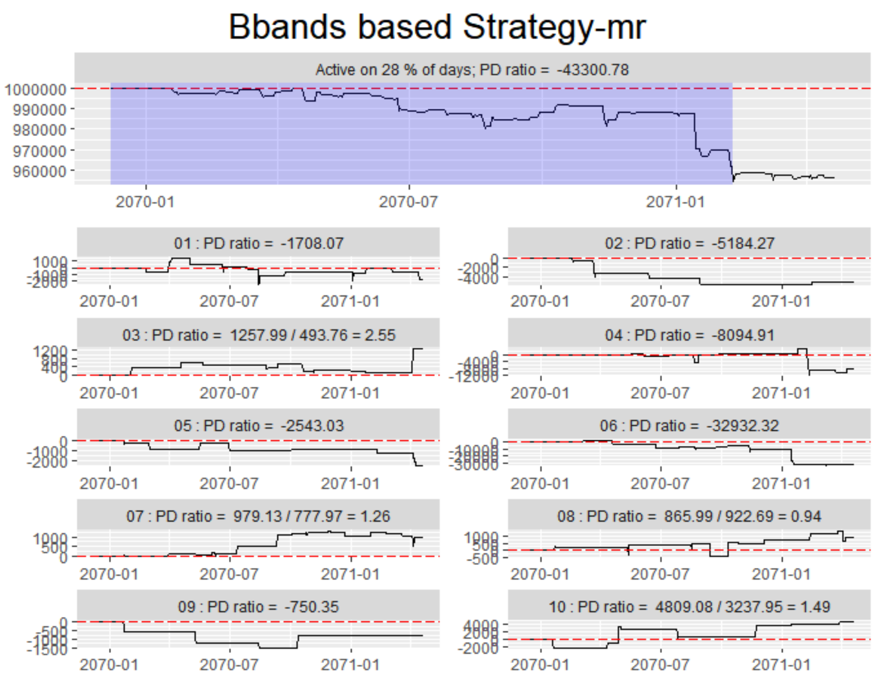
Graph E.9: Lawrence Macmillan Volatility Trading System (day 1-500 with 0.2 slippage and $100,000 wager per time per series)



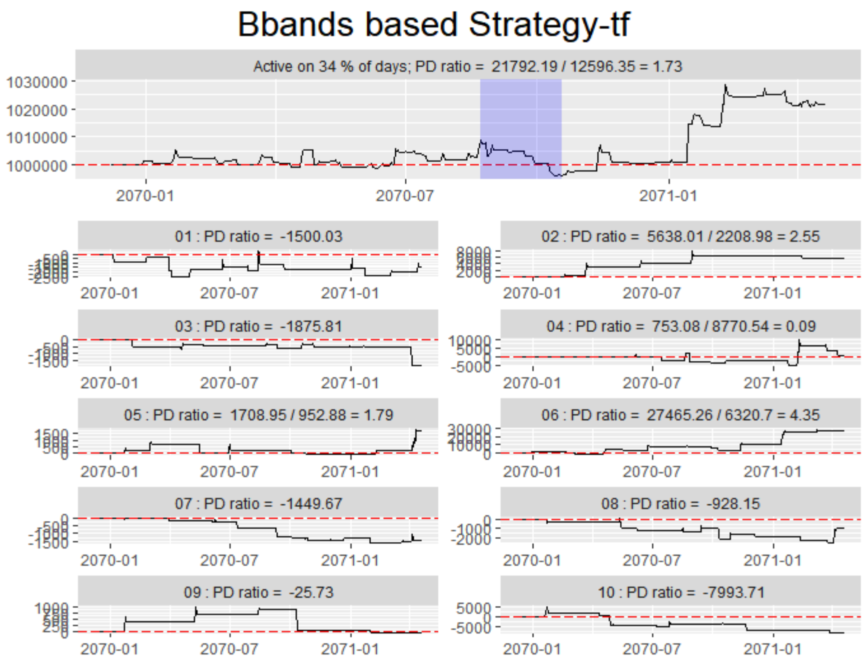
Graph E.10: Lawrence Macmillan Volatility Trading System (day 1-500 without 0.2 slippage and $100,000 wager per time per series)



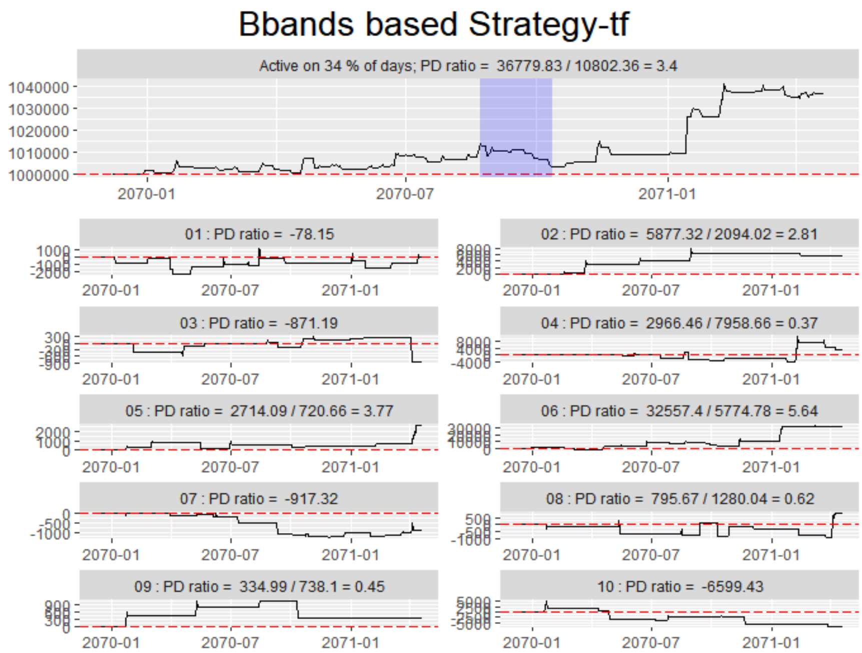
Graph E.11: BBands based Strategy (Mean-reversion) (day 1-500 with 0.2 slippage and $100,000 wager per time per series)



Graph E.12: BBands based Strategy (Mean-reversion) (day 1-500 without 0.2 slippage and $100,000 wager per time per series)

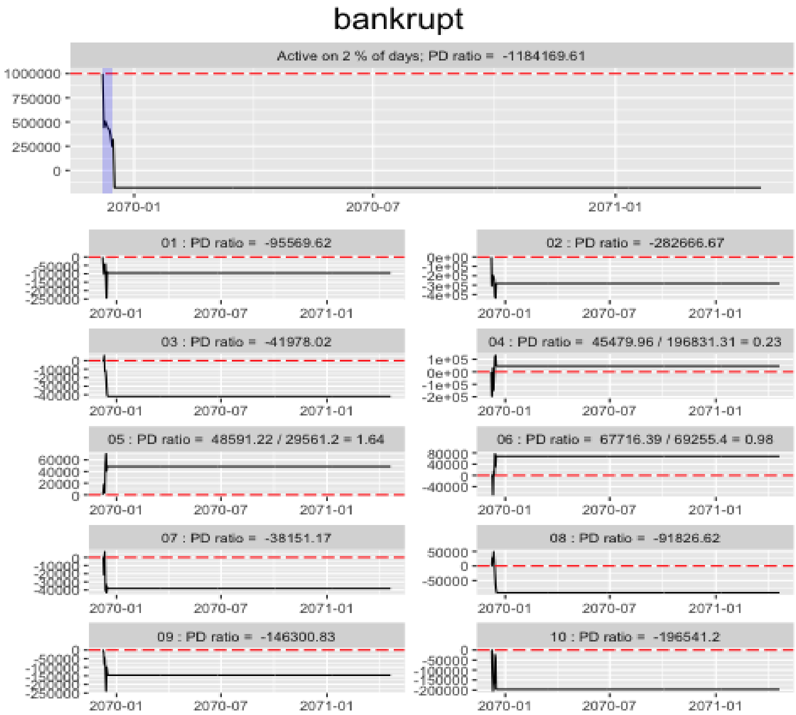


Graph E.13: BBands based Strategy (Trend-following) (day 1-500 with 0.2 slippage and $100,000 wager per time per series)

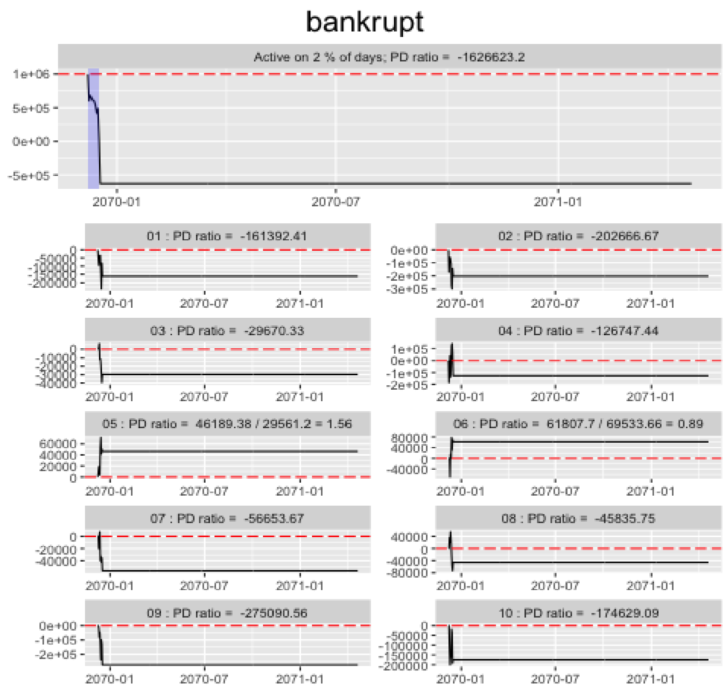


Graph E.14: BBands based Strategy (Trend-following) (day 1-500 without 0.2 slippage and $100,000 wager per time per series)

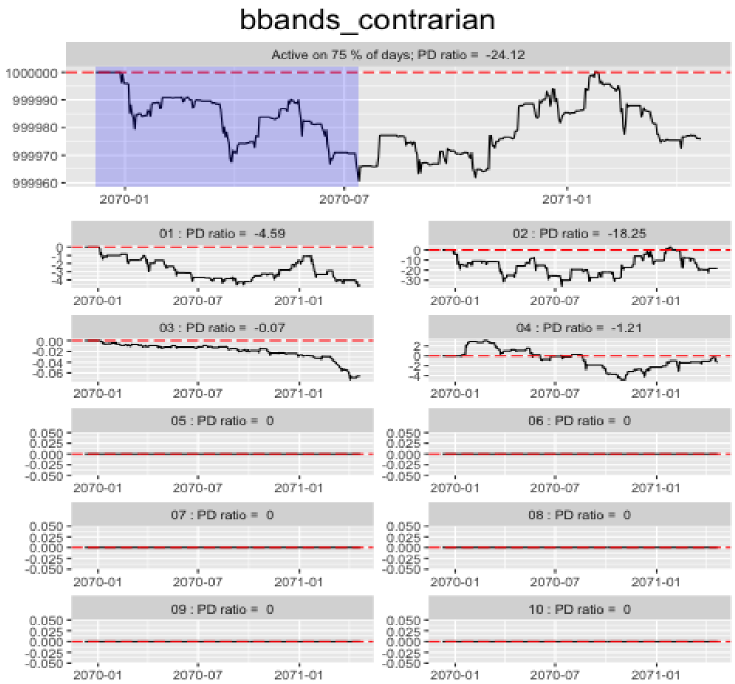
Appendix F



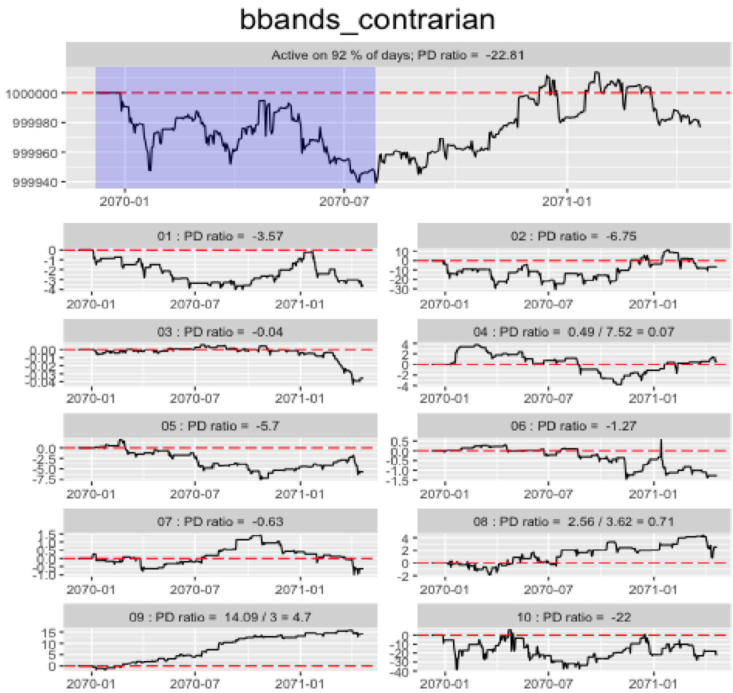
Graph F.1: Bankrupt (day 1-500 with 0.2 slippage and 1-unit fixed wager)



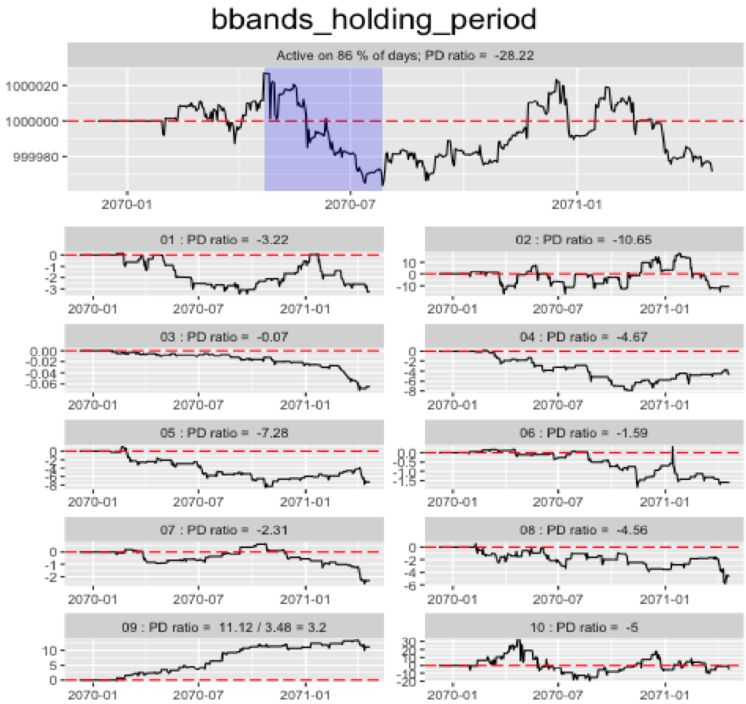
Graph F.2: Bankrupt(day 1-500 without 0.2 slippage and 1-unit fixed wager)



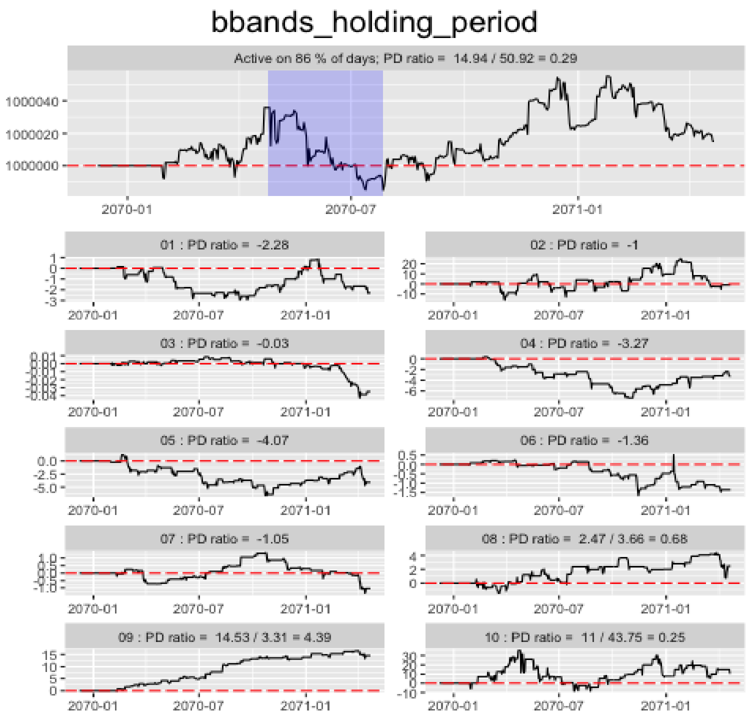
Graph F.3: BBands contrarian (day 1-500 with 0.2 slippage and 1-unit fixed wager)



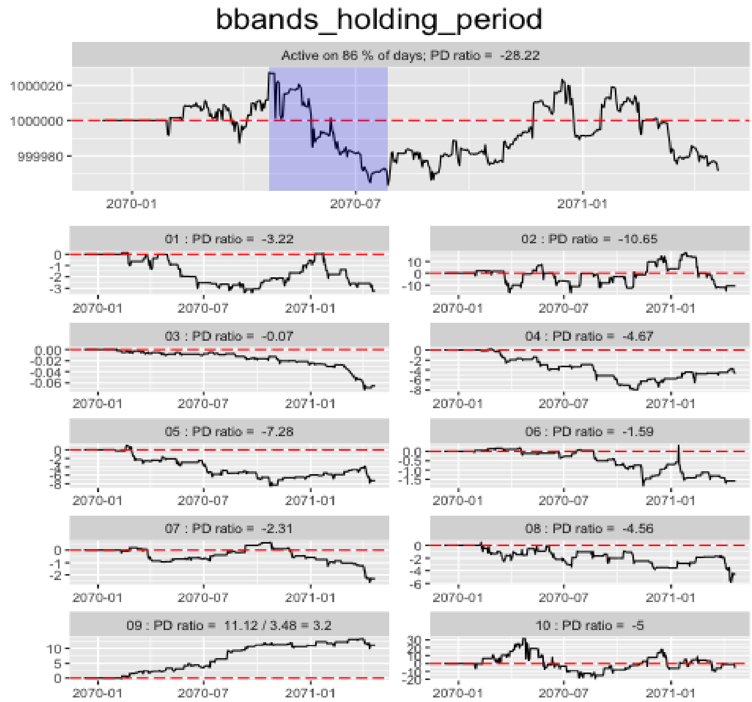
Graph F.4: BBands contrarian (day 1-500 without 0.2 slippage and 1-unit fixed wager)



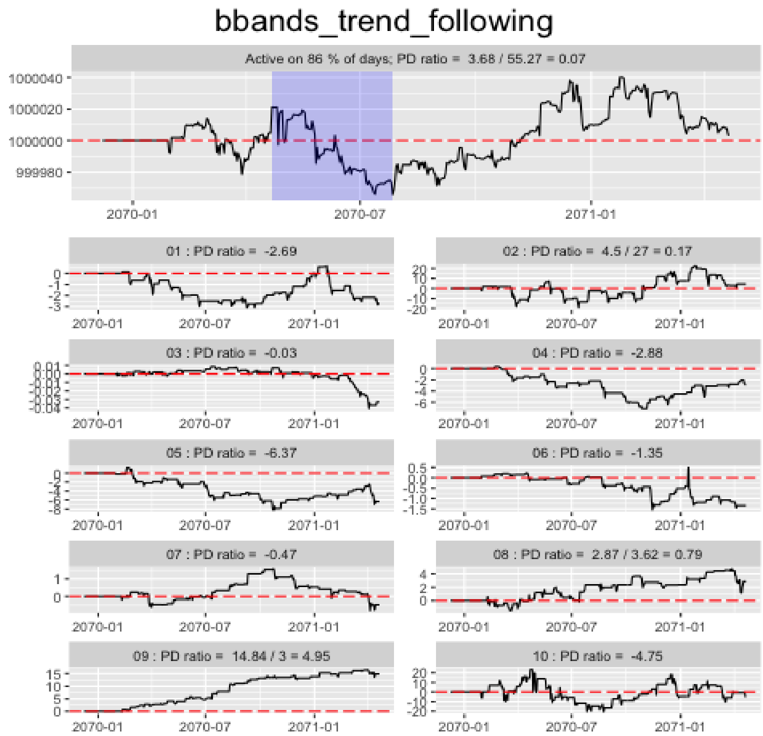
Graph F.5: BBands holding period (day 1-500 with 0.2 slippage and 1-unit fixed wager)



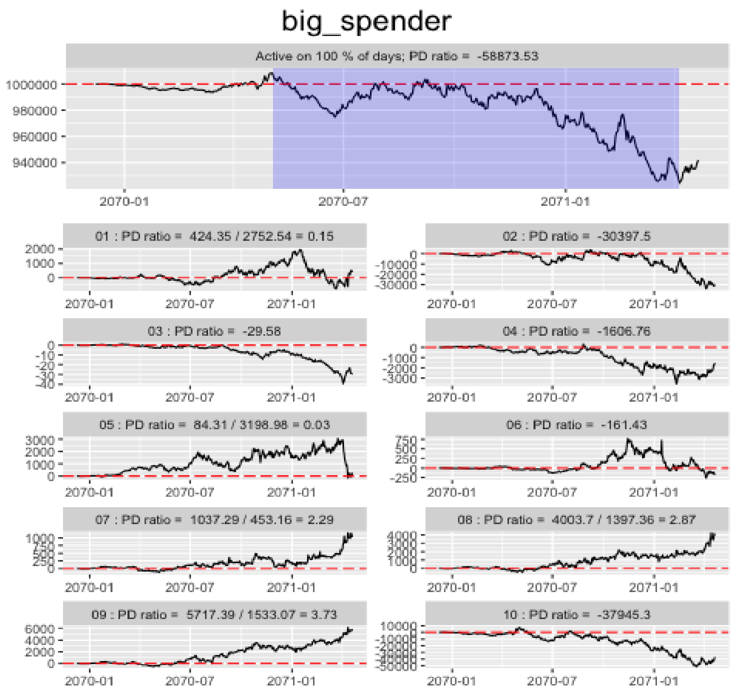
Graph F.6: BBands holding period (day 1-500 without 0.2 slippage and 1-unit fixed wager)



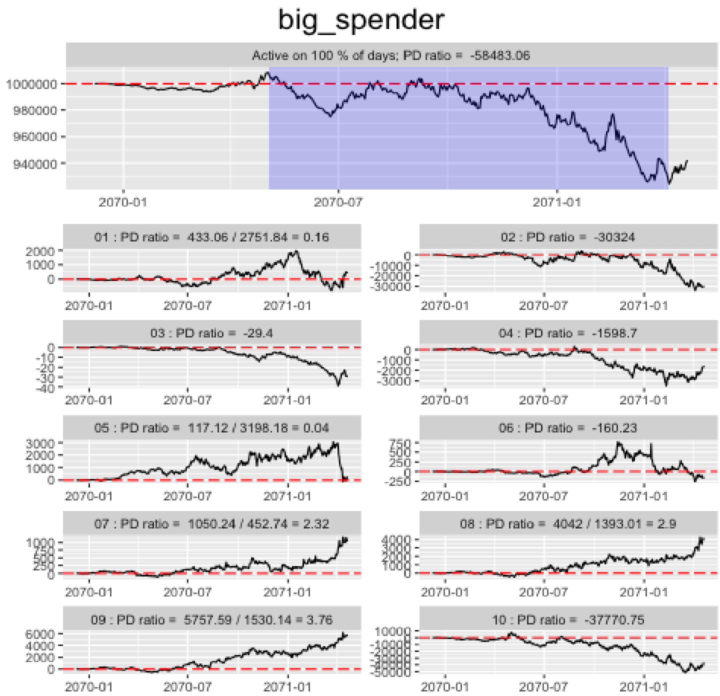
Graph F.7: BBands trend following (day 1-500 with 0.2 slippage and 1-unit fixed wager)



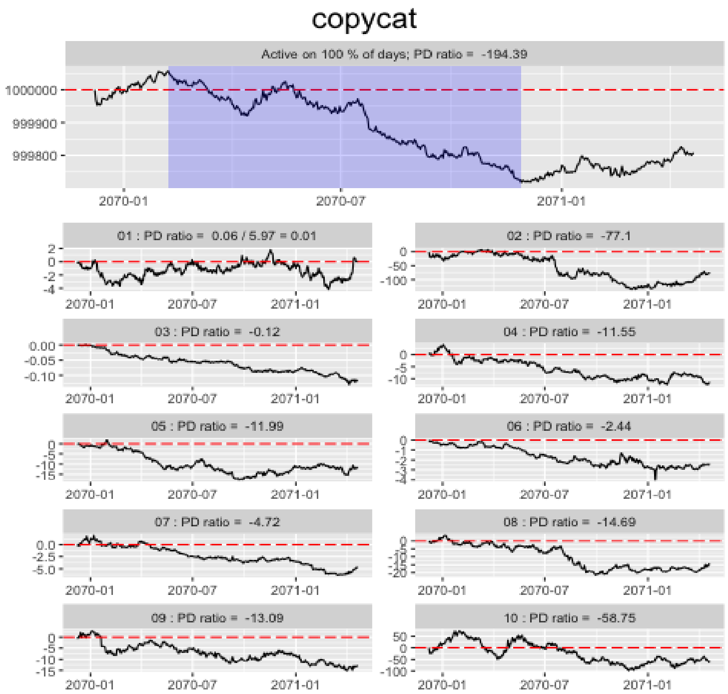
Graph F.8: BBands trend following (day 1-500 without 0.2 slippage and 1-unit fixed wager)



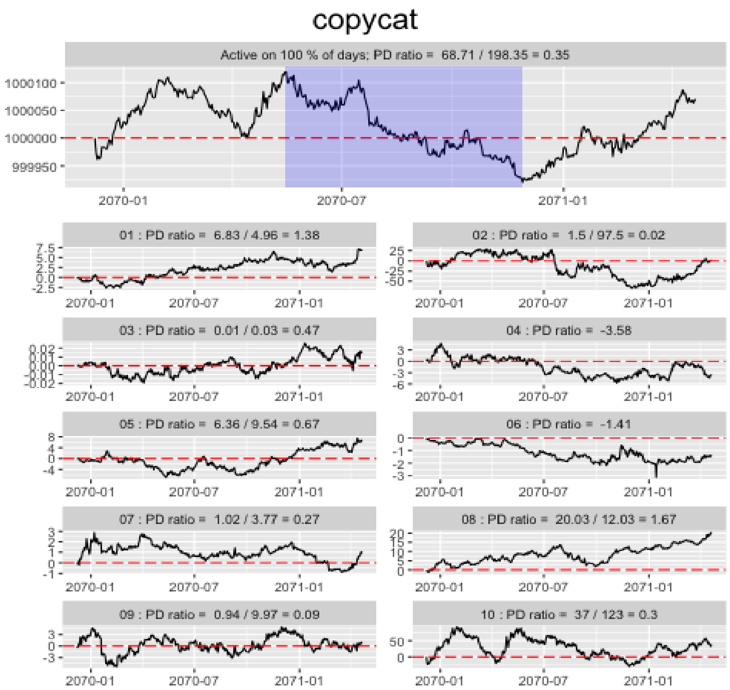
Graph F.9: Big spender (day 1-500 with 0.2 slippage and 1-unit fixed wager)



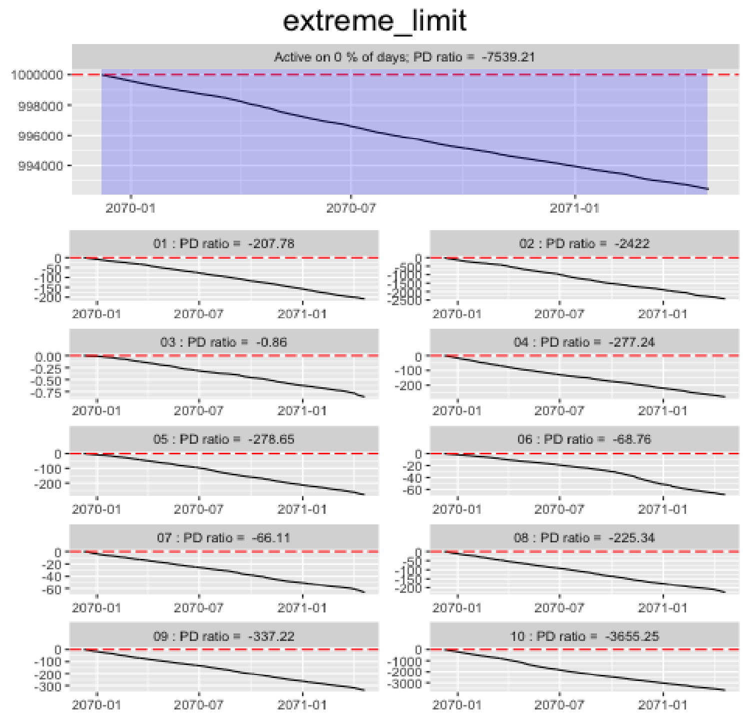
Graph F.10: Big spender (day 1-500 without 0.2 slippage and 1-unit fixed wager)



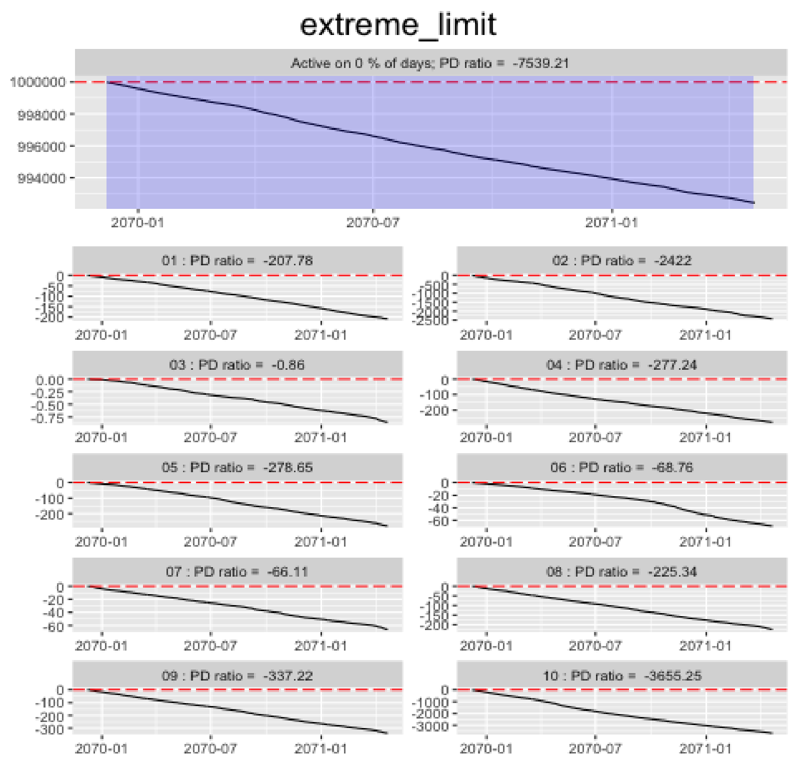
Graph F.11: Copycat (day 1-500 with 0.2 slippage and 1-unit fixed wager)



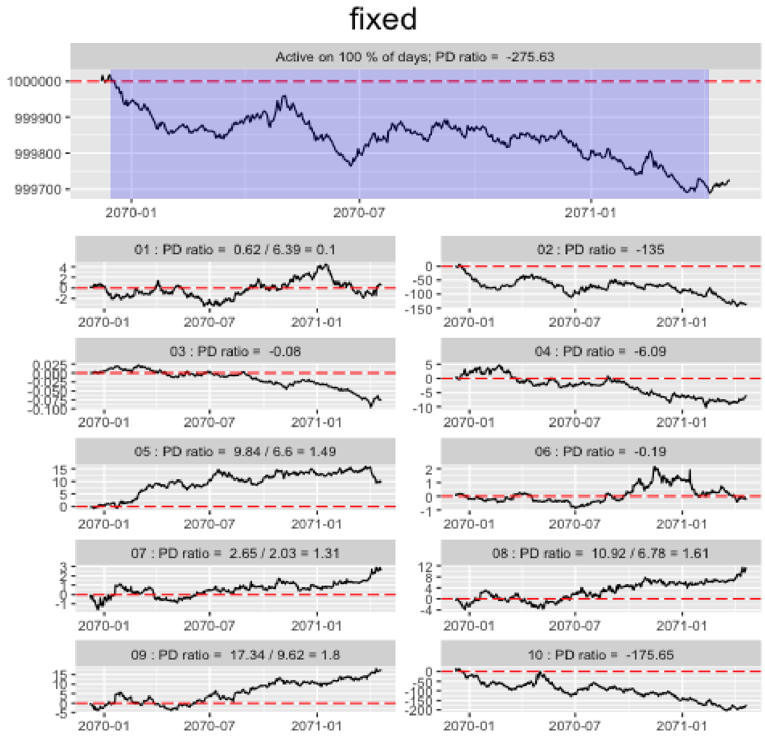
Graph F.12: Copycat (day 1-500 without 0.2 slippage and 1-unit fixed wager)



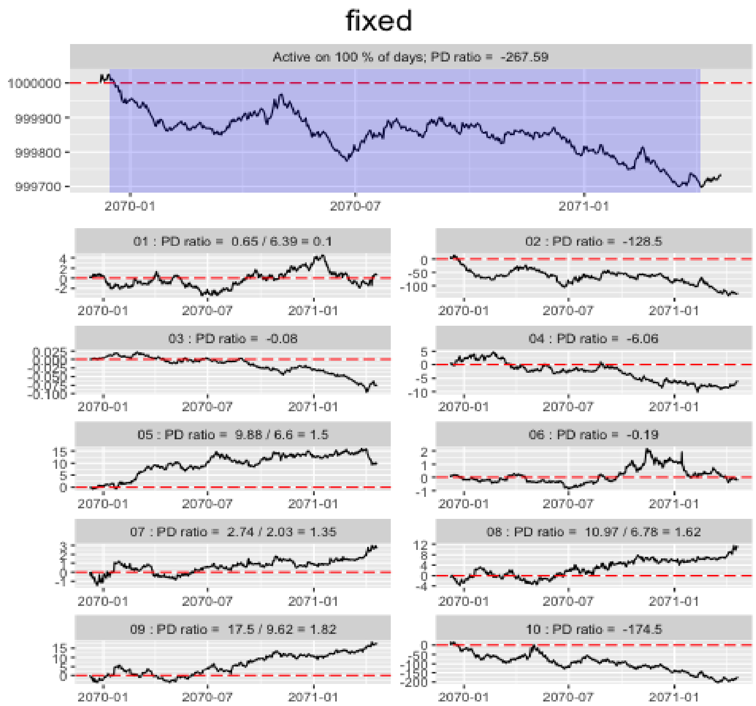
Graph F.13: Fxtreme limit (day 1-500 with 0.2 slippage and 1-unit fixed wager)



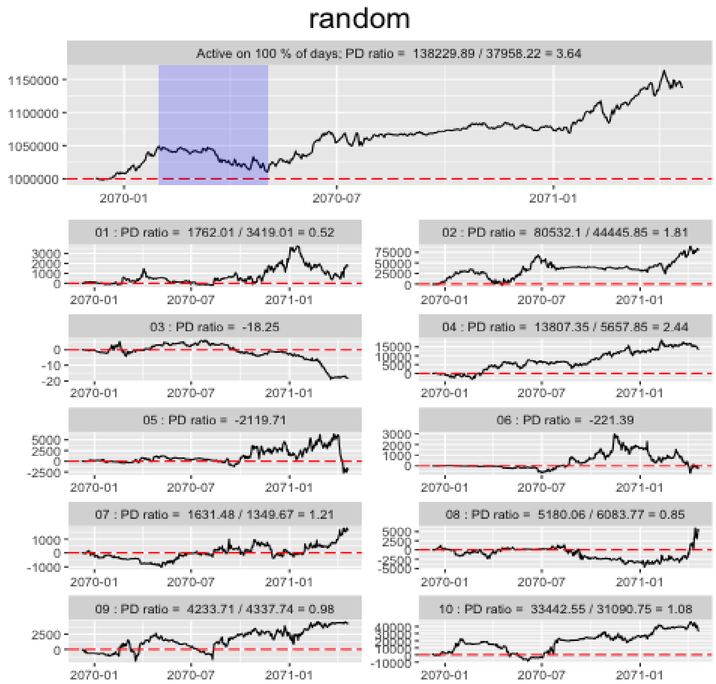
Graph F.14: Fxtreme limit (day 1-500 without 0.2 slippage and 1-unit fixed wager)



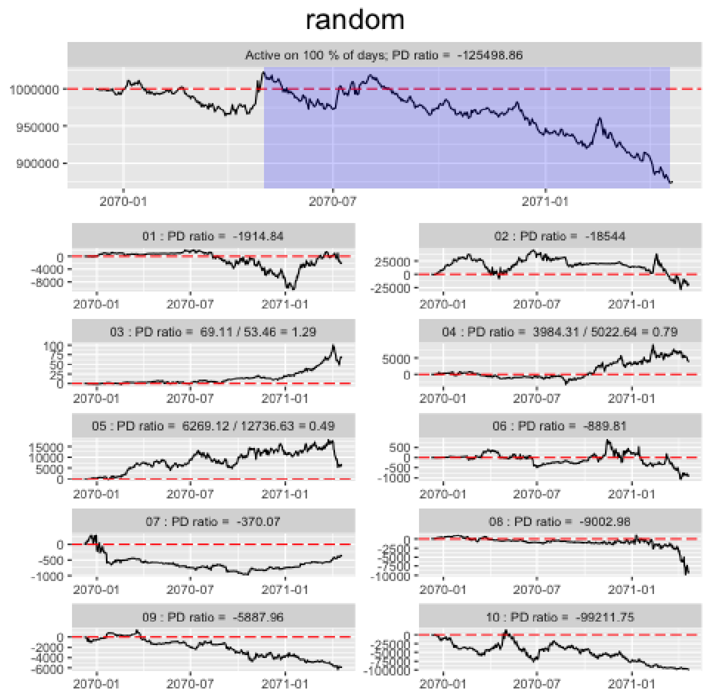
Graph F.15: Fixed (buy & hold) (day 1-500 with 0.2 slippage and 1-unit fixed wager)



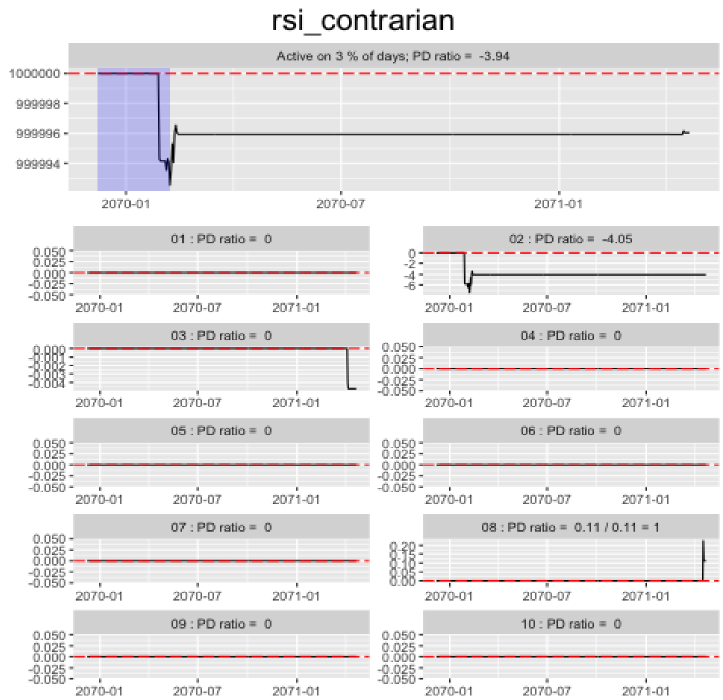
Graph F.16: Fixed (buy & hold) (day 1-500 without 0.2 slippage and 1-unit fixed wager)



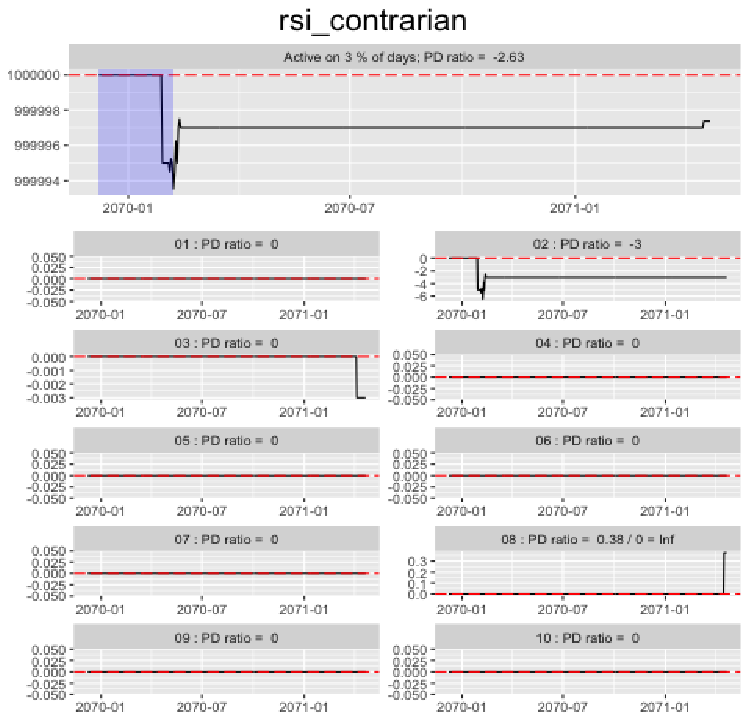
Graph F.17: Random (day 1-500 with 0.2 slippage and 1-unit fixed wager)



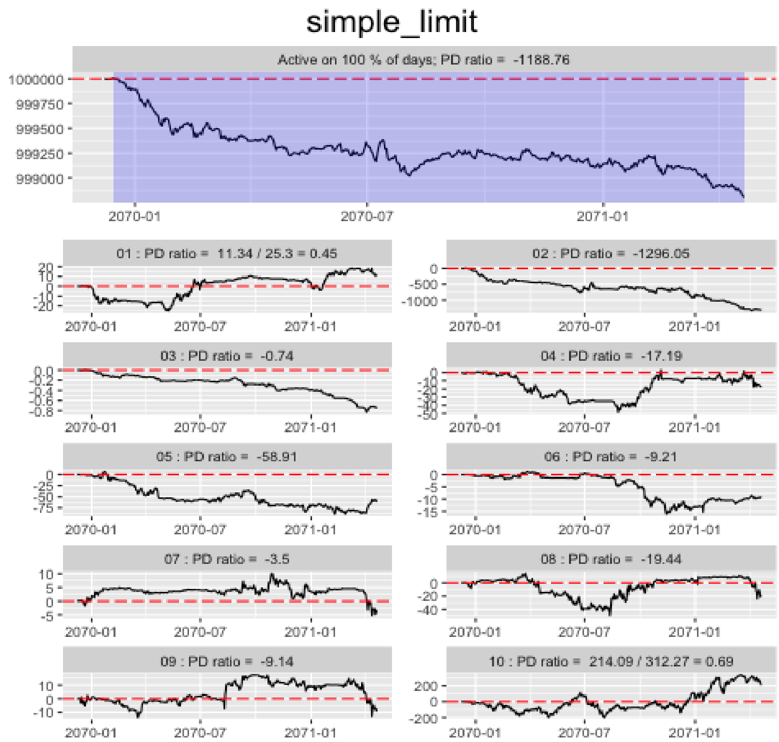
Graph F.18: Random (day 1-500 without 0.2 slippage and 1-unit fixed wager)



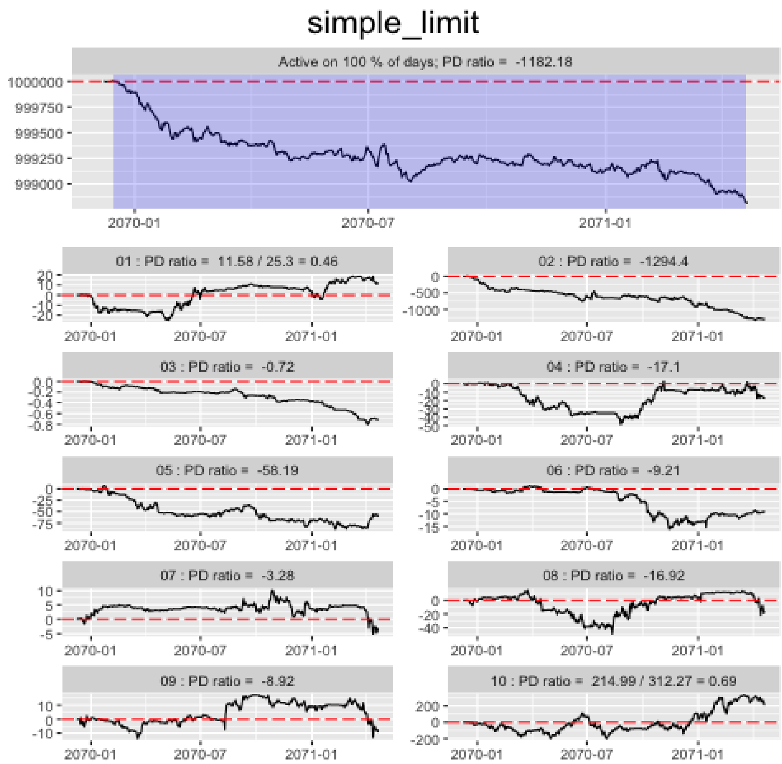
Graph F.19: Rsi contrarian (day 1-500 with 0.2 slippage and 1-unit fixed wager)



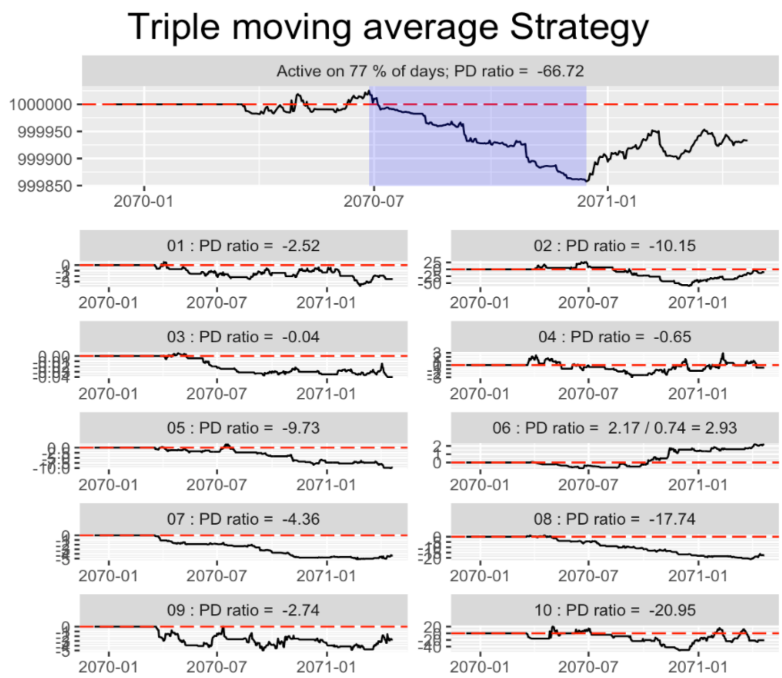
Graph F.20: Rsi contrarian (day 1-500 without 0.2 slippage and 1-unit fixed wager)



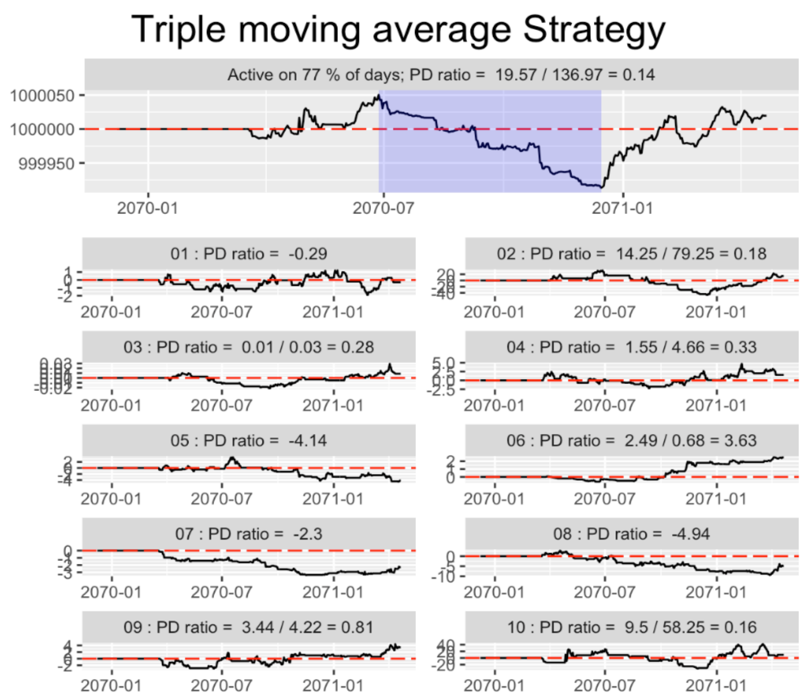
Graph F.21: Simple limit (day 1-500 with 0.2 slippage and 1-unit fixed wager)



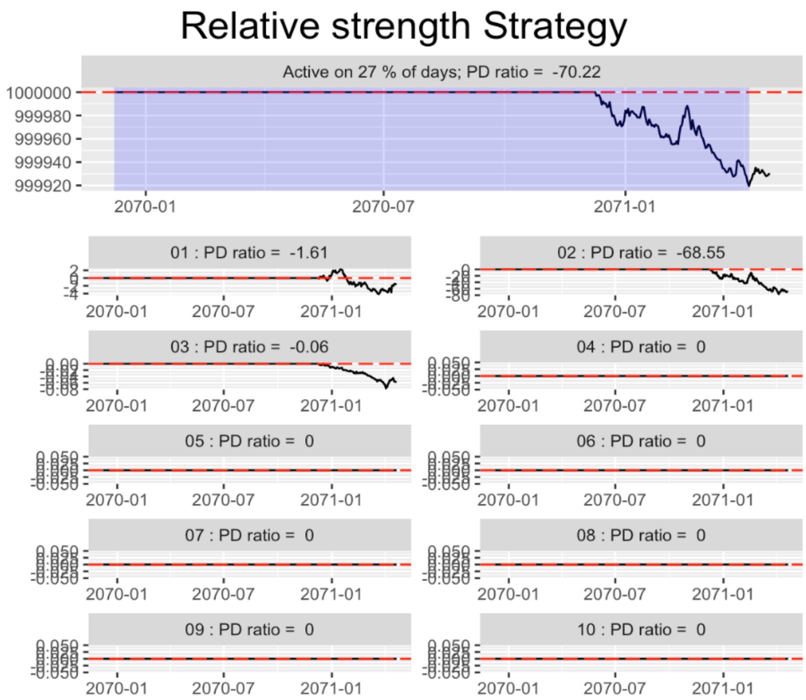
Graph F.22: Simple limit (day 1-500 without 0.2 slippage and 1-unit fixed wager)



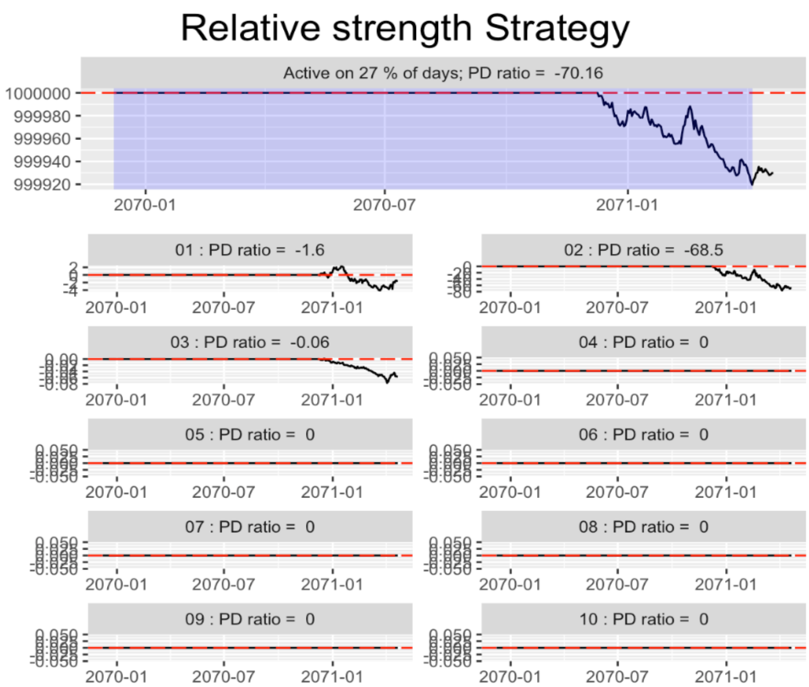
Graph F.23: Triple Moving Average Strategy (day 1-500 with 0.2 slippage and 1-unit fixed wager)



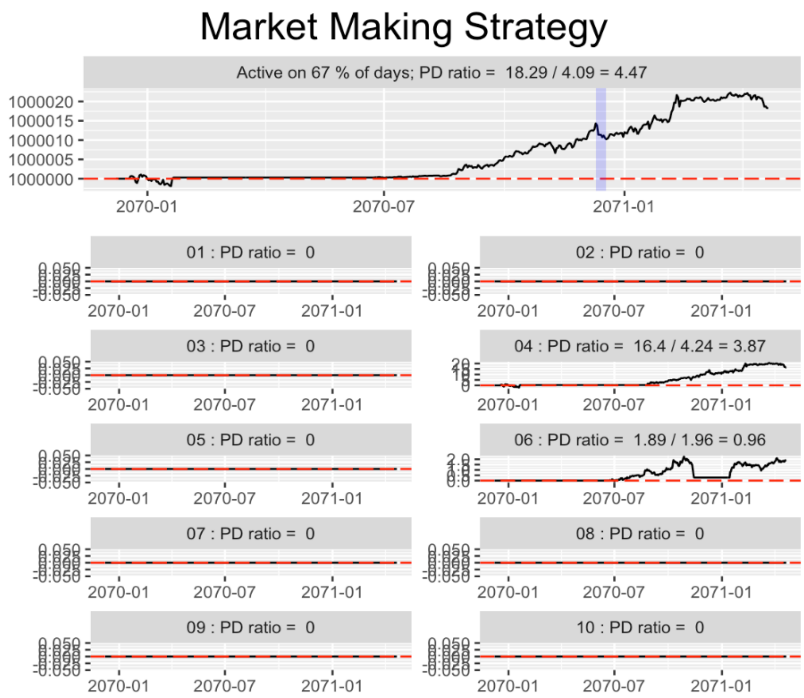
Graph F.24: Triple Moving Average Strategy (day 1-500 without 0.2 slippage and 1-unit fixed wager)



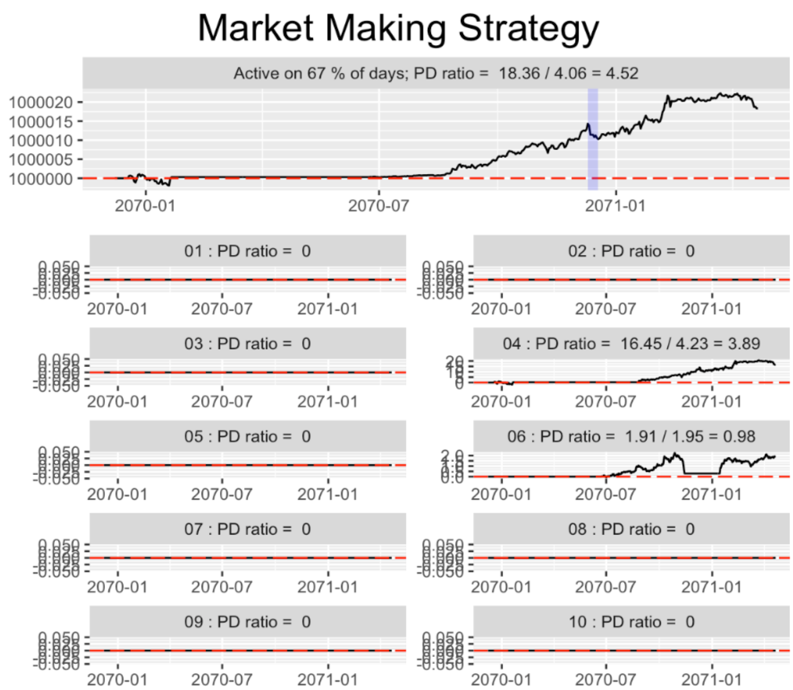
Graph F.25: Relative Strength Strategy (day 1-500 with 0.2 slippage and 1-unit fixed wager)



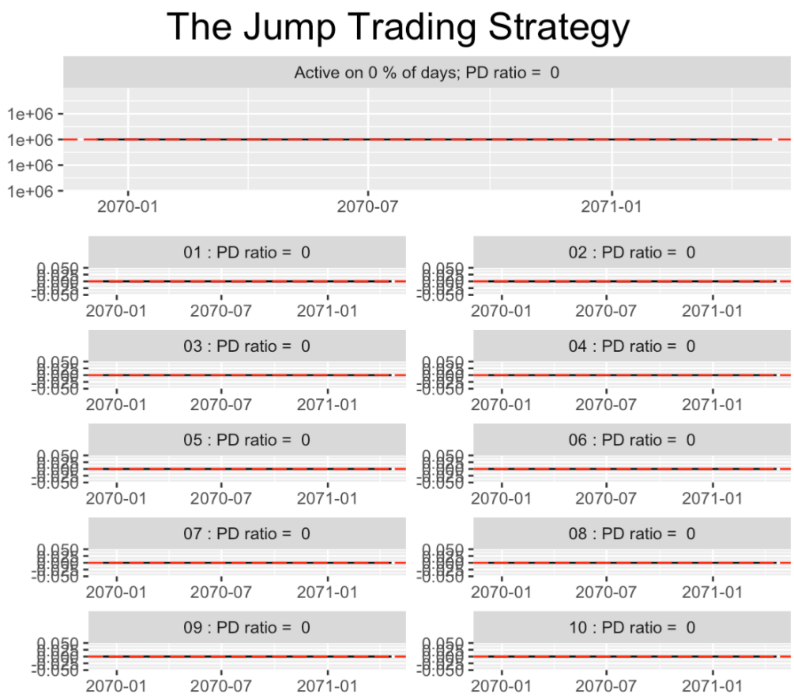
Graph F.26: Relative Strength Strategy (day 1-500 without 0.2 slippage and 1-unit fixed wager)



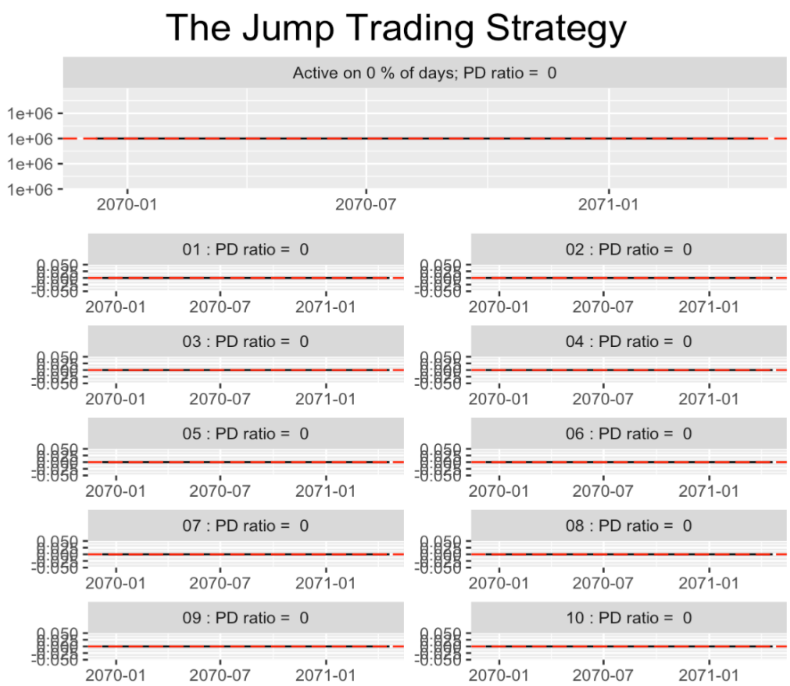
Graph F.27: Market Making Strategy (day 1-500 with 0.2 slippage and 1-unit fixed wager)



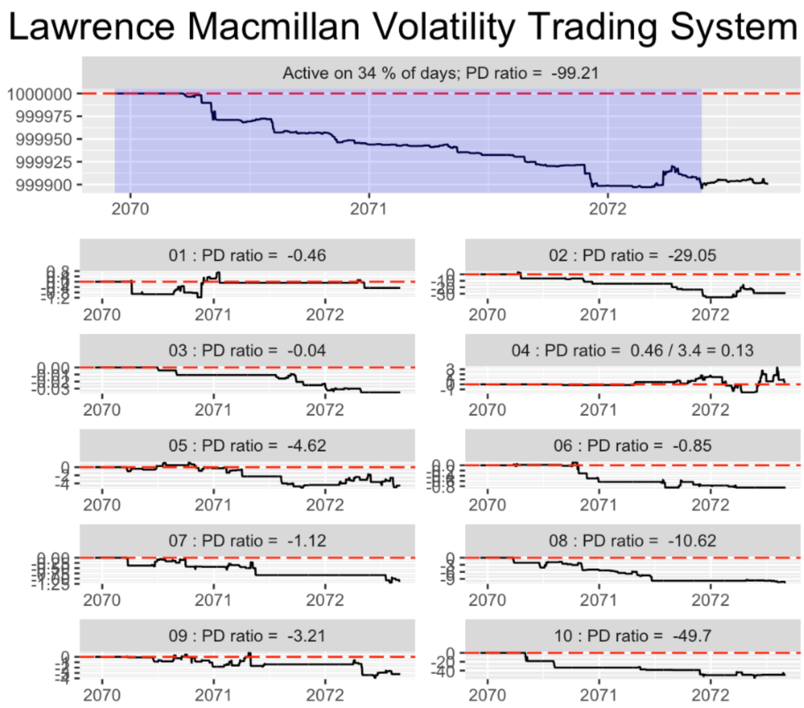
Graph F.28: Market Making Strategy (day 1-500 without 0.2 slippage and 1-unit fixed wager)



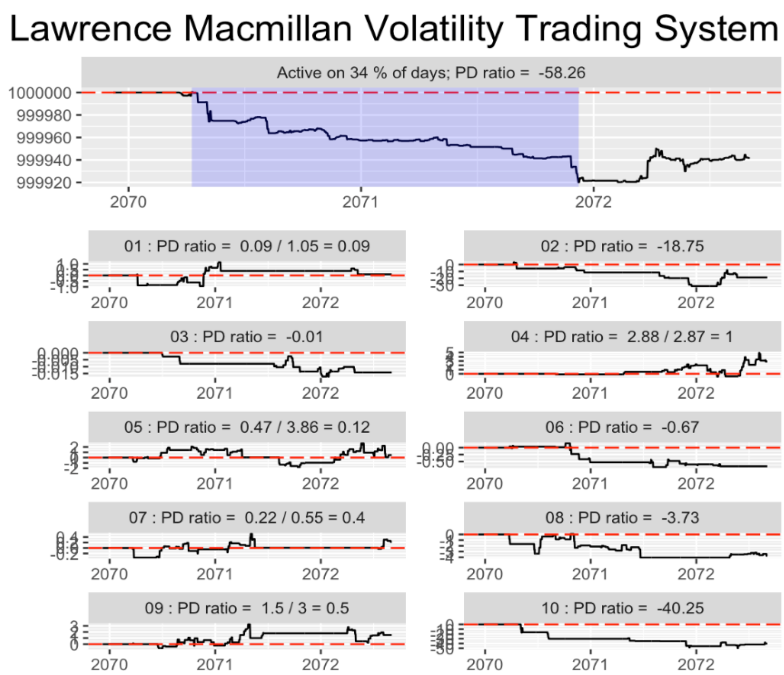
Graph F.29: The Jump Trading Strategy (day 1-500 with 0.2 slippage and 1-unit fixed wager)



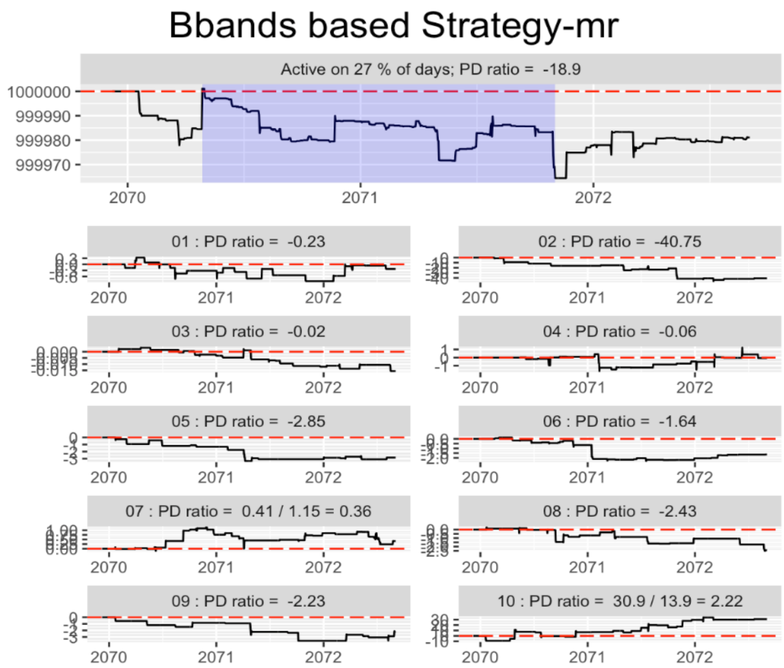
Graph F.30: The Jump Trading Strategy (day 1-500 without 0.2 slippage and 1-unit fixed wager)



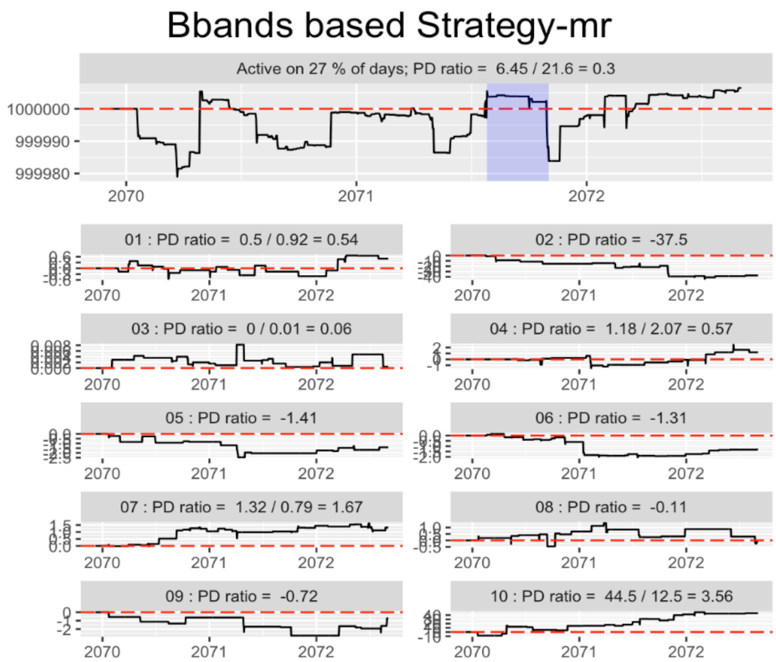
Graph F.31: Lawrence Macmillan Volatility Trading System (day 1-500 with 0.2 slippage and 1-unit fixed wager)



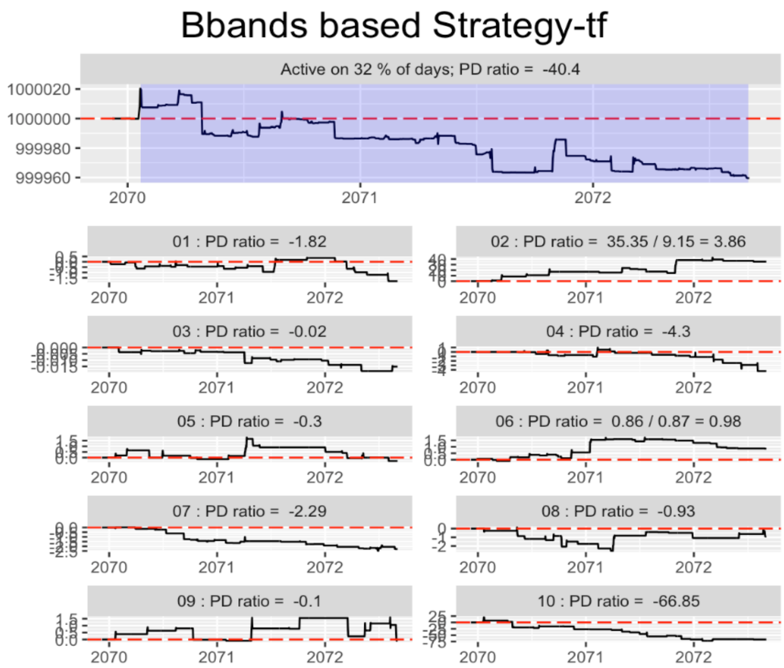
Graph F.32: Lawrence Macmillan Volatility Trading System (day 1-500 without 0.2 slippage and 1-unit fixed wager)



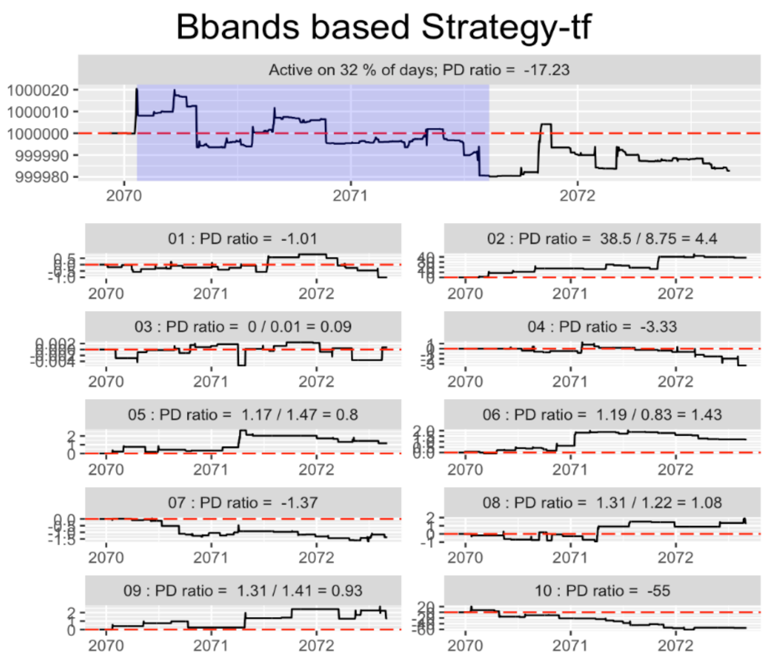
Graph F.33: BBands based Strategy (Mean-reversion) (day 1-500 with 0.2 slippage and 1-unit fixed wager)



Graph F.34: BBands based Strategy (Mean-reversion) (day 1-500 without 0.2 slippage and 1-unit fixed wager)



Graph F.35: BBands based Strategy (Trend-following) (day 1-500 with 0.2 slippage and 1-unit fixed wager)



Graph F.36: BBands based Strategy (Trend-following) (day 1-500 without 0.2 slippage and 1-unit fixed wager)