Arbitrage Modeling of SPY and IVV Exchange Funds

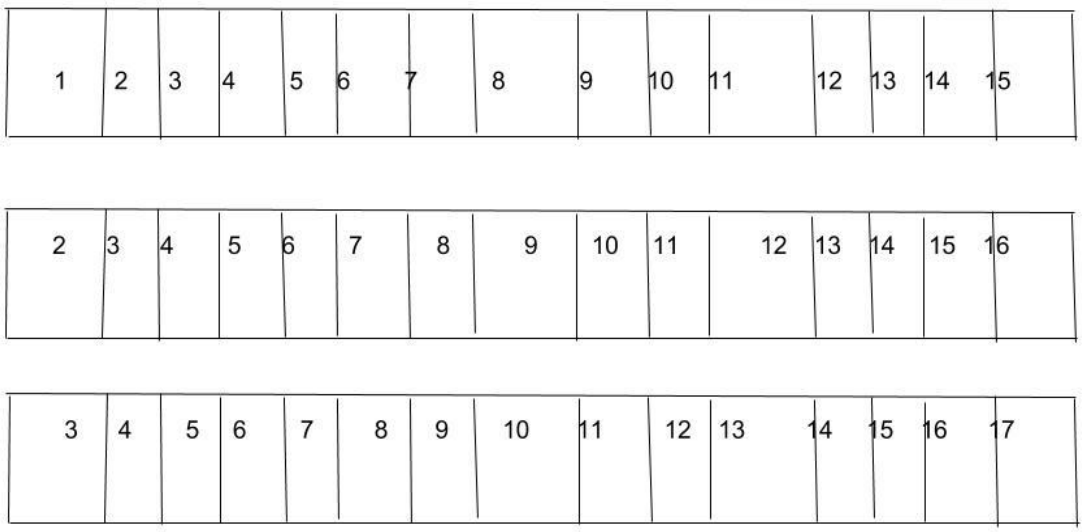
When two columns of data have a Pearson's product-moment correlation coefficient close to 1, then the columns of data are said to have a positive correlation. In layman's terms, this means both columns of data will move up and down together. The image below from Wikipedia is the fundamental argument the software is built upon:

$$r = \frac{\sum_{i=1}^{n} ((x_i - \bar{x})(y_i - \bar{y}))}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}}$$

The variables for this correlation coefficient are: sample mean x, sample mean y, Xi and Yi. For my software, PtIVV is Xi, PtSPY is Yi and so on. The software I have only runs if the value of r is greater than .99. This is the first "if" statement in the code to prevent trading when there does not exist a strong positive correlation. The code below runs through my two columns of data and computes the value of r without using the built in function; this code can be transferred to C++ or Python with only minor changes. I won't go into detail because I feel the comments below are sufficient in explaining the result. I hardcoded the math equations because hedge funds and investment banks care about speed. The idea of having a program run as fast as possible is the goal for making decisions on the algorithms, this means not using built in functions.

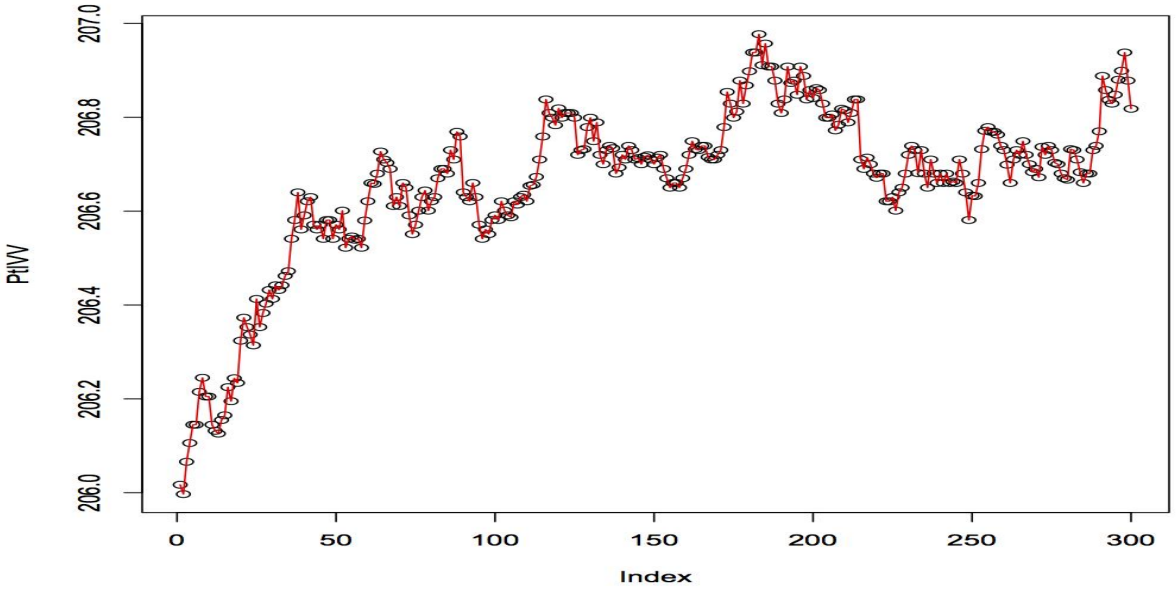
The next step of the model uses machine learning to compute the average distance between PtIVV and PtSPY over the last 15 minutes. Below is the graph of PtSPY and PtIVV on May 24, 2016. Looking at the two graphs just as a simple thought experiment, you can see that PtIVV is always greater than PtSPY on May 24, 2016. If I have the sum of the last 15 data points

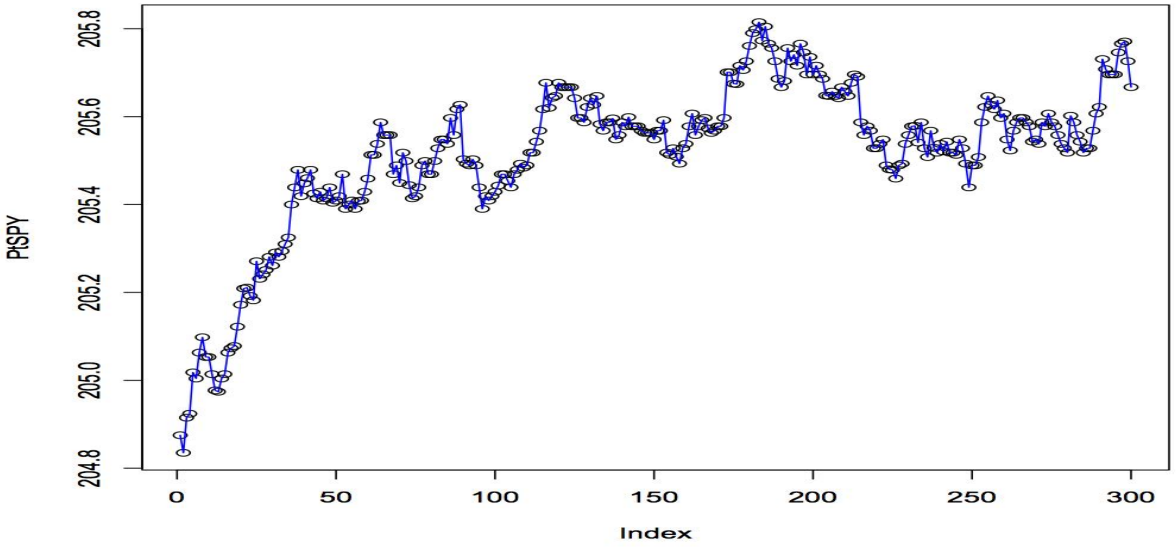
of PtIVV, divide this number by 15 that is the sample mean of PtIVV for 15 minutes. The next step is to do the same thing for PtSPY. Now with the sample mean of PtSPY and PtIVV for the last 15 minutes, I simply subtract this PtSPY sample mean from and PtIVV sample mean. The result is a machine learned value for the distance of PtIVV and PtSPY given the last 15 minutes. This idea at first sight is very complicated so I will show an image that easy demonstrates what I am talking about. Notice the first array goes from 1 to 15. The next array goes from 2 to 16 and then 3 to 17. The result of my machine learning test only takes as inputs the “last 15 minutes”. I don’t care what happened yesterday or 16 minutes before time t.



I made this image in Google Drawings to give a visual of what the machine learning average distance equation is doing. For simplicity, say this value is called MLD15, machine learned distance over fifteen minutes. After this value is computed, I compute the value between

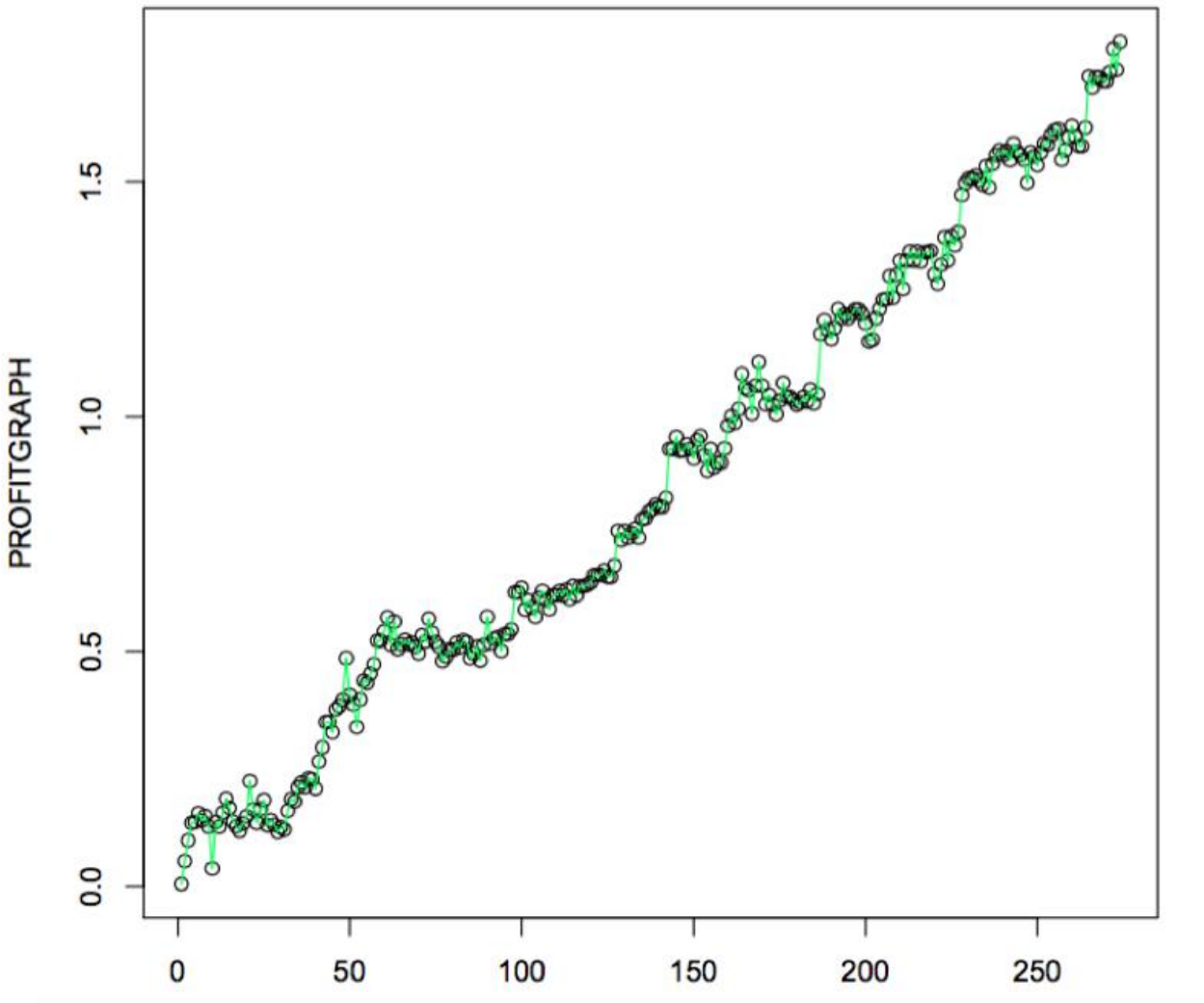
the actual difference at time t and MLD15 at time t.





The next stage of the software is comparing the MLD15 to the actual distance at time t. If the MLD15 is less than the actual distance at time t, I expect based on the positive correlation that the two assets will converge. In laymans terms, either PtIVV will drop or PtSPY will go. A simple derivative test of PtIVV and PtSPY gives me a value for the next stage of the software.

Below I have commented out the code extensively for the derivative test for the four decision algorithms. There are four decision algorithms to determine whether or not to: Short IVV, Long SPY, Long IVV, and Short SPY. Here is graph of the profit generated on May 24, 2016 by running the software:



In conclusion, even with only minute by minute price data this model works for ETF IVV and ETF SPY everyday the Pearson's coefficient is greater than .99. More refining can be done to use this model for other ETFs that track the S&P 500 index like VOO. This model would work very well for a company that is a market maker for the NYSE because both securities are

traded there. I have commented the code extensively to explain every step of the software. Utilizing machine learning on these two correlated assets, this model can determine the best times for a market maker to provide liquidity for the NYSE.

Work Cited

"Correlation and Dependence." Wikipedia. Wikimedia Foundation, 08 May 2017. Web. 19 May 2017.

R Code

```
cor(PtIVV, PtSPY) # This line of code demonstrates the R built in cor function

sum=0 # This is for calculating the sample mean of PtIVV

sampleMEANX=0
```

```
sum2=0 # This is for calculating the sample mean of PtSPY
sampleMEANY=0 # All of this is instantiating variables. In R I do not need to do this but is makes the code easily transferable
sumPROD=0
sumPROD2=0
sumPROD3=0
SQUAREsumPROD2=0
SQUAREsumPROD3=0
PROFITGRAPH=0
graphcounter=0
r=0
for(i in 1:300) {
  sum=PtIVV[i]+sum # Refer to line 2
  sampleMEANX= sum/i
  sum2=PtSPY[i]+sum2 # Refer to line 4
  sampleMEANY= sum2/i
  XiMINUSSAMPLEMEANX= PtIVV[i]-sampleMEANX # (Xi-XiMINUSSAMPLEMEANX) for cor function
  YiMINUSSAMPLEMEANY= PtSPY[i]-sampleMEANY # Again same idea as line 19
  PROD=(XiMINUSSAMPLEMEANX)*(YiMINUSSAMPLEMEANY) # Using this for cor function
  sumPROD=PROD+sumPROD # Sum of line 21, also the numerator for my r
```

```
    sumPROD2=(XiMINUSSAMPLEMEANX)^2 + sumPROD2 # Sum of
(XiMINUSSAMPLEMEANX)^2 as t increases
    SQUAREsumPROD2=(sumPROD2)^(1/2) # Value for one part of denominator
    sumPROD3=(YiMINUSSAMPLEMEANY)^2 + sumPROD3 # Same idea as line 23
    SQUAREsumPROD3=(sumPROD3)^(1/2) # Value for other part of denominator
    r=(sumPROD)/(SQUAREsumPROD2*SQUAREsumPROD3) # Finally, the value of r
  }
  print(r)# Print the value

  if(r>.99){ # Now start the algorithm
    amean=0 # All of the local variables set to 0
    bmean=0
    machineDIFFmean=0
    percentOFF=0
    i=0
    accSPY=0
    accIVV=0
    PROFIT1=0
    DtIVV=0
    DtSPY=0
    sumDt=0
    guy=0
```

```
guy2=0
counterA=0
counterAloss=0
counterB=0
counterBloss=0
counterC=0
counterCloss=0
counterD=0
counterDloss=0
p1=0
p2=0
for (j in 16:299){
 i=j
 if(j>15){
  amean=(PtSPY[i-15]+PtSPY[i-14]+PtSPY[i-13] # Computation for the mean of
PtSPY over 15 minutes
      +PtSPY[i-12]+PtSPY[i-11]+PtSPY[i-10]+PtSPY[i-9]+PtSPY[i-8]
      +PtSPY[i-7]+PtSPY[i-6]+PtSPY[i-5]+PtSPY[i-4]+PtSPY[i-3]
      +PtSPY[i-2]+PtSPY[i-1])/15
  bmean=(PtIVV[i-15]+PtIVV[i-14]+PtIVV[i-13] # Computation for the mean of
PtIVV over 15 minutes
      +PtIVV[i-12]+PtIVV[i-11]+PtIVV[i-10]+PtIVV[i-9]+PtIVV[i-8]
```

```
        +PtIVV[i-7]+PtIVV[i-6]+PtIVV[i-5]+PtIVV[i-4]+PtIVV[i-3]
        +PtIVV[i-2]+PtIVV[i-1])/15
      machineDIFFmean= bmean- amean # Machine diff mean is bmean- amean ( In this
data set always + because PtIVV is always greater than PtSPY)
      actualDIFF= PtIVV[i]-PtSPY[i] # Actual diff PtIVV and PtSPY at time t
      DtIVV= (PtIVV[i]-PtIVV[i-1]) # Simple derivative test IVV
      DtSPY= (PtSPY[i]-PtSPY[i-1]) # Again, simple derivative test for SPY

    }
    if(machineDIFFmean<actualDIFF){
      guy="Long SPY/ Short IVV" # Theory, if the machine diff is less than actual diff the
next time t, PtIVV and PtSPY should CONVERGE because the difference should go towards the
machine diff at time t
      if((DtSPY)>(-1*DtIVV)){ # Decision algorithm 1: Long SPY if: (r>.99) and
(machineDIFFmean<actualDIFF) and (DtSPY> (-1*DtIVV))
        print("Long SPY profit: ") # Print line for looking at what happened
        p1= PtSPY[i+1]-PtSPY[i] # Long profit SPY
        print(p1) # Print profit either - or +
        if(p1>0){ # Setting up a counter for winning and losing traded on Decision
algorithm 1
          counterA=counterA+1
        }
```

```
                if(p1<0){ # Losing counter
                  counterAloss=counterAloss+1
                }
                PROFIT1= PROFIT1+p1 # Profit sum for graphing
                print(PROFIT1) # Print total profit
                PROFITGRAPH[graphcounter]=PROFIT1 # For graphing purposes in R
                graphcounter=graphcounter+1 # Increase index for graphing purposes in R
              }
              if((-1*DtIVV)>(DtSPY)){# Decision algorithm 2: Short IVV if: (r>.99) and
(machineDIFFmean<actualDIFF) and ((-1*DtIVV)> DtSPY)
                print("Short IVV profit: ") # Print line for looking at what happened
                p3= PtIVV[i]-PtIVV[i+1] # Short profit IVV
                print(p3) # Print either + or -
                if(p3>0){ # Again, setting up counter for counting win/ losses
                  counterC=counterC+1
                }
                if(p3<0){
                  counterCloss=counterCloss+1
                }
                PROFIT1= PROFIT1+p3 # Same as above, not needed code only for graphing
purposes
                print(PROFIT1)
```

```
    PROFITGRAPH[graphcounter]=PROFIT1
    graphcounter=graphcounter+1
   }
  }
 if(actualDIFF<machineDIFFmean){
  guy2= "short spy/ long IVV" # Theory, if the machine diff is greater than actual diff the next time t, PtIVV and PtSPY should DIVERAGE because the difference should go towards the machine diff at time t
   if((DtSPY)<(-1*DtIVV)){ # Decision algorithm 3: Short SPY if: (r>.99) and (actualDIFF<machineDIFFmean) and (DtSPY<(-1*DtIVV))
    print("Short SPY profit: ") # Print line statement for looking at values
    p2= PtSPY[i]-PtSPY[i+1] # Short SPY profit either + or -
    print(p2)
    if(p2>0){ # counter again
     counterB=counterB+1
    }
    if(p2<0){
     counterBloss=counterBloss+1
    }
    PROFIT1= PROFIT1+p2 # graphing R code
    print(PROFIT1)
    PROFITGRAPH[graphcounter]=PROFIT1
```

```
    graphcounter=graphcounter+1
   }
  if((DtSPY)<(-1*DtIVV)){ # Decision algorithm 4: Long IVV if: (r>.99) and
(actualDIFF<machineDIFFmean) and ((-1*DtIVV)>DtSPY)
    print("Long IVV profit: ") # Print line for looking at profit
    p4= PtIVV[i+1]-PtIVV[i] # Long IVV profit
    print(p4)
    if(p4>0){ # Counting winners and losers
     counterD=counterD+1
    }
    if(p4<0){
     counterDloss=counterDloss+1
    }
    PROFIT1= PROFIT1+p4 # graph code again for R
    print(PROFIT1)
    PROFITGRAPH[graphcounter]=PROFIT1
    graphcounter=graphcounter+1
   }
  }
  if(i==299){ # Statistical print out of profit, winner, losers for each decision algorithm
   print(PROFIT1) # Total profit
   print(counterA) # Winners on decision 1 algo
```

```
            print(counterAloss) # Losers decision 1 algo
            print((counterA)/(counterA+counterAloss)) # Percent winning algo 1 (doesnt include
0 profit only + or -)
            print(counterB)# Winners on decision 2 algo
            print(counterBloss) # Losers decision 2 algo
            print((counterB)/(counterB+counterBloss))# Percent winning algo 2 (doesnt include 0
profit only + or -)
            print(counterC) # Winners on decision 3 algo
            print(counterCloss) # Losers decision 3 algo
            print((counterC)/(counterC+counterCloss)) # Percent winning algo 3 (doesnt include
0 profit only + or -)
            print(counterD) # Winners on decision 4 algo
            print(counterDloss) #  Losers decision 4 algo
            print((counterD)/(counterD+counterDloss)) # Percent winning algo 4 (doesnt include
0 profit only + or -)
            print("TOTAL WIN PERCENTAGE: ") # Self explanitory

print((counterA+counterB+counterC+counterD)/(counterA+counterB+counterC+counterD+

counterAloss+counterBloss+counterCloss+counterDloss))
          }
        }
```

```
}
plot(PROFITGRAPH) # Plot the graph of profit
lines(PROFITGRAPH, col="green") # Give the profit graph lines betwen points that are
green
```

Output

```
[1] 0.9979957
> sum=0 # This is for calculating the sample mean of PtIVV
> sampleMEANX=0
> sum2=0 # This is for calculating the sample mean of PtSPY
> sampleMEANY=0 # All of this is instantiating variables. In R I do not need to do this but is
makes the code easily transferable
> sumPROD=0
> sumPROD2=0
> sumPROD3=0
> SQUAREsumPROD2=0
> SQUAREsumPROD3=0
> PROFITGRAPH=0
> graphcounter=0
> r=0
> for(i in 1:300) {
```

```
+ sum=PtIVV[i]+sum # Refer to line 2
+ sampleMEANX= sum/i
+ sum2=PtSPY[i]+sum2 # Refer to line 4
+ sampleMEANY= sum2/i
+ XiMINUSSAMPLEMEANX= PtIVV[i]-sampleMEANX # (Xi- XiMINUSSAMPLEMEANX)
for cor function
+ YiMINUSSAMPLEMEANY= PtSPY[i]-sampleMEANY # Again same idea as line 19
+ PROD=(XiMINUSSAMPLEMEANX)*(YiMINUSSAMPLEMEANY) # Using this for cor
function
+ sumPROD=PROD+sumPROD # Sum of line 21, also the numerator for my r
+ sumPROD2=(XiMINUSSAMPLEMEANX)^2 + sumPROD2 # Sum of
(XiMINUSSAMPLEMEANX)^2 as t increases
+ SQUAREsumPROD2=(sumPROD2)^(1/2) # Value for one part of denominator
+ sumPROD3=(YiMINUSSAMPLEMEANY)^2 + sumPROD3 # Same idea as line 23
+ SQUAREsumPROD3=(sumPROD3)^(1/2) # Value for other part of denominator
+ r=(sumPROD)/(SQUAREsumPROD2*SQUAREsumPROD3) # Finally, the value of r
+ }
> print(r)         # Print the value
[1] 0.9980206
>
> if(r>.99){ # Now start the algorithm
+ amean=0 # All of the local variables set to 0
```

+ bmean=0

+ machineDIFFmean=0

+ percentOFF=0

+ i=0

+ accSPY=0

+ accIVV=0

+ PROFIT1=0

+ DtIVV=0

+ DtSPY=0

+ sumDt=0

+ guy=0

+ guy2=0

+ counterA=0

+ counterAloss=0

+ counterB=0

+ counterBloss=0

+ counterC=0

+ counterCloss=0

+ counterD=0

+ counterDloss=0

+ p1=0

+ p2=0

```
+ for (j in 16:299){
+ i=j
+ if(j>15){
+ amean=(PtSPY[i-15]+PtSPY[i-14]+PtSPY[i-13] # Computation for the mean of PtSPY over
15 minutes
+ +PtSPY[i-12]+PtSPY[i-11]+PtSPY[i-10]+PtSPY[i-9]+PtSPY[i-8]
+ +PtSPY[i-7]+PtSPY[i-6]+PtSPY[i-5]+PtSPY[i-4]+PtSPY[i-3]
+ +PtSPY[i-2]+PtSPY[i-1])/15
+ bmean=(PtIVV[i-15]+PtIVV[i-14]+PtIVV[i-13] # Computation for the mean of PtIVV over 15
minutes
+ +PtIVV[i-12]+PtIVV[i-11]+PtIVV[i-10]+PtIVV[i-9]+PtIVV[i-8]
+ +PtIVV[i-7]+PtIVV[i-6]+PtIVV[i-5]+PtIVV[i-4]+PtIVV[i-3]
+ +PtIVV[i-2]+PtIVV[i-1])/15
+ machineDIFFmean= bmean- amean # Machine diff mean is bmean- amean ( In this data set
always + because PtIVV is always greater than PtSPY)
+ actualDIFF= PtIVV[i]-PtSPY[i] # Actual diff PtIVV and PtSPY at time t
+ DtIVV= (PtIVV[i]-PtIVV[i-1]) # Simple derivative test IVV
+ DtSPY= (PtSPY[i]-PtSPY[i-1]) # Again, simple derivative test for SPY
+
+ }
+ if(machineDIFFmean<actualDIFF){
```

```
+ guy="Long SPY/ Short IVV" # Theory, if the machine diff is less than actual diff the next time
t, PtIVV and PtSPY should CONVERGE because the difference should go towards the machine
diff at time t
+ if((DtSPY)>(-1*DtIVV)){ # Decision algorithm 1: Long SPY if: (r>.99) and
(machineDIFFmean<actualDIFF) and (DtSPY> (-1*DtIVV))
+ print("Long SPY profit: ") # Print line for looking at what happened
+ p1= PtSPY[i+1]-PtSPY[i] # Long profit SPY
+ print(p1) # Print profit either - or +
+ if(p1>0){ # Setting up a counter for winning and losing traded on Decision algorithm 1
+ counterA=counterA+1
+ }
+ if(p1<0){ # Losing counter
+ counterAloss=counterAloss+1
+ }
+ PROFIT1= PROFIT1+p1 # Profit sum for graphing
+ print(PROFIT1) # Print total profit
+ PROFITGRAPH[graphcounter]=PROFIT1 # For graphing purposes in R
+ graphcounter=graphcounter+1 # Increase index for graphing purposes in R
+ }
+ if((-1*DtIVV)>(DtSPY)){# Decision algorithm 2: Short IVV if: (r>.99) and
(machineDIFFmean<actualDIFF) and ((-1*DtIVV)> DtSPY)
+ print("Short IVV profit: ") # Print line for looking at what happened
```

+ p3= PtIVV[i]-PtIVV[i+1] # Short profit IVV

+ print(p3) # Print either + or -

+ if(p3>0){ # Again, setting up counter for counting win/ losses

+ counterC=counterC+1

+ }

+ if(p3<0){

+ counterCloss=counterCloss+1

+ }

+ PROFIT1= PROFIT1+p3 # Same as above, not needed code only for graphing purposes

+ print(PROFIT1)

+ PROFITGRAPH[graphcounter]=PROFIT1

+ graphcounter=graphcounter+1

+ }

+ }

+ if(actualDIFF<machineDIFFmean){

+ guy2= "short spy/ long IVV" # Theory, if the machine diff is greater than actual diff the next time t, PtIVV and PtSPY should DIVERAGE because the difference should go towards the machine diff at time t

+ if((DtSPY)<(-1*DtIVV)){ # Decision algorithm 3: Short SPY if: (r>.99) and (actualDIFF<machineDIFFmean) and (DtSPY<(-1*DtIVV))

+ print("Short SPY profit: ") # Print line statement for looking at values

+ p2= PtSPY[i]-PtSPY[i+1] # Short SPY profit either + or -

```
+ print(p2)
+ if(p2>0){ # counter again
+ counterB=counterB+1
+ }
+ if(p2<0){
+ counterBloss=counterBloss+1
+ }
+ PROFIT1= PROFIT1+p2 # graphing R code
+ print(PROFIT1)
+ PROFITGRAPH[graphcounter]=PROFIT1
+ graphcounter=graphcounter+1
+ }
+ if((DtSPY)<(-1*DtIVV)){ # Decision algorithm 4: Long IVV if: (r>.99) and
(actualDIFF<machineDIFFmean) and ((-1*DtIVV)>DtSPY)
+ print("Long IVV profit: ") # Print line for looking at profit
+ p4= PtIVV[i+1]-PtIVV[i] # Long IVV profit
+ print(p4)
+ if(p4>0){ # Counting winners and losers
+ counterD=counterD+1
+ }
+ if(p4<0){
+ counterDloss=counterDloss+1
```

```
+ }
+ PROFIT1= PROFIT1+p4 # graph code again for R
+ print(PROFIT1)
+ PROFITGRAPH[graphcounter]=PROFIT1
+ graphcounter=graphcounter+1
+ }
+ }
+ if(i==299){ # Statistical print out of profit, winner, losers for each decision algorithm
+ print(PROFIT1) # Total profit
+ print(counterA) # Winners on decision 1 algo
+ print(counterAloss) # Losers decision 1 algo
+ print((counterA)/(counterA+counterAloss)) # Percent winning algo 1 (doesnt include 0 profit
only + or -)
+ print(counterB)# Winners on decision 2 algo
+ print(counterBloss) # Losers decision 2 algo
+ print((counterB)/(counterB+counterBloss))# Percent winning algo 2 (doesnt include 0 profit
only + or -)
+ print(counterC) # Winners on decision 3 algo
+ print(counterCloss) # Losers decision 3 algo
+ print((counterC)/(counterC+counterCloss)) # Percent winning algo 3 (doesnt include 0 profit
only + or -)
+ print(counterD) # Winners on decision 4 algo
```

```
+ print(counterDloss) #  Losers decision 4 algo
+ print((counterD)/(counterD+counterDloss)) # Percent winning algo 4 (doesnt include 0 profit
only + or -)
+ print("TOTAL WIN PERCENTAGE: ") # Self explanitory
+ print((counterA+counterB+counterC+counterD)/(counterA+counterB+counterC+counterD+
+ counterAloss+counterBloss+counterCloss+counterDloss))
+ }
+ }
+ }
[1] "Long SPY profit: "
[1] 0.01
[1] 0.01
[1] "Short SPY profit: "
[1] -0.005
[1] 0.005
[1] "Long IVV profit: "
[1] 0.049
[1] 0.054
[1] "Long SPY profit: "
[1] 0.044
[1] 0.098
[1] "Long SPY profit: "
```

[1] 0.037

[1] 0.135

[1] "Long SPY profit: "

[1] 0.002

[1] 0.137

[1] "Short SPY profit: "

[1] 0.019

[1] 0.156

[1] "Long IVV profit: "

[1] -0.016

[1] 0.14

[1] "Short SPY profit: "

[1] 0.01

[1] 0.15

[1] "Long IVV profit: "

[1] -0.023

[1] 0.127

[1] "Short SPY profit: "

[1] -0.089

[1] 0.038

[1] "Long IVV profit: "

[1] 0.099

[1] 0.137

[1] "Short SPY profit: "

[1] -0.01

[1] 0.127

[1] "Long IVV profit: "

[1] 0.03

[1] 0.157

[1] "Long SPY profit: "

[1] 0.03

[1] 0.187

[1] "Long SPY profit: "

[1] -0.02

[1] 0.167

[1] "Short IVV profit: "

[1] -0.029

[1] 0.138

[1] "Long SPY profit: "

[1] -0.01

[1] 0.128

[1] "Short IVV profit: "

[1] -0.01

[1] 0.118

[1] "Long SPY profit: "

[1] 0.016

[1] 0.134

[1] "Long SPY profit: "

[1] 0.015

[1] 0.149

[1] "Long SPY profit: "

[1] 0.075

[1] 0.224

[1] "Long SPY profit: "

[1] -0.06

[1] 0.164

[1] "Short SPY profit: "

[1] -0.029

[1] 0.135

[1] "Long IVV profit: "

[1] 0.03

[1] 0.165

[1] "Long SPY profit: "

[1] 0.019

[1] 0.184

[1] "Long SPY profit: "

[1] -0.054

[1] 0.13

[1] "Short SPY profit: "

[1] 0.011

[1] 0.141

[1] "Long IVV profit: "

[1] -0.01

[1] 0.131

[1] "Short SPY profit: "

[1] -0.015

[1] 0.116

[1] "Long IVV profit: "

[1] 0.01

[1] 0.126

[1] "Short SPY profit: "

[1] -0.005

[1] 0.121

[1] "Long IVV profit: "

[1] 0.04

[1] 0.161

[1] "Long SPY profit: "

[1] 0.025

[1] 0.186

[1] "Short SPY profit: "

[1] -0.005

[1] 0.181

[1] "Long IVV profit: "

[1] 0.03

[1] 0.211

[1] "Long SPY profit: "

[1] 0.01

[1] 0.221

[1] "Short SPY profit: "

[1] -0.01

[1] 0.211

[1] "Long IVV profit: "

[1] 0.019

[1] 0.23

[1] "Short IVV profit: "

[1] -0.002

[1] 0.228

[1] "Short SPY profit: "

[1] -0.02

[1] 0.208

[1] "Long IVV profit: "

[1] 0.058

[1] 0.266

[1] "Long SPY profit: "

[1] 0.03

[1] 0.296

[1] "Long SPY profit: "

[1] 0.054

[1] 0.35

[1] "Long SPY profit: "

[1] 0

[1] 0.35

[1] "Short IVV profit: "

[1] -0.022

[1] 0.328

[1] "Long SPY profit: "

[1] 0.049

[1] 0.377

[1] "Short IVV profit: "

[1] 0.007

[1] 0.384

[1] "Short IVV profit: "

[1] 0.013

[1] 0.397

[1] "Short SPY profit: "

[1] 0.089

[1] 0.486

[1] "Long IVV profit: "

[1] -0.079

[1] 0.407

[1] "Short IVV profit: "

[1] -0.019

[1] 0.388

[1] "Short IVV profit: "

[1] -0.049

[1] 0.339

[1] "Short IVV profit: "

[1] 0.059

[1] 0.398

[1] "Short IVV profit: "

[1] 0.04

[1] 0.438

[1] "Short SPY profit: "

[1] -0.005

[1] 0.433

[1] "Long IVV profit: "

[1] 0.02

[1] 0.453

[1] "Long SPY profit: "

[1] 0.02

[1] 0.473

[1] "Long SPY profit: "

[1] 0.05

[1] 0.523

[1] "Short SPY profit: "

[1] 0

[1] 0.523

[1] "Long IVV profit: "

[1] 0.02

[1] 0.543

[1] "Long SPY profit: "

[1] 0.03

[1] 0.573

[1] "Short SPY profit: "

[1] -0.059

[1] 0.514

[1] "Long IVV profit: "

[1] 0.05

[1] 0.564

[1] "Short IVV profit: "

[1] -0.059

[1] 0.505

[1] "Long SPY profit: "

[1] 0.01

[1] 0.515

[1] "Short SPY profit: "

[1] 0.01

[1] 0.525

[1] "Long IVV profit: "

[1] -0.01

[1] 0.515

[1] "Short SPY profit: "

[1] 0.004

[1] 0.519

[1] "Long IVV profit: "

[1] -0.009

[1] 0.51

[1] "Short SPY profit: "

[1] -0.014

[1] 0.496

[1] "Long IVV profit: "

[1] 0.039

[1] 0.535

[1] "Long SPY profit: "

[1] -0.014

[1] 0.521

[1] "Short SPY profit: "

[1] 0.049

[1] 0.57

[1] "Long IVV profit: "

[1] -0.03

[1] 0.54

[1] "Short IVV profit: "

[1] -0.02

[1] 0.52

[1] "Long SPY profit: "

[1] -0.01

[1] 0.51

[1] "Short IVV profit: "

[1] -0.03

[1] 0.48

[1] "Long SPY profit: "

[1] 0.01

[1] 0.49

[1] "Long SPY profit: "

[1] 0.014

[1] 0.504

[1] "Long SPY profit: "

[1] 0

[1] 0.504

[1] "Short SPY profit: "

[1] 0.015

[1] 0.519

[1] "Long IVV profit: "

[1] -0.01

[1] 0.509

[1] "Short SPY profit: "

[1] 0.015

[1] 0.524

[1] "Long IVV profit: "

[1] -0.004

[1] 0.52

[1] "Short IVV profit: "

[1] -0.034

[1] 0.486

[1] "Long SPY profit: "

[1] 0.01

[1] 0.496

[1] "Short IVV profit: "

[1] 0.014

[1] 0.51

[1] "Short SPY profit: "

[1] -0.029

[1] 0.481

[1] "Long IVV profit: "

[1] 0.033

[1] 0.514

[1] "Long SPY profit: "

[1] 0.06

[1] 0.574

[1] "Long SPY profit: "

[1] -0.057

[1] 0.517

[1] "Short IVV profit: "

[1] 0.01

[1] 0.527

[1] "Long SPY profit: "

[1] 0.004

[1] 0.531

[1] "Short SPY profit: "

[1] -0.03

[1] 0.501

[1] "Long IVV profit: "

[1] 0.036

[1] 0.537

[1] "Short SPY profit: "

[1] 0

[1] 0.537

[1] "Long IVV profit: "

[1] 0.01

[1] 0.547

[1] "Short IVV profit: "

[1] 0.079

[1] 0.626

[1] "Short SPY profit: "

[1] 0

[1] 0.626

[1] "Long IVV profit: "

[1] 0.01

[1] 0.636

[1] "Short IVV profit: "

[1] -0.047

[1] 0.589

[1] "Long SPY profit: "

[1] 0.02

[1] 0.609

[1] "Long SPY profit: "

[1] -0.015

[1] 0.594

[1] "Short SPY profit: "

[1] -0.02

[1] 0.574

[1] "Long IVV profit: "

[1] 0.04

[1] 0.614

[1] "Short SPY profit: "

[1] 0.015

[1] 0.629

[1] "Long IVV profit: "

[1] -0.02

[1] 0.609

[1] "Short SPY profit: "

[1] -0.019

[1] 0.59

[1] "Long IVV profit: "

[1] 0.03

[1] 0.62

[1] "Long SPY profit: "

[1] 0

[1] 0.62

[1] "Long SPY profit: "

[1] 0.009

[1] 0.629

[1] "Short SPY profit: "

[1] -0.01

[1] 0.619

[1] "Long IVV profit: "

[1] 0.013

[1] 0.632

[1] "Short SPY profit: "

[1] -0.021

[1] 0.611

[1] "Long IVV profit: "

[1] 0.029

[1] 0.64

[1] "Long SPY profit: "

[1] -0.021

[1] 0.619

[1] "Short IVV profit: "

[1] 0.02

[1] 0.639

[1] "Short SPY profit: "

[1] 0

[1] 0.639

[1] "Long IVV profit: "

[1] 0.003

[1] 0.642

[1] "Short SPY profit: "

[1] 0.005

[1] 0.647

[1] "Long IVV profit: "

[1] 0.016

[1] 0.663

[1] "Long SPY profit: "

[1] 0

[1] 0.663

[1] "Long SPY profit: "

[1] 0

[1] 0.663

[1] "Short IVV profit: "

[1] 0.01

[1] 0.673

[1] "Short IVV profit: "

[1] -0.014

[1] 0.659

[1] "Long SPY profit: "

[1] 0

[1] 0.659

[1] "Long SPY profit: "

[1] 0.024

[1] 0.683

[1] "Short SPY profit: "

[1] 0.074

[1] 0.757

[1] "Long IVV profit: "

[1] -0.02

[1] 0.737

[1] "Short IVV profit: "

[1] 0.02

[1] 0.757

[1] "Short SPY profit: "

[1] -0.015

[1] 0.742

[1] "Long IVV profit: "

[1] 0.01

[1] 0.752

[1] "Short IVV profit: "

[1] 0.01

[1] 0.762

[1] "Short IVV profit: "

[1] -0.02

[1] 0.742

[1] "Long SPY profit: "

[1] 0.04

[1] 0.782

[1] "Short IVV profit: "

[1] 0.002

[1] 0.784

[1] "Long SPY profit: "

[1] 0.014

[1] 0.798

[1] "Long SPY profit: "

[1] 0.005

[1] 0.803

[1] "Short SPY profit: "

[1] 0.01

[1] 0.813

[1] "Long IVV profit: "

[1] -0.005

[1] 0.808

[1] "Short IVV profit: "

[1] 0

[1] 0.808

[1] "Long SPY profit: "

[1] 0.019

[1] 0.827

[1] "Long SPY profit: "

[1] 0.104

[1] 0.931

[1] "Long SPY profit: "

[1] 0

[1] 0.931

[1] "Short SPY profit: "

[1] 0.026

[1] 0.957

[1] "Long IVV profit: "

[1] -0.03

[1] 0.927

[1] "Short SPY profit: "

[1] 0.001

[1] 0.928

[1] "Long IVV profit: "

[1] 0.013

[1] 0.941

[1] "Long SPY profit: "

[1] -0.01

[1] 0.931

[1] "Short SPY profit: "

[1] -0.02

[1] 0.911

[1] "Long IVV profit: "

[1] 0.039

[1] 0.95

[1] "Long SPY profit: "

[1] 0.009

[1] 0.959

[1] "Long SPY profit: "

[1] -0.042

[1] 0.917

[1] "Short SPY profit: "

[1] -0.032

[1] 0.885

[1] "Long IVV profit: "

[1] 0.046

[1] 0.931

[1] "Long SPY profit: "

[1] -0.039

[1] 0.892

[1] "Short SPY profit: "

[1] 0.01

[1] 0.902

[1] "Long IVV profit: "

[1] 0

[1] 0.902

[1] "Short IVV profit: "

[1] 0.03

[1] 0.932

[1] "Short IVV profit: "

[1] 0.049

[1] 0.981

[1] "Short IVV profit: "

[1] 0.02

[1] 1.001

[1] "Short SPY profit: "

[1] -0.014

[1] 0.987

[1] "Long IVV profit: "

[1] 0.029

[1] 1.016

[1] "Long SPY profit: "

[1] 0.075

[1] 1.091

[1] "Long SPY profit: "

[1] -0.03

[1] 1.061

[1] "Short IVV profit: "

[1] -0.005

[1] 1.056

[1] "Short SPY profit: "

[1] -0.05

[1] 1.006

[1] "Long IVV profit: "

[1] 0.06

[1] 1.066

[1] "Short SPY profit: "

[1] 0.05

[1] 1.116

[1] "Long IVV profit: "

[1] -0.05

[1] 1.066

[1] "Short SPY profit: "

[1] -0.04

[1] 1.026

[1] "Long IVV profit: "

[1] 0.02

[1] 1.046

[1] "Short IVV profit: "

[1] -0.021

[1] 1.025

[1] "Long SPY profit: "

[1] -0.02

[1] 1.005

[1] "Short IVV profit: "

[1] 0.029

[1] 1.034

[1] "Short SPY profit: "

[1] 0.038

[1] 1.072

[1] "Long IVV profit: "

[1] -0.03

[1] 1.042

[1] "Short IVV profit: "

[1] 0

[1] 1.042

[1] "Short IVV profit: "

[1] -0.007

[1] 1.035

[1] "Long SPY profit: "

[1] -0.01

[1] 1.025

[1] "Short SPY profit: "

[1] 0.005

[1] 1.03

[1] "Long IVV profit: "

[1] 0.012

[1] 1.042

[1] "Long SPY profit: "

[1] -0.01

[1] 1.032

[1] "Short IVV profit: "

[1] 0.026

[1] 1.058

[1] "Short SPY profit: "

[1] -0.03

[1] 1.028

[1] "Long IVV profit: "

[1] 0.02

[1] 1.048

[1] "Short IVV profit: "

[1] 0.128

[1] 1.176

[1] "Short SPY profit: "

[1] 0.029

[1] 1.205

[1] "Long IVV profit: "

[1] -0.02

[1] 1.185

[1] "Short SPY profit: "

[1] -0.02

[1] 1.165

[1] "Long IVV profit: "

[1] 0.024

[1] 1.189

[1] "Short SPY profit: "

[1] 0.04

[1] 1.229

[1] "Long IVV profit: "

[1] -0.02

[1] 1.209

[1] "Short IVV profit: "

[1] 0.009

[1] 1.218

[1] "Short IVV profit: "

[1] -0.009

[1] 1.209

[1] "Long SPY profit: "

[1] 0.01

[1] 1.219

[1] "Short SPY profit: "

[1] 0.009

[1] 1.228

[1] "Long IVV profit: "

[1] 0

[1] 1.228

[1] "Short IVV profit: "

[1] -0.009

[1] 1.219

[1] "Long SPY profit: "

[1] -0.02

[1] 1.199

[1] "Short IVV profit: "

[1] -0.039

[1] 1.16

[1] "Long SPY profit: "

[1] 0.004

[1] 1.164

[1] "Long SPY profit: "

[1] 0.045

[1] 1.209

[1] "Long SPY profit: "

[1] 0.02

[1] 1.229

[1] "Long SPY profit: "

[1] 0.02

[1] 1.249

[1] "Long SPY profit: "

[1] 0.001

[1] 1.25

[1] "Short IVV profit: "

[1] 0.049

[1] 1.299

[1] "Short SPY profit: "

[1] -0.046

[1] 1.253

[1] "Long IVV profit: "

[1] 0.049

[1] 1.302

[1] "Short IVV profit: "

[1] 0.03

[1] 1.332

[1] "Short SPY profit: "

[1] -0.06

[1] 1.272

[1] "Long IVV profit: "

[1] 0.06

[1] 1.332

[1] "Short IVV profit: "

[1] 0.02

[1] 1.352

[1] "Short SPY profit: "

[1] -0.02

[1] 1.332

[1] "Long IVV profit: "

[1] 0.02

[1] 1.352

[1] "Short SPY profit: "

[1] -0.022

[1] 1.33

[1] "Long IVV profit: "

[1] 0.02

[1] 1.35

[1] "Short SPY profit: "

[1] 0

[1] 1.35

[1] "Long IVV profit: "

[1] 0.003

[1] 1.353

[1] "Short IVV profit: "

[1] -0.05

[1] 1.303

[1] "Long SPY profit: "

[1] -0.02

[1] 1.283

[1] "Short IVV profit: "

[1] 0.04

[1] 1.323

[1] "Short IVV profit: "

[1] 0.059

[1] 1.382

[1] "Short SPY profit: "

[1] -0.05

[1] 1.332

[1] "Long IVV profit: "

[1] 0.052

[1] 1.384

[1] "Short SPY profit: "

[1] -0.019

[1] 1.365

[1] "Long IVV profit: "

[1] 0.028

[1] 1.393

[1] "Long SPY profit: "

[1] 0.079

[1] 1.472

[1] "Long SPY profit: "

[1] 0.025

[1] 1.497

[1] "Short SPY profit: "

[1] 0.01

[1] 1.507

[1] "Long IVV profit: "

[1] 0

[1] 1.507

[1] "Short IVV profit: "

[1] 0.006

[1] 1.513

[1] "Short SPY profit: "

[1] -0.01

[1] 1.503

[1] "Long IVV profit: "

[1] -0.009

[1] 1.494

[1] "Short IVV profit: "

[1] 0.039

[1] 1.533

[1] "Short SPY profit: "

[1] -0.045

[1] 1.488

[1] "Long IVV profit: "

[1] 0.05

[1] 1.538

[1] "Long SPY profit: "

[1] 0.019

[1] 1.557

[1] "Long SPY profit: "

[1] 0.01

[1] 1.567

[1] "Long SPY profit: "

[1] -0.01

[1] 1.557

[1] "Short SPY profit: "

[1] 0.009

[1] 1.566

[1] "Long IVV profit: "

[1] -0.02

[1] 1.546

[1] "Short SPY profit: "

[1] 0.035

[1] 1.581

[1] "Long IVV profit: "

[1] -0.017

[1] 1.564

[1] "Short IVV profit: "

[1] -0.007

[1] 1.557

[1] "Long SPY profit: "

[1] -0.01

[1] 1.547

[1] "Short SPY profit: "

[1] -0.049

[1] 1.498

[1] "Long IVV profit: "

[1] 0.065

[1] 1.563

[1] "Long SPY profit: "

[1] -0.009

[1] 1.554

[1] "Short IVV profit: "

[1] -0.019

[1] 1.535

[1] "Short IVV profit: "

[1] 0.027

[1] 1.562

[1] "Short SPY profit: "

[1] 0.02

[1] 1.582

[1] "Long IVV profit: "

[1] -0.003

[1] 1.579

[1] "Short IVV profit: "

[1] 0.02

[1] 1.599

[1] "Short IVV profit: "

[1] 0.01

[1] 1.609

[1] "Short IVV profit: "

[1] 0.003

[1] 1.612

[1] "Short IVV profit: "

[1] -0.065

[1] 1.547

[1] "Short IVV profit: "

[1] 0.02

[1] 1.567

[1] "Short IVV profit: "

[1] 0.027

[1] 1.594

[1] "Short SPY profit: "

[1] 0.025

[1] 1.619

[1] "Long IVV profit: "

[1] -0.023

[1] 1.596

[1] "Short IVV profit: "

[1] -0.02

[1] 1.576

[1] "Long SPY profit: "

[1] 0

[1] 1.576

[1] "Long SPY profit: "

[1] 0.039

[1] 1.615

[1] "Long SPY profit: "

[1] 0.109

[1] 1.724

[1] "Long SPY profit: "

[1] -0.023

[1] 1.701

[1] "Short IVV profit: "

[1] 0.021

[1] 1.722

[1] "Short SPY profit: "

[1] 0

[1] 1.722

[1] "Long IVV profit: "

[1] -0.008

[1] 1.714

[1] "Short SPY profit: "

[1] 0

[1] 1.714

[1] "Long IVV profit: "

[1] 0.019

[1] 1.733

[1] "Long SPY profit: "

[1] 0.05

[1] 1.783

[1] "Long SPY profit: "

[1] -0.045

[1] 1.738

[1] "Short IVV profit: "

[1] 0.06

[1] 1.798

[1] 1.798

[1] 46

[1] 23

[1] 0.6666667

[1] 27

[1] 35

[1] 0.4354839

[1] 34

[1] 24

[1] 0.5862069

[1] 43

[1] 23

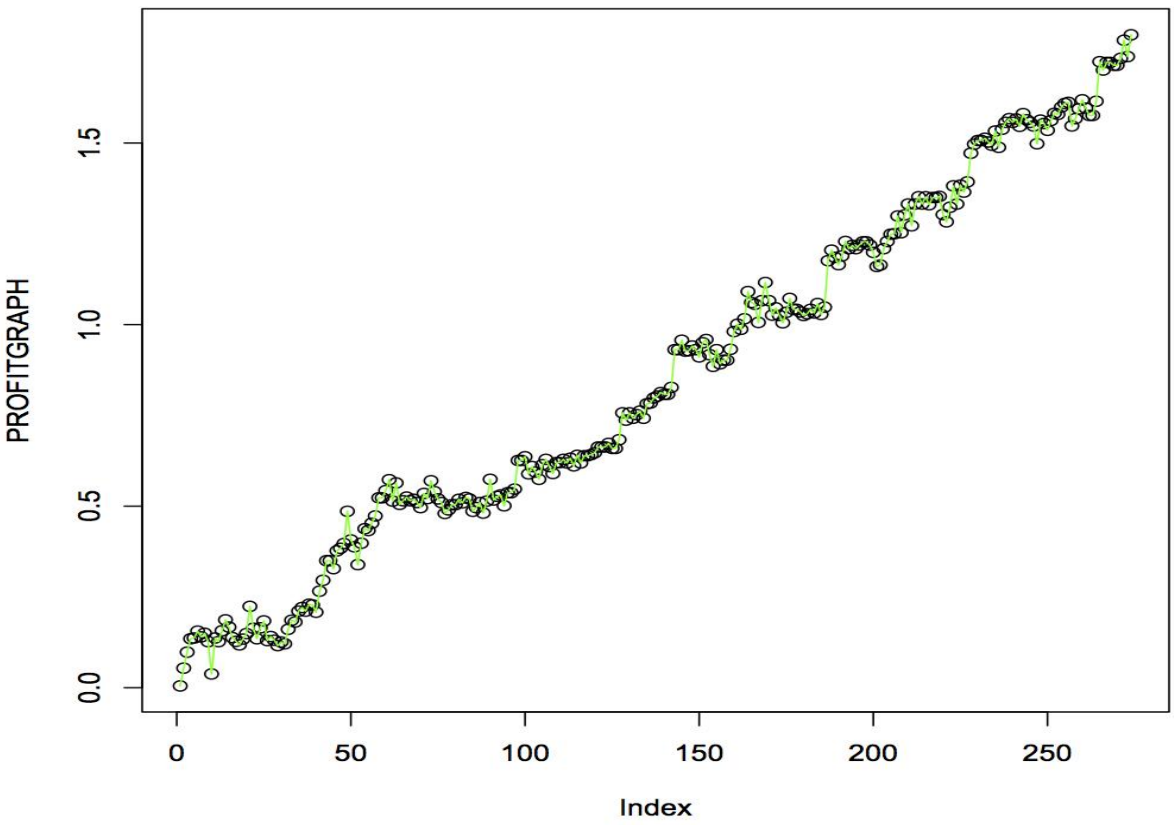
[1] 0.6515152

[1] "TOTAL WIN PERCENTAGE: "

[1] 0.5882353

> plot(PROFITGRAPH) # Plot the graph of profit

> lines(PROFITGRAPH, col="green") # Give the profit graph lines betwen points that are green


PROFITGRAPH
0.0
0.5
1.0
1.5
0
50
100
150
200
250
Index