# Weekly Homework 3 570

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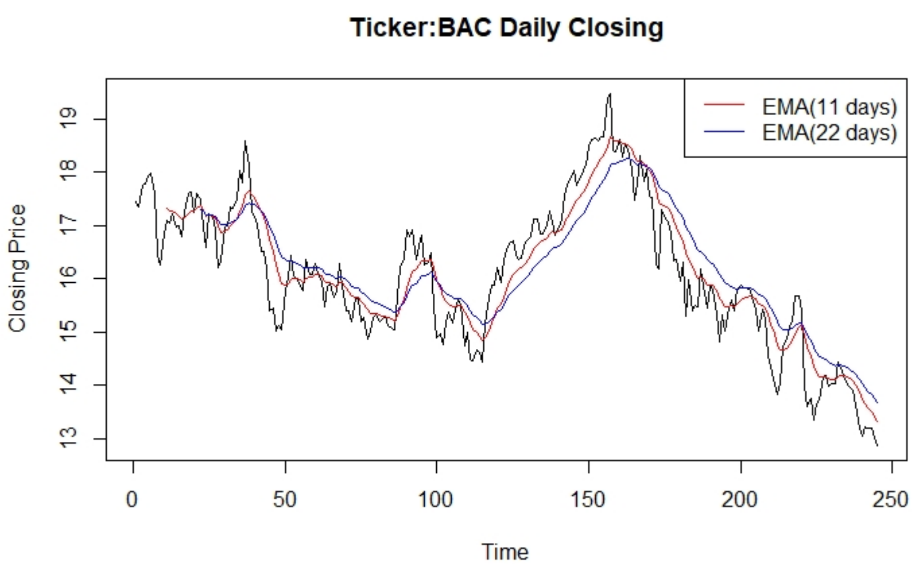
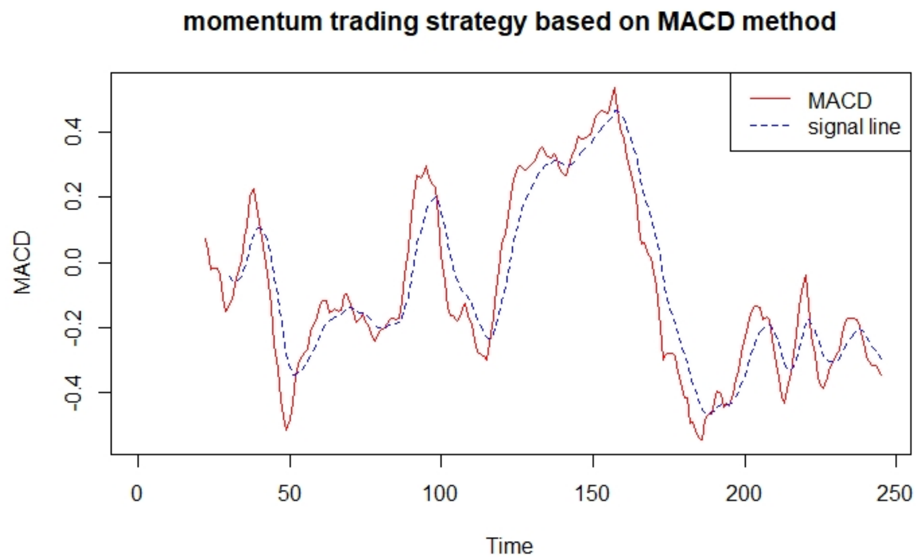
**Problem 1.**

*Solution.*
(1):
Firstly, we derive the EMA(11 days) time series and EMA(22 days) time series




Based on EMA(11 days) and EMA(22 days), we thus have the MACD series and EMA(MACD,9)



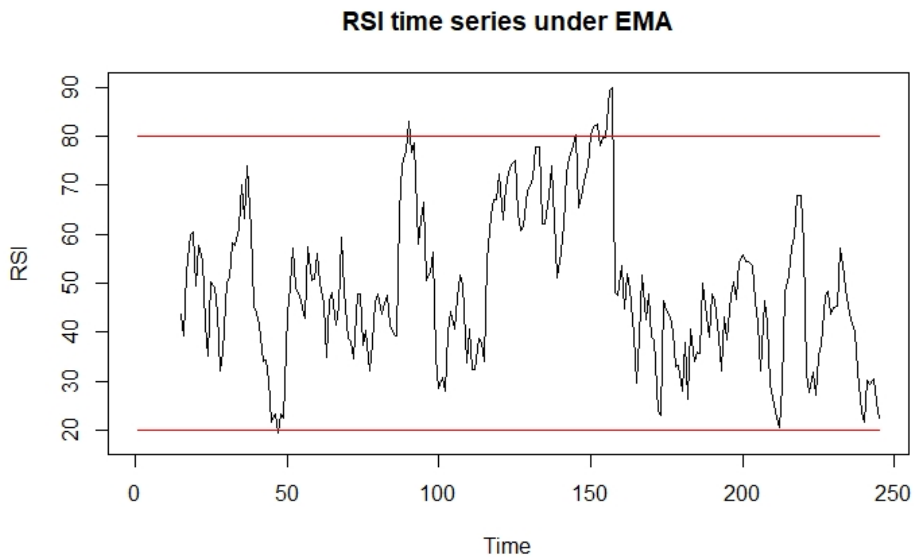

When the MACD falls below the signal line, it is a bearish signal, which indicates that it may be time to sell. Conversely, when the MACD rises above the signal line, the indicator gives a bullish signal, which suggests that the price of the asset is likely to experience upward momentum.

Based on this rules, we can first compare series MACD and series Signal. Assumed that there is a state vector, and we initialize it to be all zero.when MACD[i]>Signal[i], we reset the state[i] equal 1. Conversly, when MACD[i]<Signal[i], we reset the state[i] equal -1. Therefore, in this way, when the MACD rises above the signal line, the difference between state[i] and state[i-1] will be 2,and when MACD falls below the signal line, the difference between state[i] and state[i-1] will be -2. Based on this algorithm, we can thus derive the trading signal for the specified price.

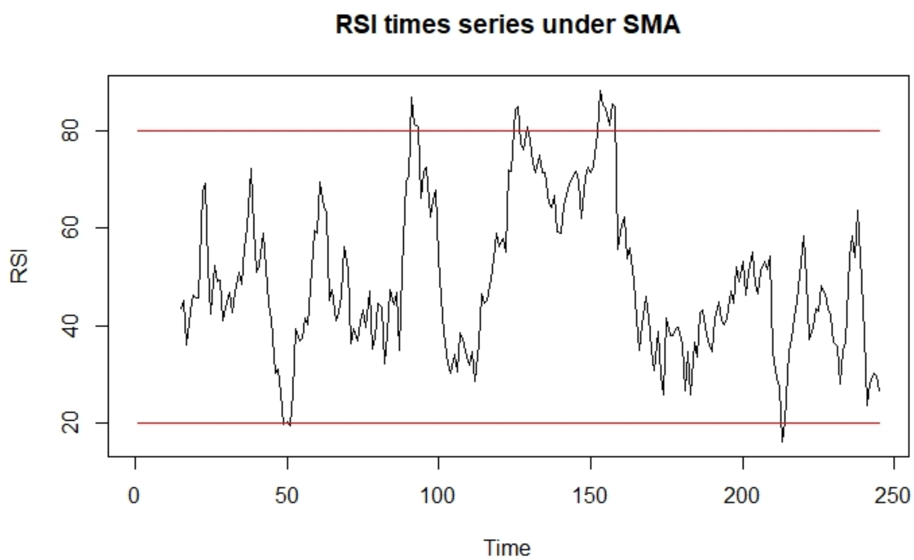
```
> trade_signal
      price_bac trade
 [1,] "17.33"   "buy"
 [2,] "17.01"   "sell"
 [3,] "16.06"   "buy"
 [4,] "15.39"   "sell"
 [5,] "15.25"   "buy"
 [6,] "15.47"   "sell"
 [7,] "15.66"   "buy"
 [8,] "16.82"   "sell"
 [9,] "17.57"   "buy"
[10,] "18.39"   "sell"
[11,] "15.89"   "buy"
[12,] "14.83"   "sell"
[13,] "15.33"   "buy"
[14,] "15.01"   "sell"
[15,] "15.46"   "buy"
[16,] "14.57"   "sell"
[17,] "15.11"   "buy"
[18,] "13.61"   "sell"
[19,] "14.03"   "buy"
[20,] "13.19"   "sell"
```

(2):

RSI under EMA:




RSI under SMA:




An asset is deemed to be overbought once the RSI approaches the 80 level, meaning that it may be getting overvalued and is a good candidate for a pullback. Likewise, if the RSI approaches 20, it is an indication that the asset may be getting oversold and therefore likely to become undervalued.

Based on this rules, we first compared the RSI series with the thresold series. Similarly, we assumed there is a state vector, and we initialize it to be all zero. When RSI[i]>80, we reset state[i] to be -1, and when RSI[i]<20, we reset state[i] to be 1. Therefore, under this setting. Once the RSI approaches the 80 level, state[i]-state[i-1] should equal -1 and state[i-1] should equal 0, and that is a sell signal. Once the RSI approaches 30, state[i]-state[i-1] should equal 1 and state[i-1] should equal 0, and that is a buy signal.

```
> trade_signal1
     price_bac trade1
[1,] "15.01"   "buy"
[2,] "16.93"   "sell"
[3,] "18.04"   "sell"
[4,] "18.49"   "sell"
[5,] "19.4"    "sell"
```

(3):
The RSI curve is similar to the MACD curve. However, we can tell the difference from the trading signals given by this two different method. In my opnion, in this case, MACD will give more signals for the traders which means the traders will have more choice for adjusting the position. This seems more like a shord period investment behavior. However, the signal from RSI is much less than that from MACD. In this way, this seems more like a long period investment behavior. And in general case, i think that MACD will usually give us more signal. In this way, the MACD may be more precise.

**R code attached:**

```
#install.packages("TTR")
library(TTR)

#Problem 1
sp500<-read.table(file.choose(),sep=",",header=TRUE)
head(sp500)
ticker<-sp500$Ticker
index<-which(ticker=="BAC")
price<-sp500$Close
price_bac<-price[index]
n1<-11
n2<-22
beta1<-2/(n1+1)
beta2<-2/(n2+1)

ema.11<-EMA(price_bac,11)
ema.22<-EMA(price_bac,22)
ema.11

#initial value
p0.11<-mean(price_bac[1:11])
p0.22<-mean(price_bac[1:22])

#EMA(11 days)
ema11<-c(rep(NA,10),rep(0,length(price_bac)-10))
ema11[11]<-p0.11
for(i in 12:length(ema11))
{
  ema11[i]<-beta1*price_bac[i]+(1-beta1)*ema11[i-1]
}
ema11
```

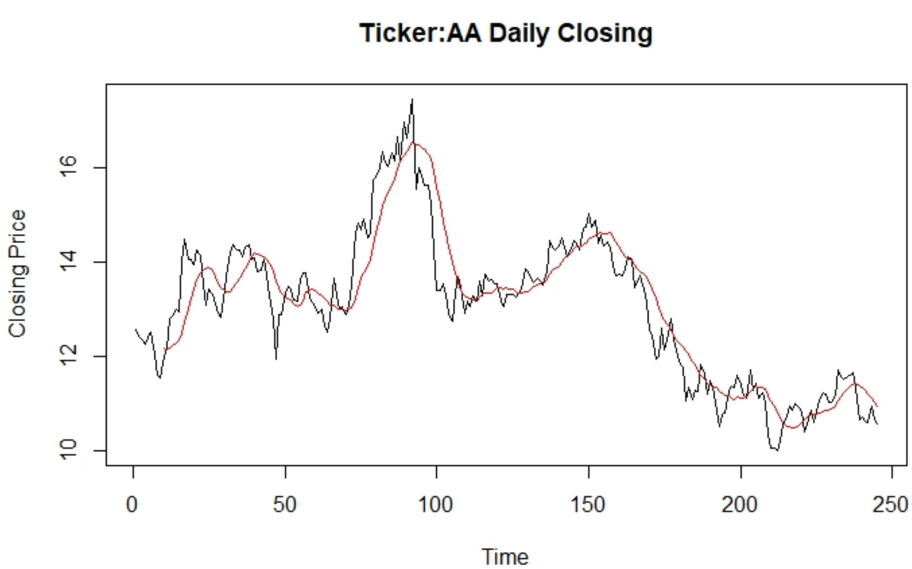
```
#EMA(22 days)
ema22<-c(rep(NA,21),rep(0,length(price_bac)-21))
ema22[22]<-p0.22
for(i in 23:length(ema22))
{
  ema22[i]<-beta2*price_bac[i]+(1-beta2)*ema22[i-1]
}

#MACD
macd<-c(rep(0,length(ema11)))
for(i in 1:length(macd))
{
  macd[i]<-ema11[i]-ema22[i]
}

ts.plot(price_bac,ylab="Closing Price",main="Ticker:BAC Daily Closing")
lines(ema11,col="red")
lines(ema22,col="blue")
legend("topright", lty=c(1,1), col=c("red", "blue"),
       legend=c("EMA(11 days)", "EMA(22 days)"))

signal<-EMA(macd,9)
ts.plot(macd,ylab="MACD",col="red",main="momentum trading strategy based on MACD me
lines(signal,col="blue",lty=2)
legend("topright", lty=c(1,2), col=c("red", "blue"),
       legend=c("MACD", "signal line"))


#trading process
state<-c(rep(0,length(macd)))
for(i in 30:length(macd))
{
  if(macd[i]>signal[i])
  {
    state[i]<-1
  }
  if(macd[i]<signal[i])
  {
    state[i]<--1
  }
}
state
trade<-c(rep(0,length(macd)))
for(i in 31:length(macd))
{
  if((state[i]-state[i-1])==2)
  {
```

```
    trade[i]<-'buy'
  }
  else if((state[i]-state[i-1])==-2)
  {
    trade[i]<-'sell'
  }
}
trade
trade_set<-cbind(price_bac,trade)
trade_signal<-subset(trade_set,trade!=0)
trade_signal


#RSI(price_bac,14)
#RSI under EMA
rsi<-RSI(price_bac,14,maType = EMA)
rsi
ts.plot(rsi,ylim=c(18,90),main="RSI time series under EMA",ylab="RSI")
overbought<-c(rep(80,length(rsi)))
oversold<-c(rep(20,length(rsi)))
lines(overbought,col="red")
lines(oversold,col="red")

#self-coding
#RSI under SMA
nup<-c(rep(NA,14),rep(0,length(price_bac)-14))
ndown<-c(rep(NA,14),rep(0,length(price_bac)-14))
for(j in 15:length(price_bac))
{
for (i in (j-13):(j-1))
{
  if(price_bac[i]>price_bac[i-1])
    nup[j]<-price_bac[i]-price_bac[i-1]+nup[j]
  if(price_bac[i]<price_bac[i-1])
    ndown[j]<-price_bac[i-1]-price_bac[i]+ndown[j]
}
}
rs<-nup/ndown
rsi1<-100*rs/(1+rs)
rsi1
ts.plot(rsi1,main="RSI times series under SMA",ylab="RSI")
lines(overbought,col="red")
lines(oversold,col="red")

#trading process
state1<-c(rep(0,length(rsi)))
for(i in 15:length(rsi))
```

```
{
  if(rsi[i]<20)
    state1[i]<-1
  if(rsi[i]>80)
    state1[i]<--1
}
trade1<-c(rep(0,length(rsi)))
for(i in 15:length(rsi))
{
  if(((state1[i]-state1[i-1])==1)&(state1[i-1]==0))
  {
    trade1[i]<-'buy'
  }
  if(((state1[i]-state1[i-1])==-1)&(state1[i-1]==0))
  {
    trade1[i]<-'sell'
  }
}
trade_set1<-cbind(price_bac,trade1)
trade_signal1<-subset(trade_set1,trade1!=0)
trade_signal1
```

**Problem 2.**

*Solution.*
We first give the simple average of the closing price. And all the following analysis are based on the series $SMA(P_t, 10)$.

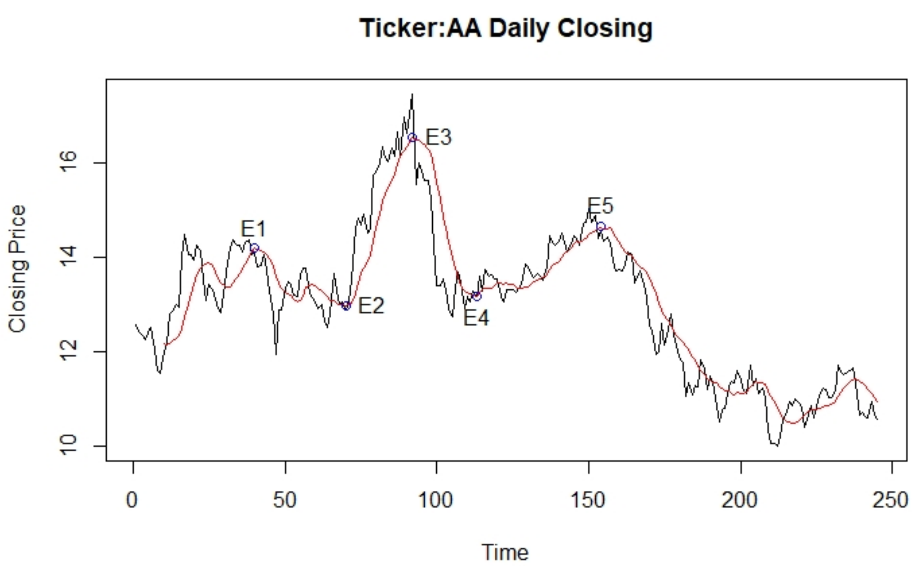



To identify the HAS pattern. In this case, we first find the maxima price in the SMA series which here we assign to be E3. Then we search E2 and E4, E1 and E5 seperatly which means divinding the range by the E3 index. To accompolish this ,we should find all the extreme maxima values and all the extreme minimum values from the left side of E3. Also, we need to search all the extreme maxima values and all the extreme minimum values from the right side of E3. Throught this way, we have many pairs of (E1,E2,E3,E4,E5). Naturally we can choose the maxima in the extreme maximum values in both sides as E1 and E5, and choose the minima in the extreme minimum values in both sides as E2 and E4. In the selected process, we should discard the points on the start or at the very end. In this way, we set the consecutive points as below:

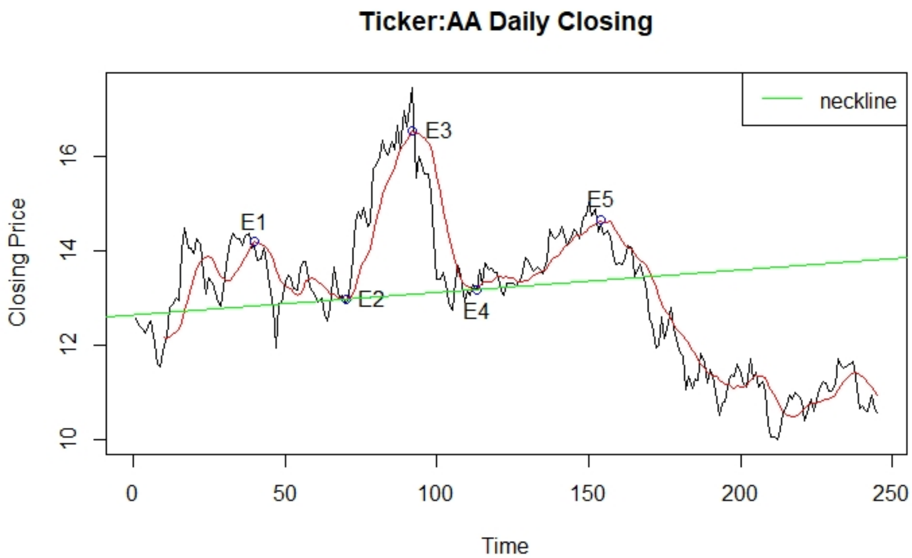
Table 1: HAS pattern

| Point | Time | Price |
|---|---|---|
| E1 | 40 | 14.183 |
| E2 | 70 | 12.972 |
| E3 | 92 | 16.538 |
| E4 | 113 | 13.176 |
| E5 | 154 | 14.611 |

Then we test whether this choice meet the requirement of the HAS pattern. Firstly, E3 is the maixima. E2 and E4 lies in (14.18104,14.61295) which is calculated by (0.985*mean(E2,E4),1.105*mean(E2,
Similarly, E1 and E5 also meet the "1.5 percent" requirement. Therefore, the choice is good enough to identify the HAS pattern.
Point it on the figure:




(2):
Nectline:




(3):
Firstly, the trading strategy is: short at E1, long at E2, short at E3, long at E4, short at E5 and long at price objective.

The price objective is calculated by subtracting the price at which the pattern breaks the neckline by the difference between the head and the neckline.

Baed on this, we first find the time index t about when the price breaks the neckline. Then we use the neckline equation to calcualte the neck value $v_t$ at time t. Thus, the price objective is then equals $v_t$ minus the difference between the head and the neckline which is 9.989535.

**R code attached:**

```
#Problem 2:
index1<-which(ticker=="AA")
price_aa<-price[index1]
ts.plot(price_aa,ylab="Closing Price",main="Ticker:AA Daily Closing")
aamv<-SMA(price_aa,10)
lines(aamv,col="red")
time<-c(1:245)
has<-cbind(time,aamv)
E3index<-has[which.max(has[,2])]

#find E2 and E4 seperately
localmin<-function(ts)
{
  min<-data.frame(time=c(NA),price=c(NA))
  if(ts[1,2]<ts[2,2])
```

```
    min<-rbind(min,ts[1,])
  for(i in 2:(nrow(ts)-1))
  {
    if((ts[i,2]<=ts[(i-1),2]) & (ts[i,2]<=ts[(i+1),2]))
    min<-rbind(min,ts[i,])
  }
  if(ts[nrow(ts),2]<ts[(nrow(ts))-1,2])
    min<-rbind(min,ts[nrow(ts),])
  return(min)
}
min1<-localmin(has[10:E3index,])[-1,]
min2<-localmin(min1)[-1,]
min2
min3<-localmin(has[E3index:nrow(has),])[-1,]
min4<-localmin(min3)[-1,]
min5<-localmin(min4)[-1,]
min5

#find E1 and E5 seperately
localmax<-function(ts)
{
  max<-data.frame(time=c(NA),price=c(NA))
  if(ts[1,2]>ts[2,2])
    max<-rbind(max,ts[1,])
  for(i in 2:(nrow(ts)-1))
  {
    if((ts[i,2]>=ts[(i-1),2]) & (ts[i,2]>=ts[(i+1),2]))
    max<-rbind(max,ts[i,])
  }
  if(ts[nrow(ts),2]>ts[(nrow(ts)-1),2])
    max<-rbind(max,ts[nrow(ts),])
  return(max)
}
max1<-localmax(has[10:E3index,])[-1,]
max2<-localmax(max1)[-1,]
max2
max3<-localmax(has[E3index:nrow(has),])[-1,]
max4<-localmax(max3)[-1,]
max5<-localmax(max4)[-1,]
max5


#setting E1,E2,E3,E4,E5
E1<-c(40,14.183)
E2<-c(70,12.972)
E3<-c(92,16.538)
E4<-c(113,13.176)
```

```
E5<-c(154,14.661)
has_pattern<-data.frame(Time=c(rbind(E1,E2,E3,E4,E5)[,1]),Price=c(rbind(E1,E2,E3,E4
has_pattern

#test
uper1<-(14.183+14.611)*1.015*0.5
lower1<-(14.183+14.611)*0.985*0.5
uper2<-(12.972+13.176)*1.015*0.5
lower2<-(12.972+13.176)*0.985*0.5
c(lower1,uper1)
c(lower2,uper2)
#So the points setting is reasonable.

#label
points(40,14.183,col="blue")
text(40,14.183,pos=3,"E1")
points(70,12.972,col="blue")
text(70,12.972,pos=4,"E2")
points(92,16.538,col="blue")
text(92,16.538,pos=4,"E3")
points(113,13.176,col="blue")
text(113,13.176,pos=1,"E4")
points(154,14.611,col="blue")
text(154,14.611,pos=3,"E5")

#neckline
y<-c(12.972,13.176)
x<-c(70,113)
k<-(y[2]-y[1])/(x[2]-x[1])
c<-12.972-70*k
abline(c,k,col="green")
legend("topright", lty=c(1), col=c("green"),
       legend=c("neckline"))

#price objective
value<-c(1:245)*k+c
thresold<-16.538-92*k-c
breakindex<-which(has[,2]<value&has[,1]>92)[1]
price_objective<-breakindex*k+c-thresold
price_objective
```