

Stat 107: Quantitative Methods for Economics Homework 8:

Due Monday, December 5

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The purpose of this problem is to test two pairs trading strategy. There are many methods to perform pairs trading; for this exercise we will use a method detailed in the paper *Evaluation of Pairs Trading Strategy at the Brazilian Financial Market*, available on the course web site, and the method used by pairslog.com (which unfortunately is currently down).

The most important parts of the Brazilian paper are on pages 6 and 7. The trading idea in the paper is as follows.

- 1) Choose two stocks that you think are related to each other
- 2) Normalize both stock prices
- 3) Trade when the absolute value of difference of the normalized value is larger than some cut-off value d (see his Table 2 for values of d).
- 4) Close out the trades when the difference crosses 0.

For the website pairslog.com they do the following.

- 1) Choose two stocks that you think are related to each other
- 2) Calculate the normalized ratio of closing prices.
- 3) Trade when the normalized value is larger than 2.
- 4) Close out the trades when the ratio crosses 0.
- 5) Note that if you try to match their numbers exactly, pairslog.com divides by the standard deviation for the population, so they divide by n instead of $n-1$ in their standard deviation formula.

Note that there are many variations of these two techniques.

Let's now implement this in R. From pairslog.com we find that AMP/OZM is potentially a good pair of stocks to trade (look the symbols up on Yahoo so you know what there are):

Pair of day: AMP-OZM

03/26/2012

The price ratio of stocks AMP (Ameriprise Financial Inc.) and OZM (Och-Ziff Capital Management Group LLC) is currently at the local extremes above its average. The correlation of these two stocks is very high (long term yearly correlation 75.86%, short term monthly correlation 21.39%) and thus we might assume that the price ratio of both stocks might return to its average. To prosper from this potential setup,

The

website pairslog.com uses a 14 day window to calculate statistics such as means and variance so will use that in our calculations.

The following R code shows how to implement the two methods

Brazilian Method

```
stock1="AMP"
stock2="OZM"
s1=getSymbols(stock1,from = "2010-01-01",auto.assign=FALSE)
s2=getSymbols(stock2,from = "2010-01-01",auto.assign=FALSE)
p1 = Ad(s1)
p2 = Ad(s2)
np1 = (p1-runMean(p1,n=14))/runSD(p1,14)
np2 = (p2-runMean(p2,n=14))/runSD(p2,14)
#Now that we have the normalized date, we form the difference.
ndiff=(np1-np2)
```

We now are ready to implement the pairs trading strategy. When the difference gets too far away from its mean value of 0, a pairs trade is entered as follows:

- If $\text{diff} < -2$, we go long stock1 and short stock2 in equal dollar amounts
- If $\text{diff} > 2$, we short stock1 and go long stock2 in equal dollar amounts
- The trade is closed when the absolute value of the difference crosses zero.

All this would be calculated with end of day prices, or in practice, with prices obtained just before the close of the market.

Here are some example trades:

	AMP.Close	OZM.Close	ndiff
2012-03-08	55.32	9.25	0.63672607
2012-03-09	56.08	9.41	1.07945215
2012-03-12	55.85	9.25	1.23936695
2012-03-13	57.60	9.44	2.31156372
2012-03-14	56.75	9.42	1.21812781
2012-03-15	58.02	9.49	1.73595062
2012-03-16	57.72	9.67	0.08564145
2012-03-19	58.09	9.69	0.08201246
2012-03-20	57.27	9.67	-0.40673004
2012-03-21	57.39	9.69	-0.44928937
2012-03-22	56.49	9.48	-0.11995505
2012-03-23	57.10	9.46	0.35458872
2012-03-26	58.25	9.33	2.15412855
2012-03-27	57.70	9.24	2.00528559
2012-03-28	57.82	9.15	2.43452438

All trades are at the close of market (end of day trades they are called).

- On 3/13 we would short AMP at 57.60 and go long OZM at 9.44
- On 3/20 we would cover AMP at 57.27 and sell OZM at 9.67
- On 3/26 we would short AMP at 58.25 and go long OZM at 9.33

Pairslog.com Method

```
stock1="AMP"  
stock2="OZM"  
s1=getSymbols(stock1,from = "2010-01-01",auto.assign=FALSE)  
s2=getSymbols(stock2,from = "2010-01-01",auto.assign=FALSE)  
rat=C1(s1)/C1(s2)  
nrat=(rat-runMean(rat,14))/runSD(rat,14)
```

We now are ready to implement the pairs trading strategy. When the normalized ratio gets too far away from its mean value of 0, a pairs trade is entered as follows:

- If $nrat < -2$, we go long stock1 and short stock2 in equal dollar amounts
- If $nrat > 2$, we short stock1 and go long stock2 in equal dollar amounts
- The trade is closed when the normalized ratio zero.

All this would be calculated with end of day prices, or in practice, with prices obtained just before the close of the market.

Here are some example trades:

	AMP.Close	OZM.Close	ndiff
2012-03-05	55.54	9.53	0.5865
2012-03-06	54.17	9.02	2.2101
2012-03-07	54.55	9.38	0.2194
2012-03-08	55.32	9.25	1.5825
2012-03-09	56.08	9.41	1.1919
2012-03-12	55.85	9.25	1.6408
2012-03-13	57.60	9.44	1.8302
2012-03-14	56.75	9.42	1.0439
2012-03-15	58.02	9.49	1.5472
2012-03-16	57.72	9.67	0.1981
2012-03-19	58.09	9.69	0.3532
2012-03-20	57.27	9.67	-0.4018
2012-03-21	57.39	9.69	-0.4996
2012-03-22	56.49	9.48	-0.1749
2012-03-23	57.10	9.46	0.6187
2012-03-26	58.25	9.33	2.3221
2012-03-27	57.70	9.24	1.9796
2012-03-28	57.82	9.15	2.0226

All trades are at the close of market (end of day trades they are called).

- On 3/6 we would short AMP at 54.17 and go long OZM at 9.02
- On 3/20 we would cover AMP at 57.27 and sell OZM at 9.67
- We lost 5.4% on AMP but made 7.02% on OZM
- On 3/26 we would short AMP at 58.25 and go long OZM at 9.33

There are four separate deliverables for this problem.

1. Run the two pairs trading strategies on BKEP/DSX from October 2013 to present. To make the coding easier, we did the coding for you! The R function is pairs.trade in the file mypairspack.txt. You will have to slightly modify the code to keep track of the individual trades though.

```
library(quantmod)
library(tseries)
library(PerformanceAnalytics)
# Calculates correlation using 180-day rolling average and then plot
mycor=function(s1,s2) {
  ap1=Ad(getSymbols(s1,auto.assign=FALSE,from="2012-01-02"))
```

```

ap2=Ad(getSymbols(s2,auto.assign=FALSE,from="2012-01-02"))
n=length(ap2) ## this is how many days we want to work with
### some math...we want to start at day 180 and take the
### correlation from day 1 to day 180
### we then continue and stop at day n-179
### store the results in vals
nn=n-179 # nn is the final length of correlation
vals=1:nn # initialize place-holder
for(i in 180:n) {
  p1 = ap1[(i-179):i]
  p2 = ap2[(i-179):i]
  vals[i-179]=cor(p1,p2) # correlation
}
plot(EMA(vals),type="l") # plot the correlation over time
}

```

Calculates co-integration p-values using 180-day rolling average and then plot

```

mycoin=function(s1,s2) {
ap1=Ad(getSymbols(s1,auto.assign=FALSE,from="2012-01-02"))
ap2=Ad(getSymbols(s2,auto.assign=FALSE,from="2012-01-02"))
n=length(ap2)
nn=n-179
vals=1:nn
for(i in 180:n) {
  p1 = ap1[(i-179):i]
  p2 = ap2[(i-179):i]
  fit=lm(p1~-1+p2)
  beta=coef(fit)[1]
  sprd=p1-beta*p2
  sprd=as.numeric(sprd)
  # Augmented Dickey-Fuller Test, Alternative: Stationary. Want to Reject with
  small p-value
  # Want larger than 0.95 (1-p value)
  vals[i-179]=1-adf.test(sprd,alternative="stationary",k=0)$p.value
}
plot(EMA(vals),type="l")
}

```

Calculates the last day cointegration p-value (ADF test) and Correlation, using prior 180 days

```

myvals=function(s1,s2) {
ap1=Ad(getSymbols(s1,auto.assign=FALSE,from="2013-01-02"))
ap2=Ad(getSymbols(s2,auto.assign=FALSE,from="2013-01-02"))
n=length(ap2)
nn=n-179
vals=1:nn

```

```

i=n
p1 = ap1[(i-179):i]
p2 = ap2[(i-179):i]
fit=lm(p1~-1+p2)
beta=coef(fit)[1]
sprd=p1-beta*p2
sprd=as.numeric(sprd)
cat("Cointegration p-value = ",adf.test(sprd,alternative="stationary",k=0)$p
.value,"\n")
cat("Correlation = ",cor(p1,p2),"\n")
}

```

Implement Brazilian Method(diff) and PairsLog.com Method(ratio)

```

pairs.trade <- function(stock1, stock2,from = "2010-01-01", to = Sys.Date(),m
a.days,method,threshold,closeout){
  require(quantmod)

```

```

  x1 <- getSymbols(stock1, auto.assign = F, from = from, to = to)
  x1 <- as.numeric(Ad(x1))

```

```

  x2 <- getSymbols(stock2, auto.assign = F, from = from, to = to)
  x2 <- as.numeric(Ad(x2))

```

```

  if (method == "diff"){
    x1.norm <- (x1 - runMean(x1, n = ma.days))/runSD(x1, ma.days)
    x2.norm <- (x2 - runMean(x2, n = ma.days))/runSD(x2, ma.days)
    out.ts <- x1.norm - x2.norm
  }
  else if (method == "ratio"){
    ts <- x1/x2
    out.ts <- (ts - runMean(ts, n = ma.days))/runSD(ts, ma.days)
  }
  numdays <- length(out.ts)

```

initialize quantities

```

x1.traded = x2.traded = 0
current = "neither"
profit = 0
all.profit=c()
maxprofit = minprofit = numtrades = winners = 0

```

```

for(i in ma.days:numdays){
  # If diff or ratio out of range <-2, then Long x1 and short x2
  if(out.ts[i] < -threshold & current == "neither"){
    x1.traded = (10000/x1[i])
    x2.traded = (-10000/x2[i])
    current = "x2"
    numtrades = numtrades + 1

```

```

#print(paste("Short", stock2, "at", x2[i], "and Long", stock1, "at", x1[i]))
}

if(out.ts[i] > threshold & current == "neither"){
# If diff or ratio out of range >2, then short x1 and Long x2
x1.traded = (-10000/x1[i])
x2.traded = (10000/x2[i])
current = "x1"
numtrades = numtrades + 1
#print(paste("Short", stock1, "at", x1[i], "and Long", stock2, "at", x2[i]))
}

# If current is short X2, it means diff/ratio is <-2 when traded executed, now the sign switches, we should close the trade
# If current is short X1, it means diff/ratio is >+2 when traded executed, now the sign switches, we should close the trade
if((out.ts[i] > 0 & current == "x2") | (out.ts[i] < 0 & current == "x1")){
profit.temp = x1.traded*x1[i] + x2.traded*x2[i]
all.profit=c(all.profit, profit.temp)
profit = profit + profit.temp
winners = winners + (profit.temp > 0)
maxprofit = max(maxprofit,profit.temp)
minprofit = min(minprofit,profit.temp)
x1.traded = 0
x2.traded = 0
current = "neither"
#print(paste("Closeout", stock1, "at", x1[i], "and", stock2, "at", x2[i]))
}
}

# Note: this optional closing out is outside the for loop!
# If x1 is still on trade and we require closeout at the end of the period
# At the end of the loop, i=numdays
if (x1.traded != 0 & closeout == T){
profit.temp = x1.traded*x1[i] + x2.traded*x2[i]
all.profit=c(all.profit, profit.temp)
profit = profit + profit.temp
winners = winners + (profit.temp > 0)
maxprofit = max(maxprofit,profit.temp)
minprofit = min(minprofit,profit.temp)
x1.traded = 0
x2.traded = 0
current = "neither"
}

# Counting issue
if (x1.traded != 0 & closeout == F){
numtrades = numtrades - 1
}

```

```

# average of winning trades and average of losing trades
ave.winning=mean(all.profit[all.profit>0])
ave.losing=mean(all.profit[all.profit<0])

# Sharpe Ratio
sharpe.ratio=mean(all.profit)/sd(all.profit)

# tabulate results as a list
results = list(Winners = winners,
number.of.trades = numtrades,
winning.percentage = 100*winners/numtrades,
max.profit = maxprofit,
min.profit = minprofit,
ave.losing = ave.losing,
ave.winning=ave.winning,
profit = profit,
all.profit=all.profit,
sharpe.ratio=sharpe.ratio
)
return(results)
}

```

- a) Using the last 180 days of data, what is the correlation between the prices of these two securities and are the two securities co-integrated? (report the appropriate pvalue). The R function myvals in the supplied R code file will be useful for this.

```

myvals('BKEP', 'DSX')

## Cointegration p-value = 0.08622883
## Correlation = 0.3228341

```

BKEP and DSX are weakly correlated (0.3228341), and the cointegration p-value (0.08622883) suggests the pairs are almost stationary, therefore, might be suited for pair trading.

- b) How much money total (today) would someone have made if they invested \$10,000 in each short and long position each time ? That is, what was the final profit, assuming they could invest \$10,000 each time? We are assuming not compounding our growth but investing the same fixed amount each time. Note that it is possible your last trade is not closed out by the end of our time perioddecide how to handle that if needed. The default in the code is to close out the trade.

```

# Brazilian Method(diff) and PairsLog.com Method(ratio)
diff.result<-pairs.trade('BKEP', 'DSX',from = "2013-10-01", to = Sys.Date(),ma
.days = 14,method = "diff",threshold = 2,closeout = F)
ratio.result<-pairs.trade('BKEP', 'DSX',from = "2013-10-01", to = Sys.Date(),m
a.days = 14,method = "ratio",threshold = 2,closeout = F)

```



```
cat("The Brazilian Method(diff) approach would result in final profit of $",  
diff.result$profit,'\n')
```

```
## The Brazilian Method(diff) approach would result in final profit of $ 1620  
6.96
```

```
cat("The Pairslog.com Method(ratio) approach would result in final profit of  
$", ratio.result$profit,'\n')
```

```
## The Pairslog.com Method(ratio) approach would result in final profit of $  
13774.83
```

c) How many pair trades triggered? How many were profitable?

```
cat("The Brazilian Method(diff) approach would trigger", diff.result$number.o  
f.trades,'pair trades.', "Among them,", diff.result$Winners, "are profitable.  
\n")
```

```
## The Brazilian Method(diff) approach would trigger 50 pair trades. Among th  
em, 38 are profitable.
```

```
cat("The Pairslog.com Method(ratio) approach would result in final profit of  
$", ratio.result$number.of.trades,'pair trades.', "Among them,", ratio.result  
$Winners, "are profitable.\n")
```

```
## The Pairslog.com Method(ratio) approach would result in final profit of $  
29 pair trades. Among them, 23 are profitable.
```

d) What was the best pair trade? The worst pair trade?

```
cat("For Brazilian Method(diff) approach, the best pair trade made a profit o  
f $", diff.result$max.profit, "the worst pair trade made a profit of $", diff  
.result$min.profit, "\n")
```

```
## For Brazilian Method(diff) approach, the best pair trade made a profit of  
$ 2546.878 the worst pair trade made a profit of $ -3469.686
```

```
cat("For Pairslog.com Method(ratio) approach, the best pair trade made a prof  
it of $", ratio.result$max.profit, "the worst pair trade made a profit of $",  
ratio.result$min.profit, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the best pair trade made a profit  
of $ 2546.878 the worst pair trade made a profit of $ -1625.43
```

e) What was the average of the losing trades and average of the winning trades?

```
cat("For Brazilian Method(diff) approach, the average of the losing trades wa  
s $", diff.result$ave.losing, "the average of the winning trades was $", diff  
.result$ave.winning, "\n")
```

```
## For Brazilian Method(diff) approach, the average of the losing trades was  
$ -933.4322 the average of the winning trades was $ 721.2671
```

```
cat("For Pairslog.com Method(ratio) approach, the average of the losing trades was $", ratio.result$ave.losing, "the average of the winning trades was $", ratio.result$ave.winning, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the average of the losing trades was $ -890.4718 the average of the winning trades was $ 831.2025
```

f) Finally, which pairs trading method would you prefer? Explain.

```
diff.result$number.of.trades
## [1] 50
ratio.result$number.of.trades
## [1] 29
diff.result$winning.percentage
## [1] 76
ratio.result$winning.percentage
## [1] 79.31034
diff.result$sharpe.ratio
## [1] 0.3310241
ratio.result$sharpe.ratio
## [1] 0.521858
diff.result$profit
## [1] 16206.96
ratio.result$profit
## [1] 13774.83
diff.result$profit/diff.result$number.of.trades
## [1] 324.1393
ratio.result$profit/ratio.result$number.of.trades
## [1] 474.994
```

I would prefer Pairslog.com Method(ratio) approach. Because it has triggered less trades, therefore, less transaction costs; higher winning percentage; higher Sharpe Ratio; slightly less final profit, but higher average profit, so the lower total profit is due to less trades in this period, but on average of each trade, the ratio approach performs better.

2. Repeat the steps above with the pair FAS and FAZ. These are ETFs that are designed to have a correlation of -1. See more information about pairs trading ETFs here:
 - a) Using the last 180 days of data, what is the correlation between the prices of these two securities and are the two securities co-integrated? (report the appropriate pvalue). The R function myvals in the supplied R code file will be useful for this.

```
myvals('FAS','FAZ')

## Cointegration p-value = 0.3894959
## Correlation = -0.9460142
```

FAZ and FAS are almost perfectly negatively correlated (-0.9460142), but the Cointegration p-value (0.3894959) suggests non-stationary. So they might not be good for pair trading, as they are not mean-reverting.

- b) How much money total (today) would someone have made if they invested \$10,000 in each short and long position each time ? That is, what was the final profit, assuming they could invest \$10,000 each time? We are assuming not compounding our growth but investing the same fixed amount each time. Note that it is possible your last trade is not closed out by the end of our time period decide how to handle that if needed. The default in the code is to close out the trade.

```
# Brazilian Method(diff) and Pairslog.com Method(ratio)
diff.result<-pairs.trade('FAS','FAZ',from = "2013-10-01", to = Sys.Date(),ma.
days = 14,method = "diff",threshold = 2,closeout = F)
ratio.result<-pairs.trade('FAS','FAZ',from = "2013-10-01", to = Sys.Date(),ma
.days = 14,method = "ratio",threshold = 2,closeout = F)

cat("The Brazilian Method(diff) approach would result in final profit of $",
diff.result$profit,'\n')

## The Brazilian Method(diff) approach would result in final profit of $ 2581
1.12

cat("The Pairslog.com Method(ratio) approach would result in final profit of
$", ratio.result$profit,'\n')

## The Pairslog.com Method(ratio) approach would result in final profit of $
16328.3
```

- c) How many pair trades triggered? How many were profitable?

```
cat("The Brazilian Method(diff) approach would trigger", diff.result$number.o
f.trades,'pair trades.', "Among them,", diff.result$Winners, "are profitable.
\n")

## The Brazilian Method(diff) approach would trigger 75 pair trades. Among th
em, 59 are profitable.
```

```
cat("The Pairslog.com Method(ratio) approach would result in final profit of $", ratio.result$number.of.trades, 'pair trades.', "Among them,", ratio.result$Winners, "are profitable.\n")
```

```
## The Pairslog.com Method(ratio) approach would result in final profit of $ 34 pair trades. Among them, 25 are profitable.
```

d) What was the best pair trade? The worst pair trade?

```
cat("For Brazilian Method(diff) approach, the best pair trade made a profit of $", diff.result$max.profit, "the worst pair trade made a profit of $", diff.result$min.profit, "\n")
```

```
## For Brazilian Method(diff) approach, the best pair trade made a profit of $ 2125.112 the worst pair trade made a profit of $ -4086.32
```

```
cat("For Pairslog.com Method(ratio) approach, the best pair trade made a profit of $", ratio.result$max.profit, "the worst pair trade made a profit of $", ratio.result$min.profit, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the best pair trade made a profit of $ 3532.045 the worst pair trade made a profit of $ -3073.992
```

e) What was the average of the losing trades and average of the winning trades?

```
cat("For Brazilian Method(diff) approach, the average of the losing trades was $", diff.result$ave.losing, "the average of the winning trades was $", diff.result$ave.winning, "\n")
```

```
## For Brazilian Method(diff) approach, the average of the losing trades was $ -1388.786 the average of the winning trades was $ 814.0965
```

```
cat("For Pairslog.com Method(ratio) approach, the average of the losing trades was $", ratio.result$ave.losing, "the average of the winning trades was $", ratio.result$ave.winning, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the average of the losing trades was $ -971.7347 the average of the winning trades was $ 1002.957
```

f) Finally, which pairs trading method would you prefer? Explain.

```
diff.result$number.of.trades
```

```
## [1] 75
```

```
ratio.result$number.of.trades
```

```
## [1] 34
```

```
diff.result$winning.percentage
```

```
## [1] 78.66667
```

```
ratio.result$winning.percentage
```

```
## [1] 73.52941
```

```

diff.result$sharpe.ratio
## [1] 0.2933879
ratio.result$sharpe.ratio
## [1] 0.3875794
diff.result$profit
## [1] 25811.12
ratio.result$profit
## [1] 16328.3
diff.result$profit/diff.result$number.of.trades
## [1] 344.1483
ratio.result$profit/ratio.result$number.of.trades
## [1] 480.2441

```

I would prefer Pairslog.com Method(ratio) approach. Because it has triggered less trades, therefore, less transaction costs; the two winning percentages are not too far off; higher Sharpe Ratio; although significant less final profit, but higher average profit, so the lower total profit is due to less trades in this period, but on average of each trade, the ratio approach performs better.

-
3. Repeat the steps above with the pair DPW and EVM. The results should be pretty good for this pair. Look up DPW on finance.yahoo.com. Does it look like a stock that would be easy to trade in a pairs trading strategy (that is, could you short it, or purchase it in volume?).
 - a) Using the last 180 days of data, what is the correlation between the prices of these two securities and are the two securities co-integrated? (report the appropriate pvalue). The R function myvals in the supplied R code file will be useful for this.

```

myvals('DPW', 'EVM')
## Cointegration p-value = 0.06656226
## Correlation = 0.2877883

```

DPW and EVM are weakly correlated(0.2877883), and the Cointegration p-value (0.06656226) suggests almost stationary. So they might be suited for pair trading, as they are mean-reverting.

- b) How much money total (today) would someone have made if they invested \$10,000 in each short and long position each time ? That is, what was the final profit, assuming they could invest \$10,000 each time? We are assuming not

compounding our growth but investing the same fixed amount each time. Note that it is possible your last trade is not closed out by the end of our time period decide how to handle that if needed. The default in the code is to close out the trade.

```
# Brazilian Method(diff) and Pairslog.com Method(ratio)
diff.result<-pairs.trade('DPW','EVM',from = "2013-10-01", to = Sys.Date(),ma.
days = 14,method = "diff",threshold = 2,closeout = F)
ratio.result<-pairs.trade('DPW','EVM',from = "2013-10-01", to = Sys.Date(),ma
.days = 14,method = "ratio",threshold = 2,closeout = F)

cat("The Brazilian Method(diff) approach would result in final profit of $",
diff.result$profit,'\n')

## The Brazilian Method(diff) approach would result in final profit of $ 5204
1.03

cat("The Pairslog.com Method(ratio) approach would result in final profit of
$", ratio.result$profit,'\n')

## The Pairslog.com Method(ratio) approach would result in final profit of $
34883.12
```

c) How many pair trades triggered? How many were profitable?

```
cat("The Brazilian Method(diff) approach would trigger", diff.result$number.o
f.trades,'pair trades.', "Among them,", diff.result$Winners, "are profitable.
\n")

## The Brazilian Method(diff) approach would trigger 54 pair trades. Among th
em, 43 are profitable.

cat("The Pairslog.com Method(ratio) approach would result in final profit of
$", ratio.result$number.of.trades,'pair trades.', "Among them,", ratio.result
$Winners, "are profitable.\n")

## The Pairslog.com Method(ratio) approach would result in final profit of $
32 pair trades. Among them, 25 are profitable.
```

d) What was the best pair trade? The worst pair trade?

```
cat("For Brazilian Method(diff) approach, the best pair trade made a profit o
f $", diff.result$max.profit, "the worst pair trade made a profit of $", diff
.result$min.profit, "\n")

## For Brazilian Method(diff) approach, the best pair trade made a profit of
$ 6280.216 the worst pair trade made a profit of $ -3588.285

cat("For Pairslog.com Method(ratio) approach, the best pair trade made a prof
it of $", ratio.result$max.profit, "the worst pair trade made a profit of $",
ratio.result$min.profit, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the best pair trade made a profit  
of $ 5706.487 the worst pair trade made a profit of $ -6050.799
```

e) What was the average of the losing trades and average of the winning trades?

```
cat("For Brazilian Method(diff) approach, the average of the losing trades wa  
s $", diff.result$ave.losing, "the average of the winning trades was $", diff  
.result$ave.winning, "\n")
```

```
## For Brazilian Method(diff) approach, the average of the losing trades was  
$ -1107.889 the average of the winning trades was $ 1493.67
```

```
cat("For Pairslog.com Method(ratio) approach, the average of the losing trade  
s was $", ratio.result$ave.losing, "the average of the winning trades was $",  
ratio.result$ave.winning, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the average of the losing trades  
was $ -1505.059 the average of the winning trades was $ 1816.741
```

f) Finally, which pairs trading method would you prefer? Explain.

```
diff.result$number.of.trades  
## [1] 54  
ratio.result$number.of.trades  
## [1] 32  
diff.result$winning.percentage  
## [1] 79.62963  
ratio.result$winning.percentage  
## [1] 78.125  
diff.result$sharpe.ratio  
## [1] 0.4897588  
ratio.result$sharpe.ratio  
## [1] 0.5130075  
diff.result$profit  
## [1] 52041.03  
ratio.result$profit  
## [1] 34883.12  
diff.result$profit/diff.result$number.of.trades  
## [1] 963.7228
```

```
ratio.result$profit/ratio.result$number.of.trades  
## [1] 1090.098
```

I would prefer Pairslog.com Method(ratio) approach. Because it has triggered less trades, therefore, less transaction costs; the two winning percentages are not too far off; higher Sharpe Ratio; although significant less final profit, but higher average profit, so the lower total profit is due to less trades in this period, but on average of each trade, the ratio approach performs better.

DPW doesn't look like easy to short in volume, there are only 3.86k shares short, it might be not enough trading volume on a daily basis so that one can easily enter and exit a trade without affecting the price severely; in addition, the price of DPW is less than \$1, but one can't short stocks priced under \$1. Therefore, technically this pair is not suitable for trading, although previous analysis suggested otherwise.

-
4. Repeat the steps above with the randomly chosen pair BECN and GOV. This pair is not highly correlated and hence not a good candidate for pairs trading. What do the trading results look like for a pair that is probably not mean reverting? Report the same items as above.
- a) Using the last 180 days of data, what is the correlation between the prices of these two securities and are the two securities co-integrated? (report the appropriate pvalue). The R function myvals in the supplied R code file will be useful for this.

```
myvals('BECN','GOV')  
## Cointegration p-value = 0.9621805  
## Correlation = 0.537037
```

BECN and GOV are moderately correlated(0.537037), but the Cointegration p-value (0.9621805) suggests strong evidence of non-stationary. So they might be not suited for pair trading, as they are not mean-reverting.

- b) How much money total (today) would someone have made if they invested \$10,000 in each short and long position each time ? That is, what was the final profit, assuming they could invest \$10,000 each time? We are assuming not compounding our growth but investing the same fixed amount each time. Note that it is possible your last trade is not closed out by the end of our time perioddecide how to handle that if needed. The default in the code is to close out the trade.

```
# Brazilian Method(diff) and PairsLog.com Method(ratio)  
diff.result<-pairs.trade('BECN','GOV',from = "2013-10-01", to = Sys.Date(),ma  
.days = 14,method = "diff",threshold = 2,closeout = F)  
ratio.result<-pairs.trade('BECN','GOV',from = "2013-10-01", to = Sys.Date(),m  
a.days = 14,method = "ratio",threshold = 2,closeout = F)
```



```
cat("The Brazilian Method(diff) approach would result in final profit of $",  
diff.result$profit,'\n')
```

```
## The Brazilian Method(diff) approach would result in final profit of $ -450  
8.912
```

```
cat("The Pairslog.com Method(ratio) approach would result in final profit of  
$", ratio.result$profit,'\n')
```

```
## The Pairslog.com Method(ratio) approach would result in final profit of $  
-5614.852
```

c) How many pair trades triggered? How many were profitable?

```
cat("The Brazilian Method(diff) approach would trigger", diff.result$number.o  
f.trades,'pair trades.', "Among them,", diff.result$Winners, "are profitable.  
\n")
```

```
## The Brazilian Method(diff) approach would trigger 34 pair trades. Among th  
em, 20 are profitable.
```

```
cat("The Pairslog.com Method(ratio) approach would result in final profit of  
$", ratio.result$number.of.trades,'pair trades.', "Among them,", ratio.result  
$Winners, "are profitable.\n")
```

```
## The Pairslog.com Method(ratio) approach would result in final profit of $  
32 pair trades. Among them, 13 are profitable.
```

d) What was the best pair trade? The worst pair trade?

```
cat("For Brazilian Method(diff) approach, the best pair trade made a profit o  
f $", diff.result$max.profit, "the worst pair trade made a profit of $", diff  
.result$min.profit, "\n")
```

```
## For Brazilian Method(diff) approach, the best pair trade made a profit of  
$ 833.2834 the worst pair trade made a profit of $ -2227.109
```

```
cat("For Pairslog.com Method(ratio) approach, the best pair trade made a prof  
it of $", ratio.result$max.profit, "the worst pair trade made a profit of $",  
ratio.result$min.profit, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the best pair trade made a profit  
of $ 612.47 the worst pair trade made a profit of $ -2227.109
```

e) What was the average of the losing trades and average of the winning trades?

```
cat("For Brazilian Method(diff) approach, the average of the losing trades wa  
s $", diff.result$ave.losing, "the average of the winning trades was $", diff  
.result$ave.winning, "\n")
```

```
## For Brazilian Method(diff) approach, the average of the losing trades was  
$ -705.4855 the average of the winning trades was $ 268.3942
```

```
cat("For Pairslog.com Method(ratio) approach, the average of the losing trades was $", ratio.result$ave.losing, "the average of the winning trades was $", ratio.result$ave.winning, "\n")
```

```
## For Pairslog.com Method(ratio) approach, the average of the losing trades was $ -526.7208 the average of the winning trades was $ 337.911
```

f) Finally, which pairs trading method would you prefer? Explain.

```
diff.result$number.of.trades
## [1] 34
ratio.result$number.of.trades
## [1] 32
diff.result$winning.percentage
## [1] 58.82353
ratio.result$winning.percentage
## [1] 40.625
diff.result$sharpe.ratio
## [1] -0.2227463
ratio.result$sharpe.ratio
## [1] -0.296581
diff.result$profit
## [1] -4508.912
ratio.result$profit
## [1] -5614.852
diff.result$profit/diff.result$number.of.trades
## [1] -132.6151
ratio.result$profit/ratio.result$number.of.trades
## [1] -175.4641
```

I would prefer Brazilian Method(diff) approach, as it would incur less loss. All the other measures are similar for the two approaches, except for Sharpe Ratio is meaningless for negative average profits. For a pair that is not mean-reverting, the trading result would more likely to loss money, rather than making any profits, both in long run and in single trade. Therefore, we should not pair-trade two securities that are not stationary/mean-reverting.