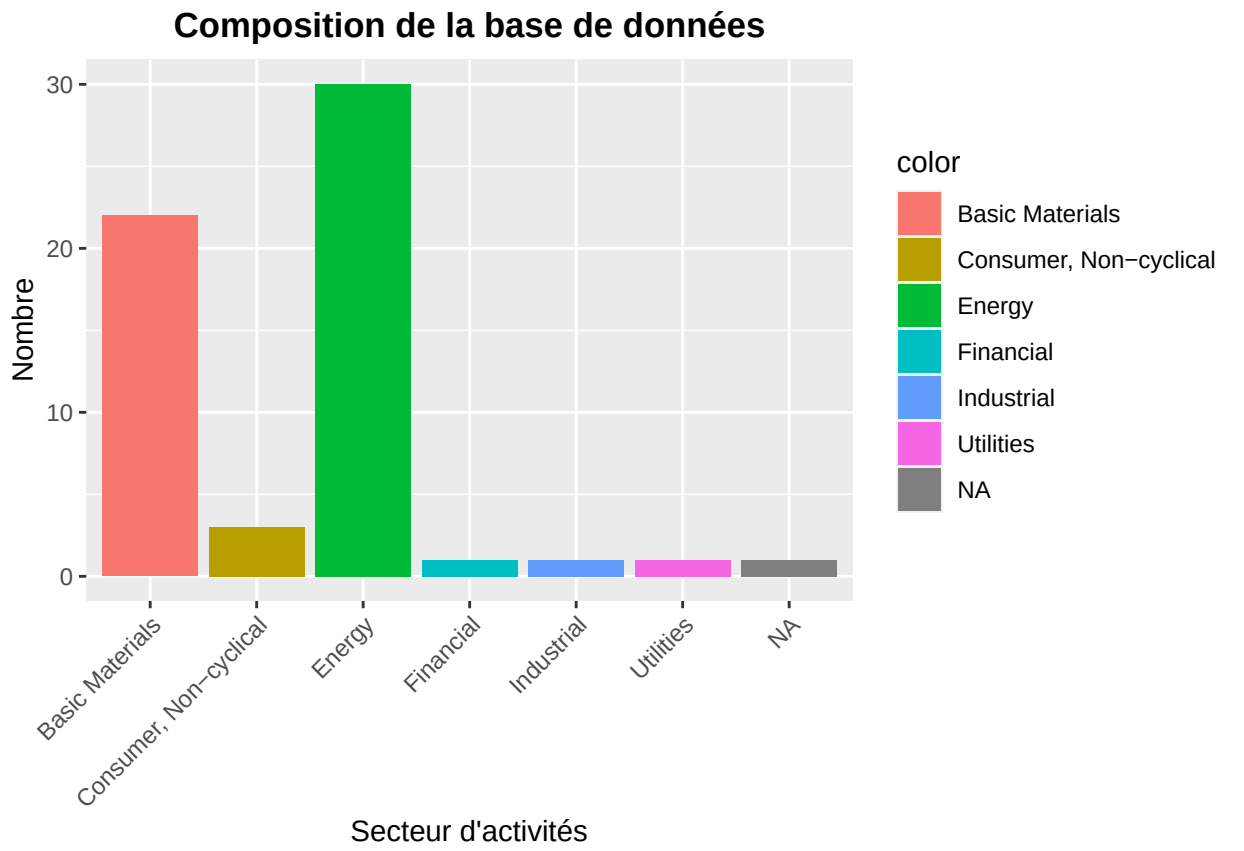
Partie 1

```
#install.packages("psych")
#install.packages(c("FactoMineR", "factoextra"))
#install.packages("moments")
#install.packages("tidyquant")
#install.packages("zoo")
#install.packages("tidyverse")
#install.packages("ggplot2")
#install.packages("panelr")
#install.packages("devtools")
#install.packages("PerformanceAnalytics")
#install.packages("imputeTS")
#install.packages("Matrix")
#install.packages("tidyquant")
#install.packages("Hmisc")
#install.packages("gridExtra")
#install.packages("tseries")
```

```
Returns <- read_excel('data/Data_projet.xlsx', sheet ='Returns')
Returns_p <- read_excel('data/Data_projet.xlsx', sheet ='Returns')#data utilisé pour construire le pane

stock <- read_excel('data/Data_Projet.xlsx', sheet = "List")

#replace NA values in all numeric columns with respective medians
Returns <- Returns %>% mutate(across(where(is.numeric), ~replace_na(., median(., na.rm=TRUE))))
Returns_p <- Returns_p %>% mutate(across(where(is.numeric), ~replace_na(., median(., na.rm=TRUE))))
#Conversion en datetime
Returns$Dates <- as.Date(Returns$Dates)
Returns <- xts(Returns[,3:59], order.by=Returns$Dates)

#Data_Projet_EBITA_MARGIN <- read_excel("Data_Projet.xlsx", sheet = "EBITA_MARGIN")
#Data_Projet_EV <- read_excel("Data_Projet.xlsx", sheet = "EV")
#Data_Projet_ROIC <- read_excel("Data_Projet.xlsx", sheet = "ROIC")
#Data_Projet_WACC <- read_excel("Data_Projet.xlsx", sheet = "WACC")
#Data_Projet_ESG <- read_excel("Data_Projet.xlsx", sheet = "ESG_Score_from_Bloomberg")
```

```
stock %>%
  count(INDUSTRY_SECTOR, color = INDUSTRY_SECTOR) %>%
  ggplot(aes(x = INDUSTRY_SECTOR, y = n, fill = color)) +
  geom_bar(stat = "identity") +
  theme(plot.title = element_text(hjust = 0.5, face = "bold"),
        axis.text.x = element_text(angle = 45, hjust = 1)) +
  ggtitle("Composition de la base de données") +
  xlab("Secteur d'activités") +
  ylab("Nombre")
```



Question 1) Analyse et Statistique descriptive _____

Analyse Statistique descriptive (moyenne, écart-type, skewness,kurtosis, histogramme,etc.) de chaque action (à l'aide de données de panel)

```
# _____________  etape 1: Construction de données de panel _____________

test_DF = Returns_p[,2:58]
require(reshape2)
require(PerformanceAnalytics)

Custom_Melt_DataFrame = function(test_data = test_DF ,dateColumnName = c("Dates Future"), columnOfInter
  molten_DF = melt(test_data,dateColumnName,stringsAsFactors=FALSE)
  colnames(molten_DF) = c(dateColumnName,columnOfInterest1,columnOfInterest2)
  molten_DF[,columnOfInterest1] = as.character(molten_DF[,columnOfInterest1])
  molten_DF$index =  rep(1:(ncol(test_data)-1),each=nrow(test_data))
  molten_DF = molten_DF[,c("index",columnOfInterest1,dateColumnName,columnOfInterest2)]
  return(molten_DF)
}

custom_data = Custom_Melt_DataFrame(test_data = test_DF ,dateColumnName = c("Dates Future"), columnOfIn

custom_data$`Dates Future`<-as.Date(custom_data$`Dates Future`)
class(custom_data$`Dates Future`)
```

```
## [1] "Date"
```

```
custom_data$return<-as.numeric(unlist(custom_data$return))

custom_data<- pdata.frame(custom_data, index = c("index"), drop.index = TRUE)
custom_data <- panel_data(custom_data, id = equities, wave = Dates.Future)
custom_data <-na.omit(custom_data)
head(custom_data)  #Affichage de panel-data
```

```
## # Panel data:    6 x 3
## # entities:      equities [1]
## # wave variable: Dates.Future [2017-10-31, 2017-11-30, 2017-12-31, ... (6
## #   waves)]
##   equities                       Dates.Future   return
##   <fct>                          <date>          <dbl>
## 1 AA US Equity - Basic Materials 2017-10-31     2.49
## 2 AA US Equity - Basic Materials 2017-11-30   -13.1
## 3 AA US Equity - Basic Materials 2017-12-31    29.8
## 4 AA US Equity - Basic Materials 2018-01-31    -3.43
## 5 AA US Equity - Basic Materials 2018-02-28   -13.6
## 6 AA US Equity - Basic Materials 2018-03-31    -0.0222
```

```
#Test de normalité de Jarque Berra

high_cols <- c()
low_cols <- c()
result <- apply(Returns[,3:ncol(Returns)], 2, jarque.bera.test)

for(i in 1:length(result)){
  if(result[[i]]$p.value > 0.05){
    high_cols <- c(high_cols, colnames(Returns)[i+2])
  }else{
    low_cols <- c(low_cols, colnames(Returns)[i+2])
  }
}
#high_cols #les titres avec une pevalue eleve
#low_cols

result  #visualisation des resultat du test
```

```
## $`IP US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 2.2244, df = 2, p-value = 0.3288
##
##
## $`UPM FH Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
```

```
## X-squared = 1.3711, df = 2, p-value = 0.5038
##
##
## $`NEM US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 8.8329, df = 2, p-value = 0.01208
##
##
## $`XOM US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 1.5487, df = 2, p-value = 0.461
##
##
## $`VLO US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 4.5686, df = 2, p-value = 0.1018
##
##
## $`NUE US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 2.8867, df = 2, p-value = 0.2361
##
##
## $`ABX CT Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 23.244, df = 2, p-value = 8.967e-06
##
##
## $`FMC US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.77641, df = 2, p-value = 0.6783
##
##
## $`FCX US Equity - Basic Materials`
##
##  Jarque Bera Test
```

```
##
## data:  newX[, i]
## X-squared = 0.59431, df = 2, p-value = 0.7429
##
##
## $`TTE FP Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 159.83, df = 2, p-value < 2.2e-16
##
##
## $`COP US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 11.076, df = 2, p-value = 0.003935
##
##
## $`ADM US Equity - Consumer, Non-cyclical`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 2.9709, df = 2, p-value = 0.2264
##
##
## $`PKX US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.43428, df = 2, p-value = 0.8048
##
##
## $`BHP US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 1.4334, df = 2, p-value = 0.4884
##
##
## $`TECK/B CT Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 2.9295, df = 2, p-value = 0.2311
##
##
## $`RIO US Equity - Basic Materials`
```

```
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.34005, df = 2, p-value = 0.8436
##
##
## $`WIL SP Equity - Consumer, Non-cyclical`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.76575, df = 2, p-value = 0.6819
##
##
## $`MNDI LN Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.58092, df = 2, p-value = 0.7479
##
##
## $`AAL LN Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.74254, df = 2, p-value = 0.6899
##
##
## $`CVE CT Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 85.676, df = 2, p-value < 2.2e-16
##
##
## $`ALA CT Equity - Utilities`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 37.106, df = 2, p-value = 8.761e-09
##
##
## $`WLK US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 7.2189, df = 2, p-value = 0.02707
##
```

```
##
## $`GLEN LN Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 25.506, df = 2, p-value = 2.894e-06
##
##
## $`MOS US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 2.7735, df = 2, p-value = 0.2499
##
##
## $`MPC US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 24.353, df = 2, p-value = 5.149e-06
##
##
## $`PSX US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 4.3782, df = 2, p-value = 0.112
##
##
## $`WY US Equity - Financial`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 6.5933, df = 2, p-value = 0.03701
##
##
## $`ET US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 365.84, df = 2, p-value < 2.2e-16
##
##
## $`VNOM UW Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
```

```
## X-squared = 49.317, df = 2, p-value = 1.954e-11
##
##
## $`SUN US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 371.95, df = 2, p-value < 2.2e-16
##
##
## $`WRK US Equity - Industrial`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 1.7367, df = 2, p-value = 0.4196
##
##
## $`PBA US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 168.89, df = 2, p-value < 2.2e-16
##
##
## $`AA US Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 1.3319, df = 2, p-value = 0.5138
##
##
## $`MTS SQ Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.43324, df = 2, p-value = 0.8052
##
##
## $`NTR CT Equity - Basic Materials`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 2.1607, df = 2, p-value = 0.3395
##
##
## $`NTR US Equity - Basic Materials`
##
##  Jarque Bera Test
```

```
##
## data:  newX[, i]
## X-squared = 2.3063, df = 2, p-value = 0.3156
##
##
## $`OXY US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 26.959, df = 2, p-value = 1.399e-06
##
##
## $`OKE US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 306.44, df = 2, p-value < 2.2e-16
##
##
## $`CVX US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 5.9095, df = 2, p-value = 0.05209
##
##
## $`PXD US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 8.9286, df = 2, p-value = 0.01151
##
##
## $`TRGP US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 226.54, df = 2, p-value < 2.2e-16
##
##
## $`SLB US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 11.501, df = 2, p-value = 0.00318
##
##
## $`BKR US Equity - Energy`
```

```
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 0.44581, df = 2, p-value = 0.8002
##
##
## $`DVN US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 41.887, df = 2, p-value = 8.022e-10
##
##
## $`HES US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 7.9552, df = 2, p-value = 0.01873
##
##
## $`MRO US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 58.62, df = 2, p-value = 1.865e-13
##
##
## $`WMB US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 19.646, df = 2, p-value = 5.418e-05
##
##
## $`CTRA US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 6.1421, df = 2, p-value = 0.04637
##
##
## $`APA US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 1577.8, df = 2, p-value < 2.2e-16
##
```

```
##
## $`EOG US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 5.1835, df = 2, p-value = 0.07489
##
##
## $`KMI US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 12.558, df = 2, p-value = 0.001875
##
##
## $`EQT US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 261.68, df = 2, p-value < 2.2e-16
##
##
## $`HAL US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 14.49, df = 2, p-value = 0.0007137
##
##
## $`FANG US Equity - Energy`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 46.433, df = 2, p-value = 8.263e-11
##
##
## $`S5ENRS Index -`
##
##  Jarque Bera Test
##
## data:  newX[, i]
## X-squared = 10.473, df = 2, p-value = 0.005318
```

- Autocorrelation des series de returns (analyse faite en amont)

```
#for (i in 3:ncol(Returns)){
#acf_result <- acf(Returns[,i])

# Plot autocorrelation function
```

```r
#plot(acf_result)
#}
```

```r
#_____________  etape2: statistique descriptive stickées dans un table  _____________

stat_descriptive = custom_data %>%
  group_by(equities) %>%
  summarise(Minimum = round(min(return), digits = 4),
            Maximum = round(max(return), digits = 4),
            Moyenne = round(mean(return), digits = 4),
            Variance = round(var(return), digits = 4),
            Volatilite = round(sd(return), digits = 4),
            Kurtosis = round(kurtosis(return), digits = 4),
            Skewness = round(skewness(return), digits = 4))

stat_descriptive
```

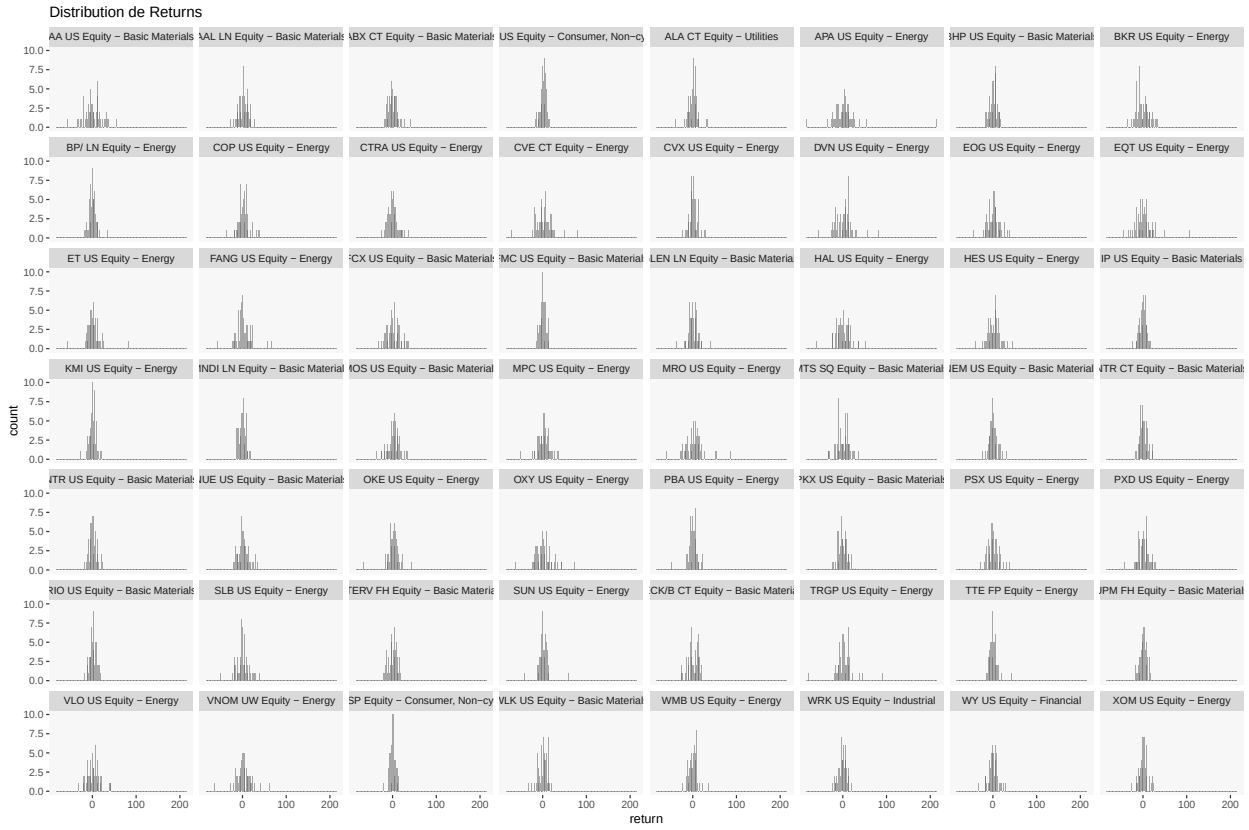
```
## # A tibble: 56 x 8
##    equities        Minimum Maximum Moyenne Variance Volatilite Kurtosis Skewness
##    <fct>             <dbl>   <dbl>   <dbl>    <dbl>      <dbl>    <dbl>    <dbl>
##  1 AA US Equity --~   -55.6    54.0   1.40     370.       19.2    0.600   -0.0495
##  2 AAL LN Equity ~   -27.1    26.1   1.92     111.       10.5   -0.116   -0.266
##  3 ABX CT Equity ~   -19.5    41.1   0.645    114.       10.7    2.11     0.982
##  4 ADM US Equity ~   -15.2    15.1   1.53      44.1       6.64  -0.0072  -0.530
##  5 ALA CT Equity ~   -39.4    33.6   0.771    115.       10.7    3.61    -0.186
##  6 APA US Equity ~   -83.2   214.    4.15    1133.       33.7   23.0      3.73
##  7 BHP US Equity ~   -15.8    17.1   1.55      67.1       8.19  -0.633   -0.253
##  8 BKR US Equity ~   -34.7    32.9   0.326    203.       14.2   -0.326    0.171
##  9 BP/ LN Equity ~   -17.4    32.6   0.341     67.5       8.22   2.54     0.682
## 10 COP US Equity ~   -36.4    38.2   2.22     157.       12.5    1.81     0.361
## # ... with 46 more rows
```

```r
#Returns<-na.omit(Returns)
#Returns<-as.numeric(unlist(Returns))
```

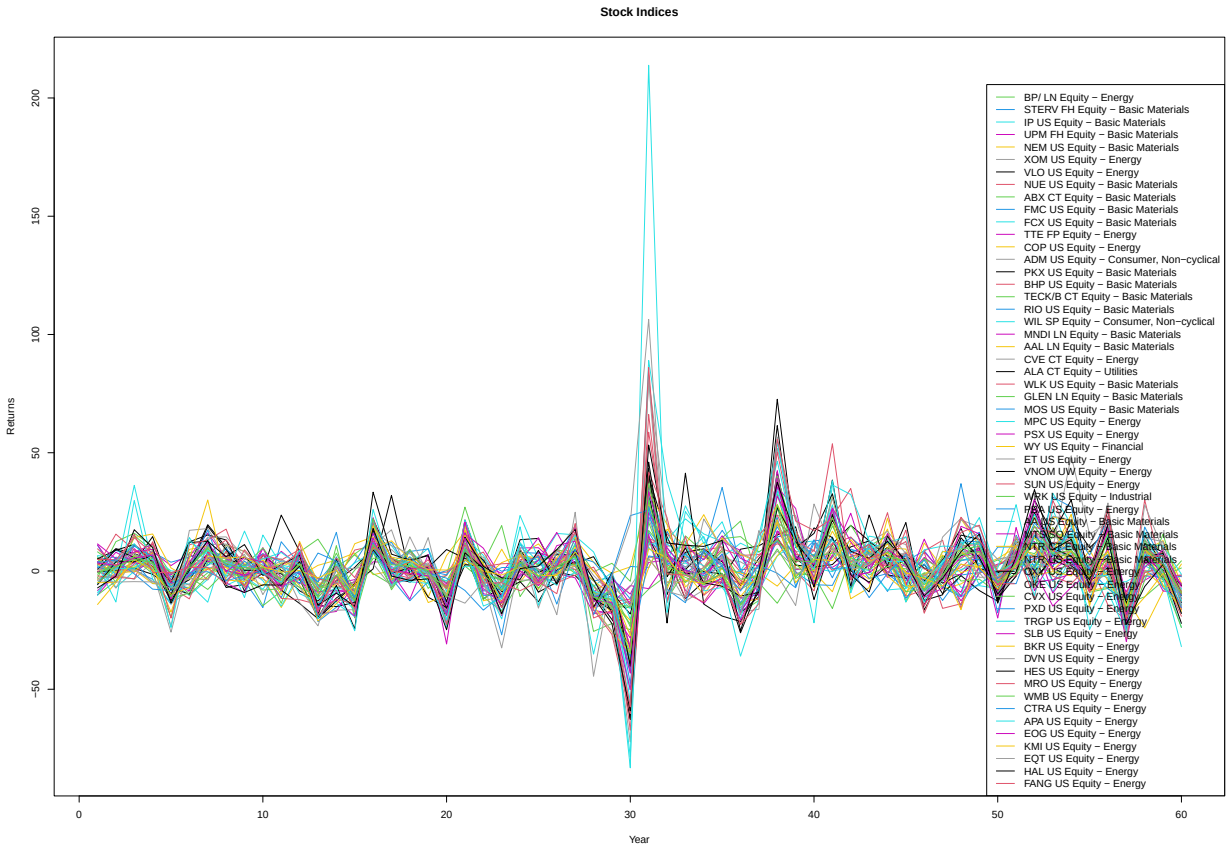
```r
#_____________  Graphiques individuelle par equity (Histogram) _____________

range = 3:58
for (i in 1:ncol(Returns)){
  chart.Histogram(
    as.numeric(unlist(Returns[,i])),
    breaks = "FD",
    main = names(Returns)[i],
    xlab = "Returns",
    ylab = "Frequency",
    methods =  "none",
    show.outliers = TRUE,
    colorset = c("#23FFDC"),
    border.col = "white",
    lwd = 2,
    xlim = NULL,
    ylim = NULL,
```

```
    element.color = "darkgray",
    note.lines = NULL,
    note.labels = NULL,
    note.cex = 0.7,
    note.color = "darkgray",
    probability = FALSE,
    p = 0.95,
    font.main=4, font.lab=4
  )
}
```


```r
#_____________ histogramme à partir des données de panel _____________

bins_fd <- function(vec) {
  diff(range(vec)) / (2 * IQR(vec) / length(vec)^(1 / 3))
}

ggplot(data = custom_data, mapping = aes(x = return)) +
  geom_histogram(
    alpha = 0.5,
    #mapping = aes(fill = equities),
    bins = bins_fd(custom_data$return)
    #bins = 50
  ) +
  facet_wrap(. ~ equities) +
  ggtitle("Distribution de Returns") +
  theme(
    panel.background = element_rect(fill = "grey97"),
    panel.grid = element_blank(),
)
```




```
#_____________  Graphiques des Returns  _____________

ts.plot(Returns, col = 3:58, xlab = "Year", ylab = "Returns", main = "Stock Indices")
legend("bottomright", colnames(Returns_p[3:58]), lty = 1, col = 3:58, bty = "c")
```



Question 2) Performance cumulée des titres (en base100): Graphique fait en Excel.

Question 3) Matrice de corrélation entre les titres

```
library(Hmisc)
```

```
## Warning: le package 'Hmisc' a été compilé avec la version R 4.2.2
```

```
## Le chargement a nécessité le package : lattice
```

```
## Le chargement a nécessité le package : survival
```

```
## Le chargement a nécessité le package : Formula
```

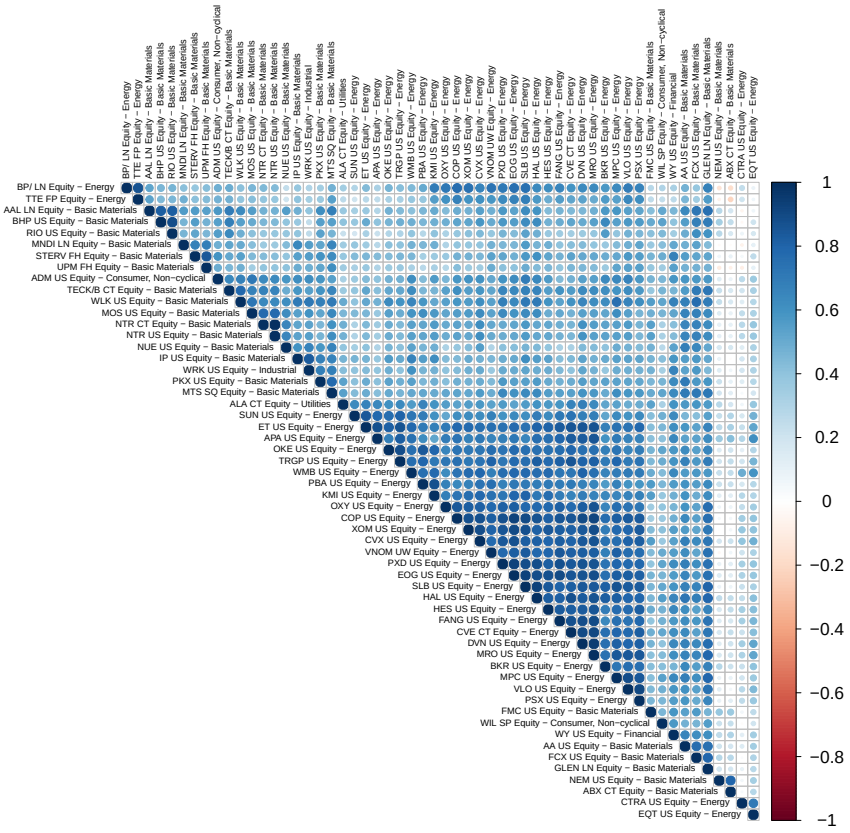
```
##
## Attachement du package : 'Hmisc'
```

```
## L'objet suivant est masqué depuis 'package:psych':
##
##     describe
```

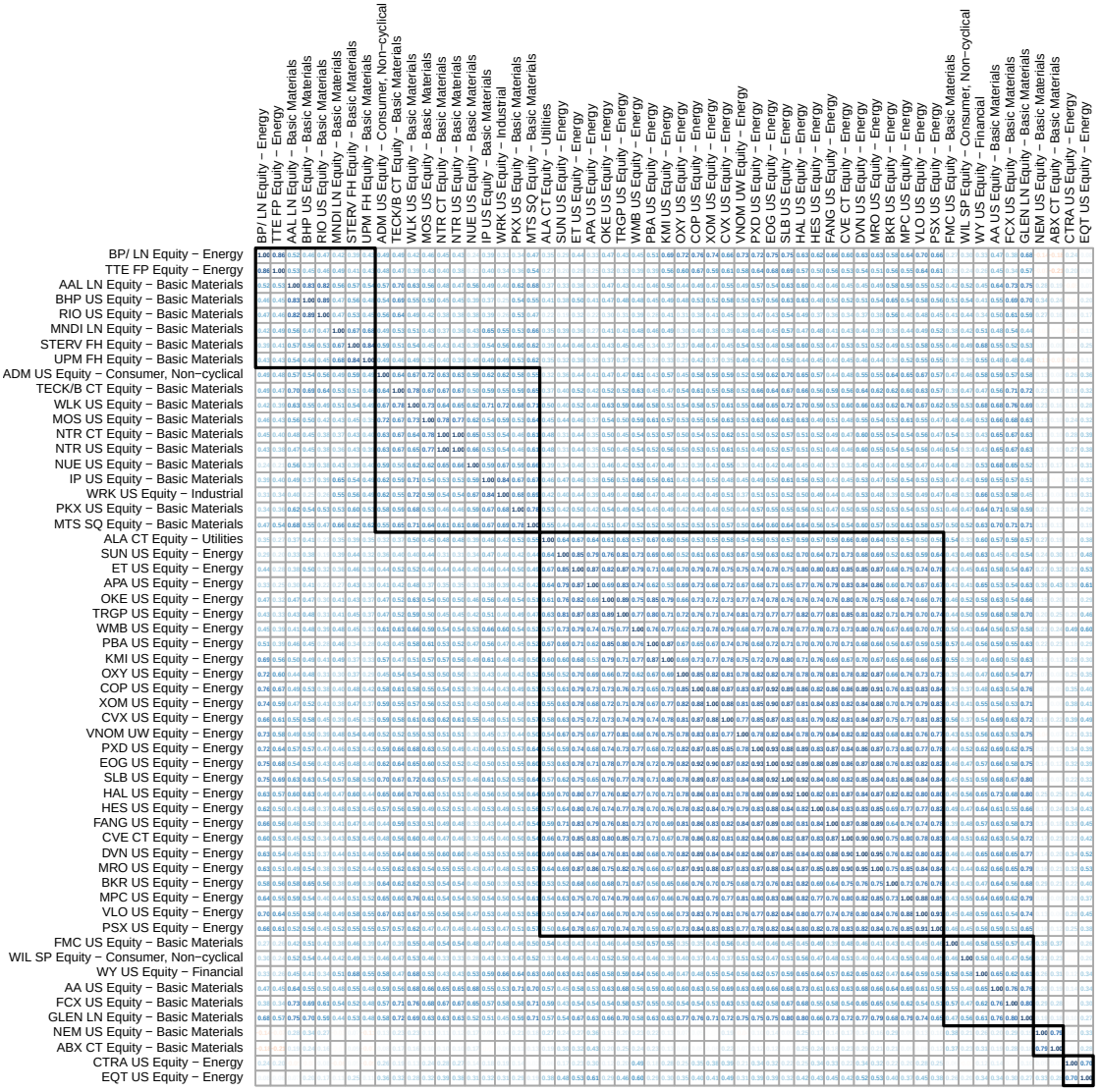
```
## Les objets suivants sont masqués depuis 'package:dplyr':
##
##     src, summarize
```

```
## L'objet suivant est masqué depuis 'package:quantmod':
##
##     Lag

## Les objets suivants sont masqués depuis 'package:base':
##
##     format.pval, units
```

```
M = cor(Returns_p[,3:58])
Matrice_corr <- as.data.frame(M)  #Pour visualiser les coeff de correlation, nous constrisons un data f
corrplot(M, type = "upper", order = "hclust", addrect =6,
         rect.col = "black", rect.lwd = 2,cl.pos = "r", tl.col = "black", tl.cex = 0.70,
         cl.cex = 1.25)
```




```
corrplot(M, method = "number", outline = T, addgrid.col = "darkgray", order="hclust", addrect = 6,
         rect.col = "black", rect.lwd = 2,cl.pos = "r", tl.col = "black", tl.cex = 0.5,
         cl.cex = 0.5, addCoef.col = "dark", number.digits = 2, number.cex = 0.25)
```



Question 4) Calcul des indicateurs synthétiques du risque:

```
# _____________ 1. Sharp Ratio _____________

Returns_xts <- xts(x = Returns_p[, 3:59],
                   order.by = as.Date(Returns_p$Dates))
Index_time_series <- ts(Returns_p[,59], start = c(2017, 08), frequency = 12)

ratios_1 = Returns_p %>%
  summarise(sharp = round(SharpeRatio(ts(Returns_p[,3:58],start = c(2017, 08), frequency = 12), Rf=0.03(
```

```
ratios_1 <- as.data.frame(ratios_1)
ratios_2 <- t(ratios_1)
#ratios_2
```

Equities with a negative Sharp Ratio :

```
ratios_2[ratios_2[,1] <0,]
```

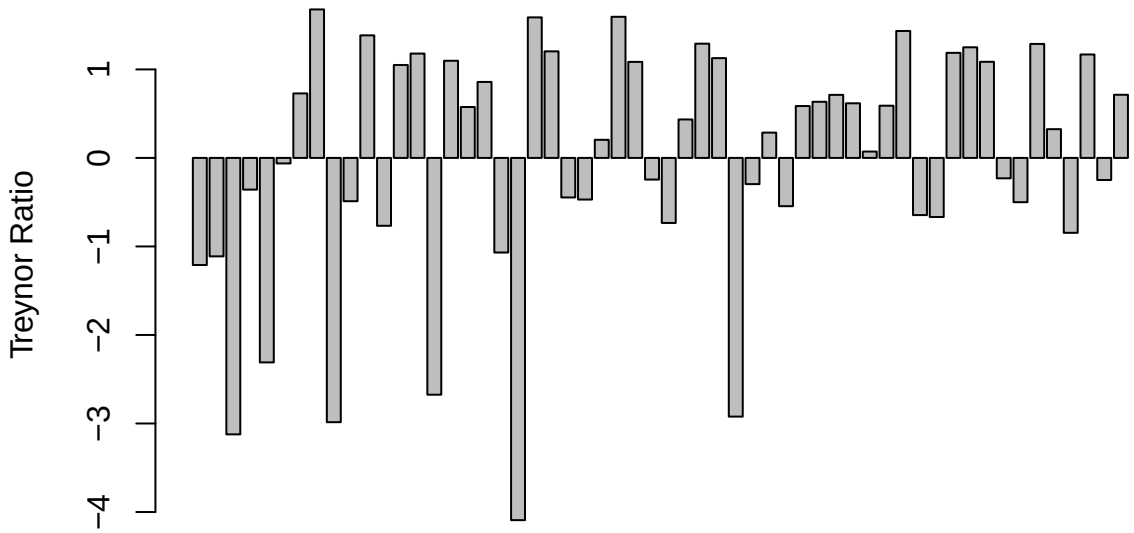
```
##   sharp.IP US Equity - Basic Materials  sharp.PKX US Equity - Basic Materials
##                                -0.0339                                -0.0330
## sharp.MNDI LN Equity - Basic Materials       sharp.WRK US Equity - Industrial
##                                -0.0427                                -0.0382
```

VaR historique

```
ratios_VaR <- lapply(3:58, function(i) round(quantile(ts(Returns_p[,i],start = c(2017, 08), frequency =
#ratios_VaR
my_df <- bind_rows(ratios_VaR)
colnames(my_df) <- c("VaR_hist")
```

Print Treynor Ratio

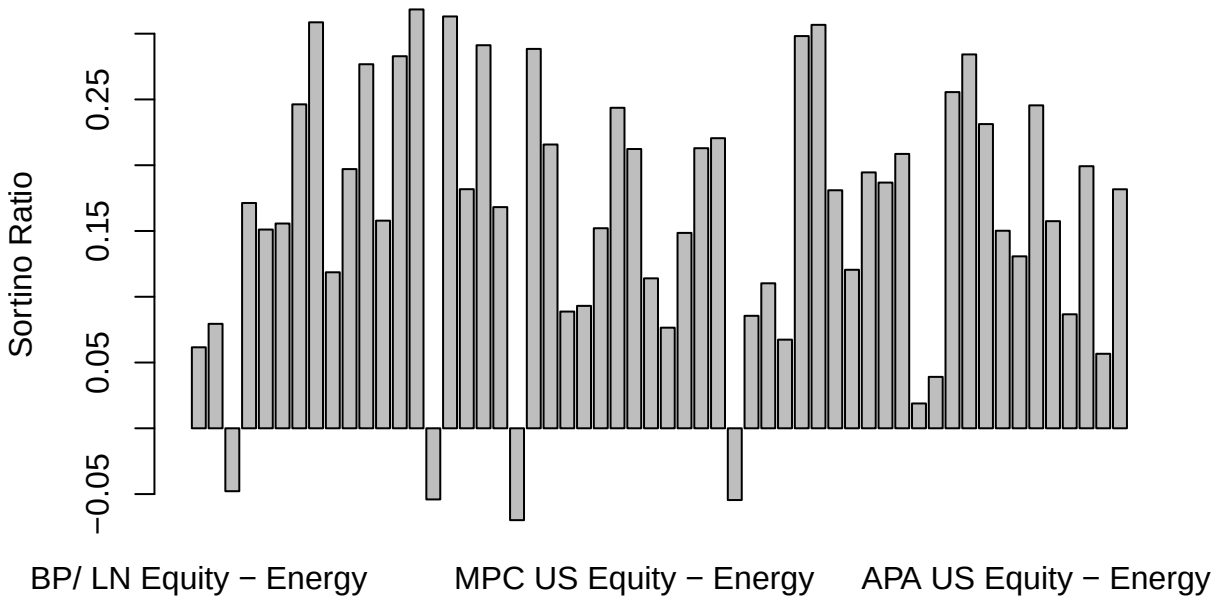
```
result_df <- data.frame(matrix(ncol = 1, nrow = 0))
colnames(result_df) <- c("Treynor_Ratio")

for (i in 4:ncol(Returns_p)-1){
    Returns_p=na.omit(Returns_p)
    portfolio_returns <- ts(Returns_p[,i])

    # Definir le benchmark returns
    benchmark_returns <- ts(Returns_p[,59])

    # Calculer portfolio beta
    portfolio_beta <- (cov(portfolio_returns,benchmark_returns)/var(benchmark_returns))

    # Calculer portfolio excess returns
    portfolio_excess_returns <- portfolio_returns - benchmark_returns

    # Calculer Treynor Ratio
    treynor_ratio <- mean(portfolio_excess_returns) / portfolio_beta

    # creer le data frame à partir des resultats
    result_df <- rbind(result_df, data.frame(Treynor_Ratio = treynor_ratio))
}

treynor <- result_df
treynor_vector <- treynor$S5ENRS.Index
barplot(treynor_vector, ylab = "Treynor Ratio")
```



Sortino Ratio

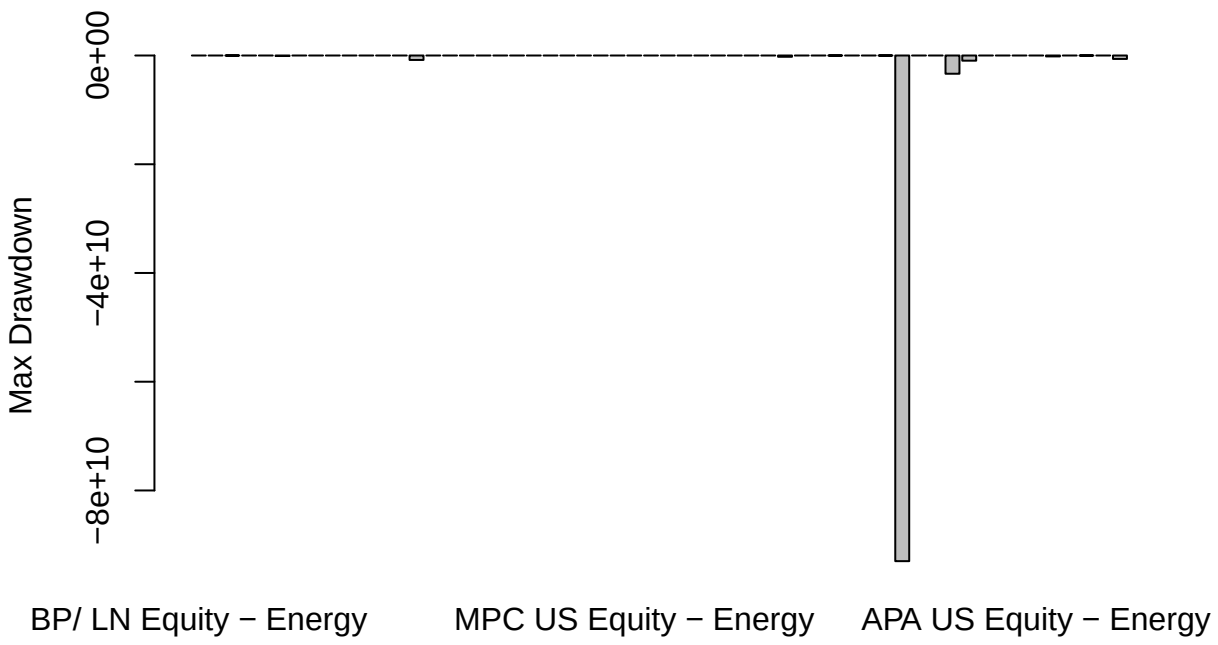
```
#une autre facon de calculer sortino ratio
for (i in 4:ncol(Returns_p)-1){
downside_deviation <- SortinoRatio(ts(Returns_p[,i]))
# Calculate the Sortino Ratio
sortino_ratio <- mean(ts(Returns_p[,i])) / downside_deviation
# Print the Sortino Ratio
#print(sortino_ratio)
}
```

```
sortino_ratio <- function(series,rf) {
    mean <- mean(series) -rf
    std_neg <- sd(series[series < 0])
    return(mean/std_neg)
}
sortinos <- apply(Returns_p[3:58], 2, sortino_ratio, rf=0.036)
barplot(sortinos, ylab = "Sortino Ratio")
```



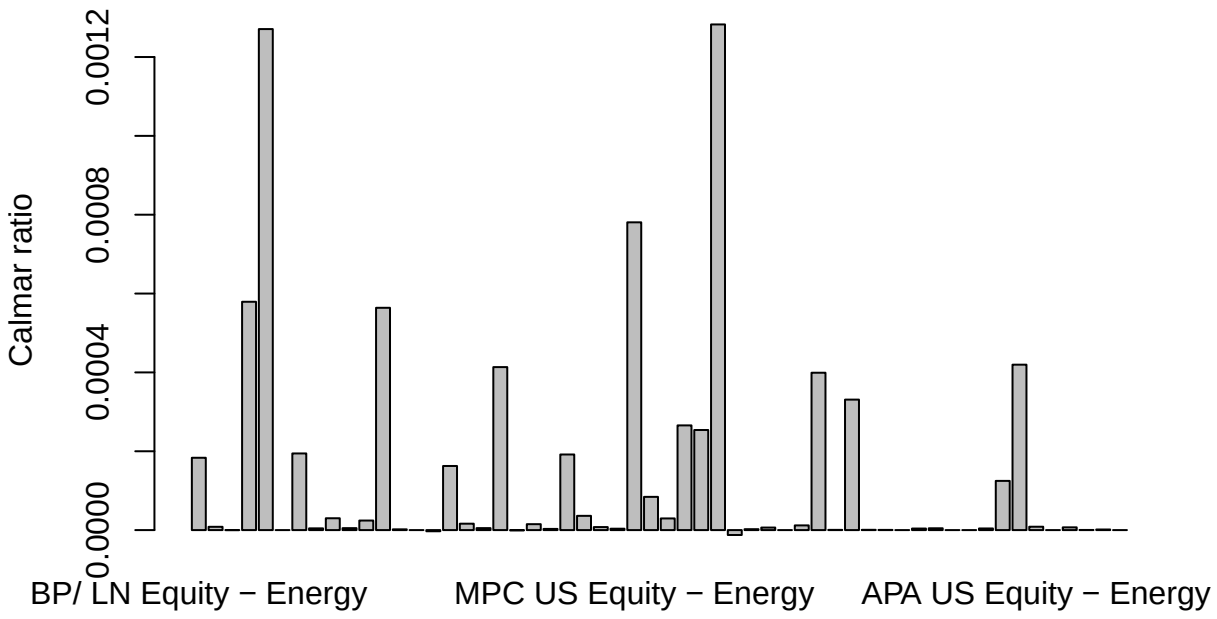
Max_drawdown

```
max_drawdown <- function(return_series) {
    comp_ret <- cumprod(return_series + 1)
    peak <- cummax(comp_ret)
    dd <- (comp_ret/peak)-1
    return(min(dd))
}

max_drawdowns <- apply(ts(Returns_p[3:58]), 2, max_drawdown)
barplot(max_drawdowns, ylab = "Max Drawdown" )
```

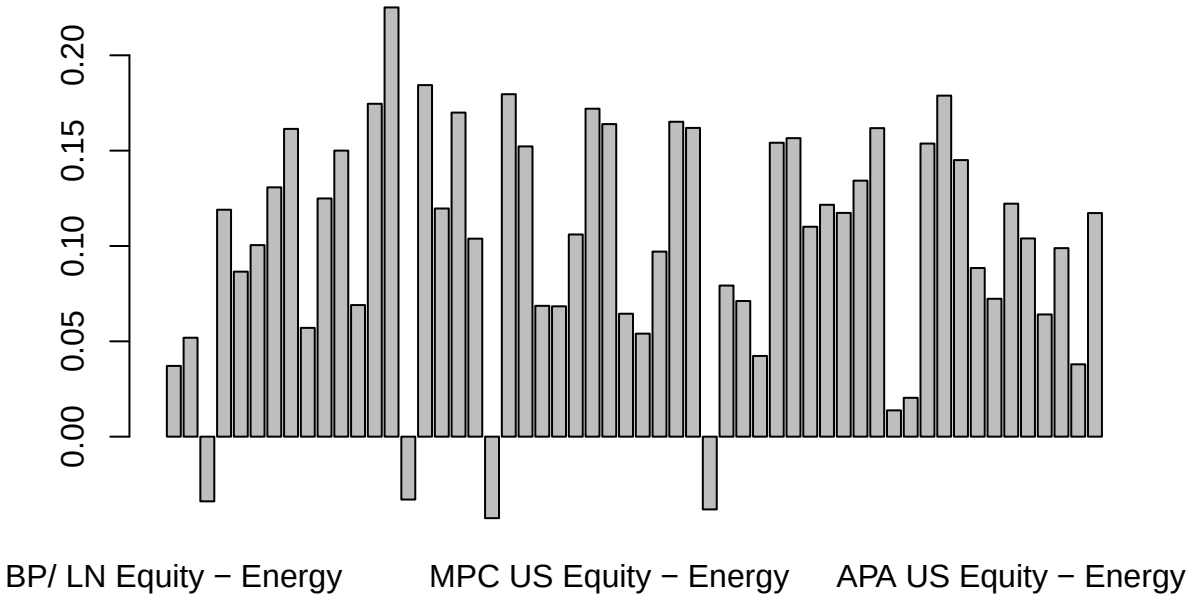


Calmars

```
calmars <- colMeans(ts(Returns_p[3:58]))/abs(max_drawdowns)
barplot(calmars, ylab = "Calmar ratio")
```




```
sharpe_ratio <- function(return_series, rf) {
    mean <- mean(return_series) -rf
    sigma <- sd(return_series)
    return(mean / sigma)
}
sharpes <- apply(ts(Returns_p[3:58]), 2, sharpe_ratio, rf=0.036)

barplot(sharpes)
```




```
btstats <- data.frame(Sharpe_ratio=sharpes,Treynor_ratio= treynor_vector, Calmar_ratio = calmars, Sorti
btstats
```

```
##                                        Sharpe_ratio Treynor_ratio  Calmar_ratio
## BP/ LN Equity - Energy                   0.03709607   -1.20980227  1.834373e-04
## STERV FH Equity - Basic Materials        0.05188998   -1.11215106  8.315754e-06
## IP US Equity - Basic Materials          -0.03391992   -3.12306755 -4.837773e-08
## UPM FH Equity - Basic Materials          0.11900928   -0.35810264  5.791805e-04
## NEM US Equity - Basic Materials          0.08653154   -2.30988433  1.270885e-03
## XOM US Equity - Energy                   0.10044684   -0.06233229  1.062104e-08
## VLO US Equity - Energy                   0.13075201    0.72863522  1.944109e-04
## NUE US Equity - Basic Materials          0.16140153    1.67747275  4.401823e-06
## ABX CT Equity - Basic Materials          0.05705127   -2.98544550  3.000677e-05
## FMC US Equity - Basic Materials          0.12493189   -0.48934278  4.949052e-06
## FCX US Equity - Basic Materials          0.15001625    1.38457806  2.420926e-05
## TTE FP Equity - Energy                   0.06900888   -0.76664565  5.638798e-04
## COP US Equity - Energy                   0.17456944    1.04988615  1.864796e-06
## ADM US Equity - Consumer, Non-cyclical   0.22510280    1.17892884  1.869795e-09
## PKX US Equity - Basic Materials         -0.03298033   -2.67505500 -2.973427e-06
## BHP US Equity - Basic Materials          0.18437973    1.09751487  1.626113e-04
## TECK/B CT Equity - Basic Materials       0.11965737    0.57502846  1.625198e-05
## RIO US Equity - Basic Materials          0.16996195    0.85830489  5.027355e-06
## WIL SP Equity - Consumer, Non-cyclical   0.10384269   -1.06876340  4.134436e-04
## MNDI LN Equity - Basic Materials        -0.04273142   -4.09202087 -7.261468e-07
## AAL LN Equity - Basic Materials          0.17958961    1.58759333  1.500918e-05
## CVE CT Equity - Energy                   0.15222555    1.20375246  2.997143e-06
```

```
## ALA CT Equity - Utilities                0.06860566   -0.44689354  1.917419e-04
## WLK US Equity - Basic Materials          0.06835489   -0.47032184  3.610778e-05
## GLEN LN Equity - Basic Materials         0.10602501    0.20464777  7.612599e-06
## MOS US Equity - Basic Materials          0.17197797    1.59420825  3.549084e-06
## MPC US Equity - Energy                   0.16391869    1.08483595  7.806311e-04
## PSX US Equity - Energy                   0.06446753   -0.24456915  8.425582e-05
## WY US Equity - Financial                 0.05401768   -0.73465887  2.957675e-05
## ET US Equity - Energy                    0.09705876    0.43437641  2.655946e-04
## VNOM UW Equity - Energy                  0.16514047    1.29062709  2.538623e-04
## SUN US Equity - Energy                   0.16191814    1.12724570  1.282658e-03
## WRK US Equity - Industrial              -0.03815180   -2.92248097 -1.241904e-05
## PBA US Equity - Energy                   0.07924825   -0.29624006  2.299310e-06
## AA US Equity - Basic Materials           0.07113807    0.28585901  6.446378e-06
## MTS SQ Equity - Basic Materials          0.04233552   -0.54514650  2.643097e-09
## NTR CT Equity - Basic Materials          0.15414034    0.58580136  1.189351e-05
## NTR US Equity - Basic Materials          0.15654867    0.63415816  3.991797e-04
## OXY US Equity - Energy                   0.11009340    0.71222422  5.744759e-07
## OKE US Equity - Energy                   0.12159327    0.61701200  3.309977e-04
## CVX US Equity - Energy                   0.11734090    0.07211163  6.668418e-07
## PXD US Equity - Energy                   0.13427194    0.58986905  4.524281e-07
## TRGP US Equity - Energy                  0.16180909    1.43389814  3.436046e-11
## SLB US Equity - Energy                   0.01379063   -0.64594048  3.910210e-06
## BKR US Equity - Energy                   0.02037337   -0.66761400  4.574792e-06
## DVN US Equity - Energy                   0.15372596    1.18703815  9.223297e-10
## HES US Equity - Energy                   0.17885129    1.24956223  2.622415e-09
## MRO US Equity - Energy                   0.14503394    1.08557116  4.157360e-06
## WMB US Equity - Energy                   0.08843638   -0.23035246  1.248188e-04
## CTRA US Equity - Energy                  0.07231892   -0.50018875  4.195965e-04
## APA US Equity - Energy                   0.12218871    1.28763502  8.555040e-06
## EOG US Equity - Energy                   0.10394165    0.32465671  8.642419e-09
## KMI US Equity - Energy                   0.06408635   -0.84607719  6.953733e-06
## EQT US Equity - Energy                   0.09887402    1.16847147  3.205416e-07
## HAL US Equity - Energy                   0.03794238   -0.24944600  1.481548e-06
## FANG US Equity - Energy                  0.11726482    0.71322636  3.338137e-09
##                                    Sortino_ratio VaR_hist Max_drawdowns
## BP/ LN Equity - Energy                0.06157247 -13.7668 -1.857583e+03
## STERV FH Equity - Basic Materials     0.07941640 -15.3464 -6.300405e+04
## IP US Equity - Basic Materials       -0.04784963 -12.6739 -4.685962e+06
## UPM FH Equity - Basic Materials       0.17127960 -12.6632 -1.612608e+03
## NEM US Equity - Basic Materials       0.15109233 -11.4248 -6.515713e+02
## XOM US Equity - Energy                0.15566521 -14.0551 -9.346614e+07
## VLO US Equity - Energy                0.24627999 -19.9502 -9.857077e+03
## NUE US Equity - Basic Materials       0.30862788 -15.8821 -4.537786e+05
## ABX CT Equity - Basic Materials       0.11859182 -13.8337 -2.150581e+04
## FMC US Equity - Basic Materials       0.19706128 -11.8128 -1.799558e+05
## FCX US Equity - Basic Materials       0.27676536 -18.3733 -9.323900e+04
## TTE FP Equity - Energy                0.15785346 -10.3882 -1.133526e+03
## COP US Equity - Energy                0.28285127 -13.5589 -1.190707e+06
## ADM US Equity - Consumer, Non-cyclical 0.31843057 -11.0920 -8.186970e+08
## PKX US Equity - Basic Materials      -0.05407899 -13.0589 -9.269446e+04
## BHP US Equity - Basic Materials       0.31309026 -13.3223 -9.506999e+03
## TECK/B CT Equity - Basic Materials    0.18177075 -22.3455 -9.018151e+04
## RIO US Equity - Basic Materials       0.29122101 -11.2929 -2.640564e+05
## WIL SP Equity - Consumer, Non-cyclical 0.16814357  -8.0204 -1.759128e+03
```

```
## MNDI LN Equity - Basic Materials         -0.06983318 -13.2633 -3.904194e+05
## AAL LN Equity - Basic Materials           0.28842328 -13.7224 -1.282145e+05
## CVE CT Equity - Energy                    0.21574796 -17.7312 -1.015515e+06
## ALA CT Equity - Utilities                 0.08874166 -12.7067 -4.019667e+03
## WLK US Equity - Basic Materials           0.09306797 -14.3757 -2.041261e+04
## GLEN LN Equity - Basic Materials          0.15209434 -16.0916 -1.597614e+05
## MOS US Equity - Basic Materials           0.24364920 -19.0833 -6.508880e+05
## MPC US Equity - Energy                    0.21232509 -17.3577 -2.905496e+03
## PSX US Equity - Energy                    0.11399734 -17.2823 -9.517672e+03
## WY US Equity - Financial                  0.07648277 -16.0152 -2.028419e+04
## ET US Equity - Energy                     0.14853600 -13.8398 -6.012952e+03
## VNOM UW Equity - Energy                   0.21291890 -16.8269 -1.113351e+04
## SUN US Equity - Energy                    0.22054104 -10.8611 -1.460120e+03
## WRK US Equity - Industrial               -0.05454993 -17.9264 -2.555177e+04
## PBA US Equity - Energy                    0.08551241 -11.8163 -3.625493e+05
## AA US Equity - Basic Materials            0.11021798 -26.4415 -2.178072e+05
## MTS SQ Equity - Basic Materials           0.06738693 -20.5190 -2.330450e+08
## NTR CT Equity - Basic Materials           0.29818051 -10.0771 -1.112914e+05
## NTR US Equity - Basic Materials           0.30669709 -10.0834 -3.365970e+03
## OXY US Equity - Energy                    0.18095923 -19.1743 -3.807466e+06
## OKE US Equity - Energy                    0.12049674 -13.2972 -5.079761e+03
## CVX US Equity - Energy                    0.19453986 -11.9772 -1.656576e+06
## PXD US Equity - Energy                    0.18679478 -15.5184 -3.710551e+06
## TRGP US Equity - Energy                   0.20859051 -17.1666 -9.300108e+10
## SLB US Equity - Energy                    0.01887535 -18.8756 -5.930451e+04
## BKR US Equity - Energy                    0.03909369 -19.8282 -7.127384e+04
## DVN US Equity - Energy                    0.25557938 -25.1637 -3.353276e+09
## HES US Equity - Energy                    0.28422256 -15.5512 -9.534391e+08
## MRO US Equity - Energy                    0.23127597 -22.7913 -7.293042e+05
## WMB US Equity - Energy                    0.15017685 -12.8729 -7.006619e+03
## CTRA US Equity - Energy                   0.13070898 -15.5493 -2.032199e+03
## APA US Equity - Energy                    0.24550409 -25.3017 -4.850492e+05
## EOG US Equity - Energy                    0.15744870 -17.3262 -1.671451e+08
## KMI US Equity - Energy                    0.08665789  -9.9445 -7.697181e+04
## EQT US Equity - Energy                    0.19924425 -23.4327 -6.512147e+06
## HAL US Equity - Energy                    0.05663444 -22.6820 -4.606382e+05
## FANG US Equity - Energy                   0.18170127 -19.9007 -6.306856e+08
```