Mjerenje uspješnosti investicijskih fondova

Priprema podataka

```
source_eval <- function(file) source(file, print.eval = TRUE)
source_eval('uncommon.r')

source('data_extraction.r')
xs <- read_normalize(CSV_DATA)
```

Priprema i analiza podataka

Podjela prema tipovima fondova

```
investment_funds <- c("ERSTEAdriaticEquity", "OTPMeridian20", "ZBAktiv")
pension_funds <- c("RaiffeisenDMF", "ERSTEPlaviEXPERT", "ERSTEPlaviPROTECT")
market_portfolio <- c("CROBEX")

xs.market_portfolio <- to_data_frame(xs, market_portfolio, xs.market_portfolio)
xs.investment <- to_data_frame(xs, investment_funds, xs.investment)
xs.pension <- to_data_frame(xs, pension_funds, xs.pension)

data_columns <- c(pension_funds, investment_funds, market_portfolio)
xs.funds <- xs[, data_columns]
```

Povrati

Računanje dnevnih povrata

```
diff_function_log <- function(St, St_minus_one) log(St) - log(St_minus_one)
xs.returns <- to_time_series_diff_df(xs, data_columns, diff_function_log)
#Postavljanje velikih skokova u 0
#xs.returns$ERSTEAdriaticEquity[2211:2212] <- 0

#diff_function_sub <- function(St, St_minus_one) St - St_minus_one
#xs.returns <- to_time_series_diff_df(xs, data_columns, diff_function_sub)
```

Sažeci

```
xs.summary <- summary(xs.funds)
xs.returns.summary <- summary(xs.returns[data_columns] * 365)
# xs.log_returns.summary <- summary(xs.log_returns[data_columns])

df_summary <- function(summary) {
  return(data.frame(unclass(summary), check.names = FALSE, stringsAsFactors = FALSE))
}
```

```
df_summary(xs.returns.summary)
```

```
##        RaiffeisenDMF   ERSTEPlaviEXPERT  ERSTEPlaviPROTECT
## 1 Min.   :-5.79209   Min.   :-5.73634   Min.   :-2.06945
## 2 1st Qu.:-0.18757   1st Qu.:-0.19025   1st Qu.:-0.05239
## 3 Median : 0.02441   Median : 0.02279   Median : 0.04456
## 4 Mean   : 0.06451   Mean   : 0.07278   Mean   : 0.06709
## 5 3rd Qu.: 0.31443   3rd Qu.: 0.39346   3rd Qu.: 0.20759
## 6 Max.   : 8.91872   Max.   : 4.58776   Max.   : 3.22798
##   ERSTEAdriaticEquity       OTPMeridian20             ZBAktiv
## 1 Min.   :-76.99109   Min.   :-23.51025   Min.   :-13.47776
## 2 1st Qu.: -0.48888   1st Qu.: -0.35673   1st Qu.: -0.41271
## 3 Median :  0.00000   Median :  0.00000   Median :  0.00000
## 4 Mean   :  0.01423   Mean   :  0.01395   Mean   :  0.03645
## 5 3rd Qu.:  0.49924   3rd Qu.:  0.63048   3rd Qu.:  0.61738
## 6 Max.   : 78.58947   Max.   : 13.60614   Max.   : 34.35281
##                CROBEX
## 1 Min.   :-17.43339
## 2 1st Qu.: -0.58382
## 3 Median :  0.00000
## 4 Mean   : -0.00203
## 5 3rd Qu.:  0.67653
## 6 Max.   : 31.25453
```

Mjere raspršenosti

```
apply(xs.returns[,-1:-3], 2, var, na.rm=T)
```

```
##       RaiffeisenDMF    ERSTEPlaviEXPERT   ERSTEPlaviPROTECT
##        3.463344e-06        4.429072e-06        9.234754e-07
## ERSTEAdriaticEquity       OTPMeridian20             ZBAktiv
##        5.514475e-05        2.236156e-05        2.212908e-05
##              CROBEX
##        3.207109e-05
```

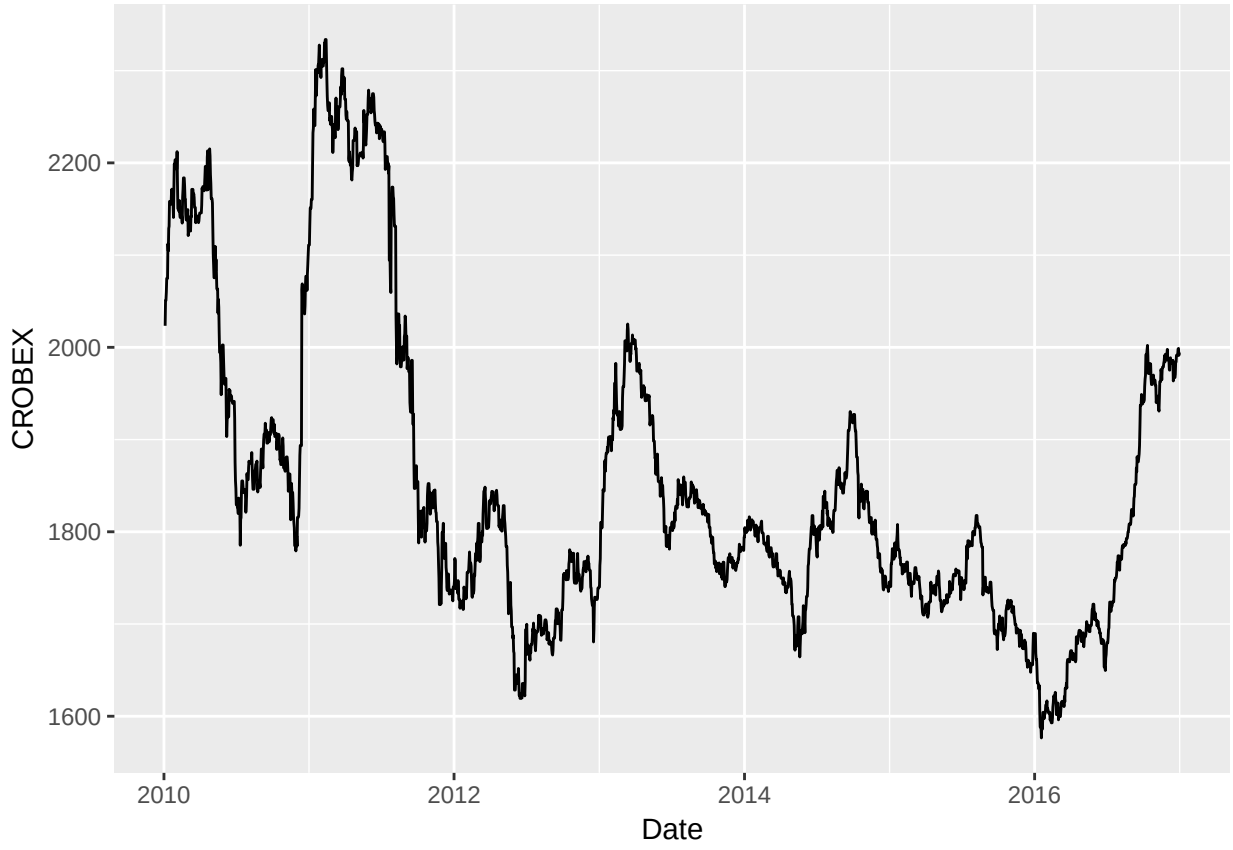
```
apply(xs.returns[,-1:-3], 2, sd, na.rm=T)
```

```
##       RaiffeisenDMF    ERSTEPlaviEXPERT   ERSTEPlaviPROTECT
##        0.0018610062        0.0021045360        0.0009609763
## ERSTEAdriaticEquity       OTPMeridian20             ZBAktiv
##        0.0074259509        0.0047288016        0.0047041558
##              CROBEX
##        0.0056631347
```

Grafički prikaz podataka

Prikaz vrijednosti CROBEX-a po danima

```
ggplot(xs, aes(Date, CROBEX)) + geom_line()
```



Prikaz vrijednosti investicijskih i mirovinskih fondova po danima

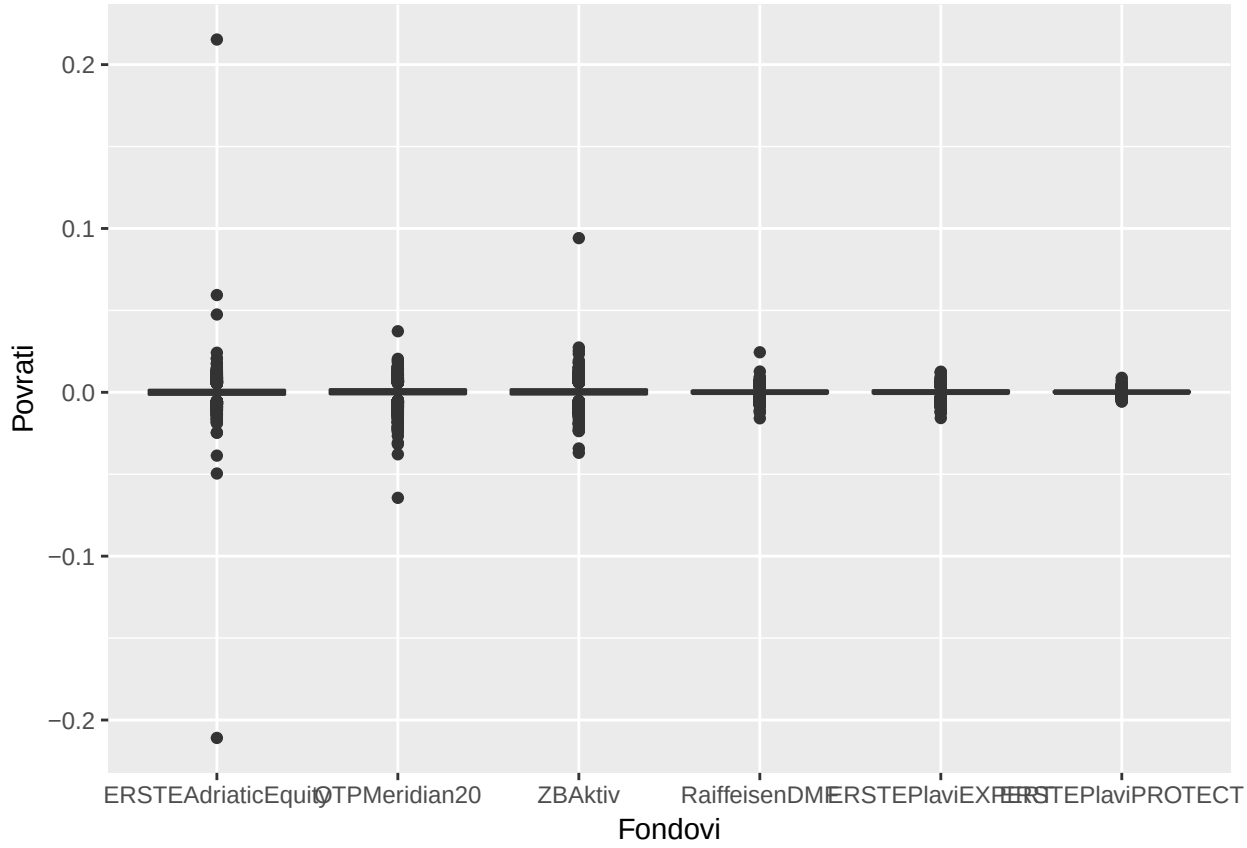
```
df <- melt(xs[c("Date", investment_funds, pension_funds)],
           id.vars = 'Date',
           variable.name = 'Fondovi')
ggplot(df, aes(Date, value)) + geom_line(aes(colour = Fondovi))
```

Prikaz boxplotova za sve fondove

Iz ovih se grafova vidi kako su investicijski fondovi (prva tri stupca) podložniji većim promjenama vrijednosti od mirovinskih na dnevnoj bazi.

```
df.returns <- melt(xs.returns[c("Date", investment_funds, pension_funds)],
                   id.vars = 'Date',
                   variable.name = 'Fondovi')
```

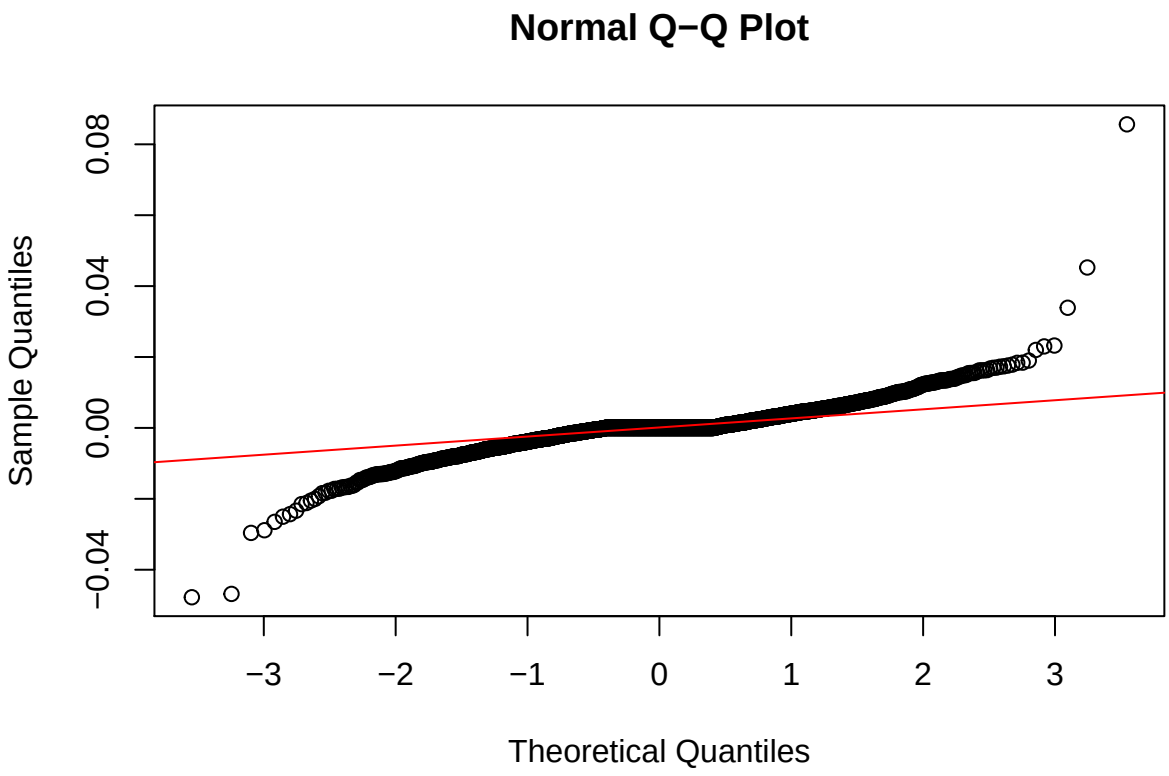
```
ggplot(df.returns, aes(Date, value)) +
  geom_boxplot(aes(Fondovi)) +
  xlab("Fondovi") +
  ylab("Povrati")
```



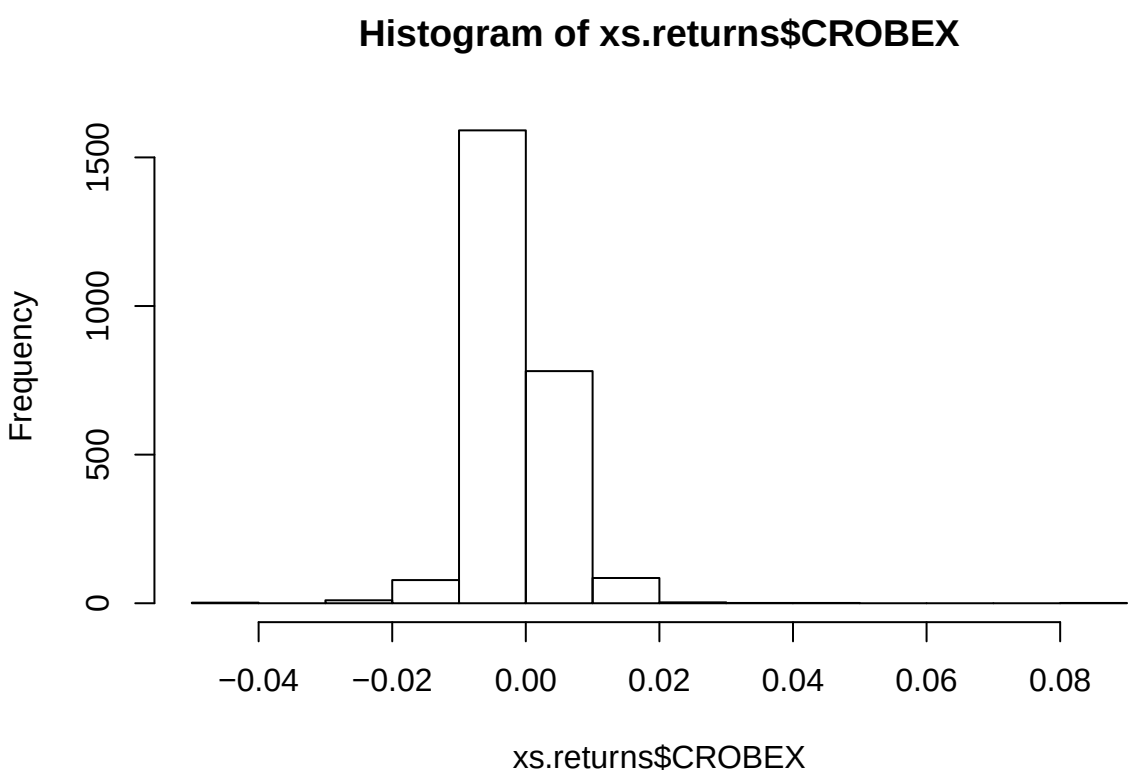
Provjera normalnosti

Sljedećim q-q plotom želimo ispitati normalnost distribucije burzovnog indeksa. Iz prvog grafa vidimo kako podaci nisu u potpunosti normalni, a iz sljedećeg, gdje su isti podaci prikazani na histogramu, jasno je i zašto. Teške repove primjećujemo radi velike granulacije, tj. dnevnog računanja prinosa; u tako kratkom roku zna se dogoditi da pojedina dionica ili naglo naraste ili naglo padne u vrijednosti.

```
qqnorm(xs.returns$CROBEX)
qqline(xs.returns$CROBEX, col = "red")
```



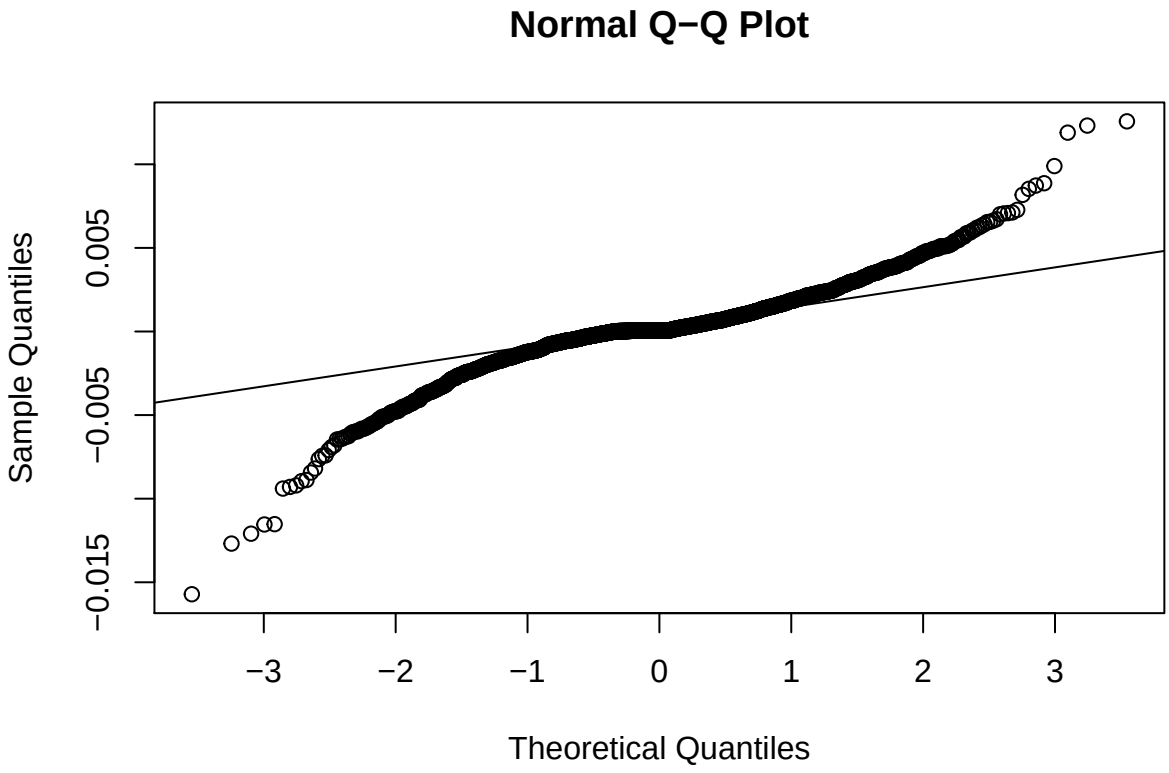

```r
hist(xs.returns$CROBEX) #, breaks = seq(from = min(xs.returns$CROBEX) - 0.5, to = max(xs.returns$CROBEX
```



Sljedećim grafom htjela se ispitati normalnost jednog mirovinskog fonda. Vidimo kako ni on nema baš normalnu distribuciju.

TODO: Kolmogorov-smirnov

```
qqnorm(xs.returns$ERSTEPlaviEXPERT)
qqline(xs.returns$ERSTEPlaviEXPERT)
```




```
#qqnorm(xs.returns$ZBAktiv)
#qqline(xs.returns$ZBAktiv)

#qqnorm(apply.weekly(xts(xs.returns$ZBAktiv, order.by = xs.returns$Date), mean))
#qqline(apply.weekly(xts(xs.returns$ZBAktiv, order.by = xs.returns$Date), mean))

#PerformanceAnalytics::chart.QQPlot(xs.returns$ZBAktiv)
#PerformanceAnalytics::chart.Regression(zbaktiv.ts, capm.m.ts, capm.rf.2010,
#                                       excess.returns = TRUE, fit = c("loess", "linear"))
#PerformanceAnalytics::SharpeRatio(capm.m.ts)

# xs.log_returns <- lapply( xs[columns_to_log_normalize], function(list) time_series_diff(list, diff_fu
# xs.log_returns <- data.frame( c(xs[2:nrow(xs), !(colnames(xs) %in% columns_to_log_normalize)], xs.log

#xs.xts <- xts(xs['CROBEX'], order.by = xs$Date)
#head( PerformanceAnalytics::Return.calculate(xs.xts) )
#head( xs.log_returns$CROBEX )

#xs.returns[xs.returns$CROBEX > 50, c('Date', 'CROBEX')]

#plot_timeseries(xs, xs$Date, xs$CROBEX)
#xs.graphs.timeseries <- mapply( function(data_col, name) plot_timeseries(xs, xs$Date, data_col, name),
#class(xs.graphs.timeseries)
#xs.graphs.boxplots <- boxplot(xs[get_data_cols_without_market_portfolio(xs)])
#xs.log_returns.graphs.boxplots <- boxplot(xs.log_returns[get_data_cols_without_market_portfolio(xs.log
```

Testovi fondova

Iako QQ grafovi pokazuju da povrati nisu normalno raspodijeljeni, radimo tu pretpostavku s obzirom na robusnost T-testa. Jasno je da globalni događaji (kriza, teroristički napadi,...) često utječu na cijelo tržište odjednom, pa koristimo T-testove za uparene podatke.

Testovi povrata investicijskih fondova u odnosu na CROBEX

```
lapply(xs.returns[investment_funds], function(r) t.test(xs.returns$CROBEX, r, paired = TRUE))
```

```
## $ERSTEAdriaticEquity
##
##  Paired t-test
##
## data:  xs.returns$CROBEX and r
## t = -0.29779, df = 2552, p-value = 0.7659
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.0003378421  0.0002487588
## sample estimates:
## mean of the differences
##           -4.454166e-05
##
##
## $OTPMeridian20
##
##  Paired t-test
##
## data:  xs.returns$CROBEX and r
## t = -0.42867, df = 2552, p-value = 0.6682
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.0002440172  0.0001564677
## sample estimates:
## mean of the differences
##           -4.377476e-05
##
##
## $ZBAktiv
##
##  Paired t-test
##
## data:  xs.returns$CROBEX and r
## t = -0.8207, df = 2552, p-value = 0.4119
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.0003573138  0.0001464648
## sample estimates:
## mean of the differences
##           -0.0001054245
```

Testovi povrata mirovinskih fondova u odnosu na CROBEX

```
lapply(xs.returns[pension_funds], function(r) t.test(xs.returns$CROBEX, r, paired = TRUE))
```

```
## $RaiffeisenDMF
##
##  Paired t-test
##
## data:  xs.returns$CROBEX and r
## t = -1.7891, df = 2552, p-value = 0.07372
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.821299e-04  1.750544e-05
## sample estimates:
## mean of the differences
##           -0.0001823123
##
##
## $ERSTEPlaviEXPERT
##
##  Paired t-test
##
## data:  xs.returns$CROBEX and r
## t = -2.1255, df = 2552, p-value = 0.03364
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.940303e-04 -1.587034e-05
## sample estimates:
## mean of the differences
##           -0.0002049503
##
##
## $ERSTEPlaviPROTECT
##
##  Paired t-test
##
## data:  xs.returns$CROBEX and r
## t = -1.7115, df = 2552, p-value = 0.08711
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -4.063254e-04  2.759556e-05
## sample estimates:
## mean of the differences
##           -0.0001893649
```

Test povrata investicijskih fondova u odnosu na mirovinske fondove

Izračunate su sredine mirovinskih i investicijskih fondova pa je sproveden test njihovih vrijednosti. Dobivamo izrazito malu p-vrijednost, stoga uz veliku sigurnost zaključujemo da možemo odbaciti nul-hipotezu koja tvrdi da su sredine jednake.

```
grouped.return.means = data.frame(Date = xs.returns[,1],
                                  MeansPension = rowMeans(xs.returns[pension_funds]),
```

```
                                    MeansInvestment = rowMeans(xs.returns[investment_funds]))

t.test(grouped.return.means$MeansPension, grouped.return.means$MeansInvestment, paired = TRUE)
```

```
##
##  Paired t-test
##
## data:  grouped.return.means$MeansPension and grouped.return.means$MeansInvestment
## t = 1.8145, df = 2552, p-value = 0.06971
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.029489e-05  2.655526e-04
## sample estimates:
## mean of the differences
##            0.0001276289
```

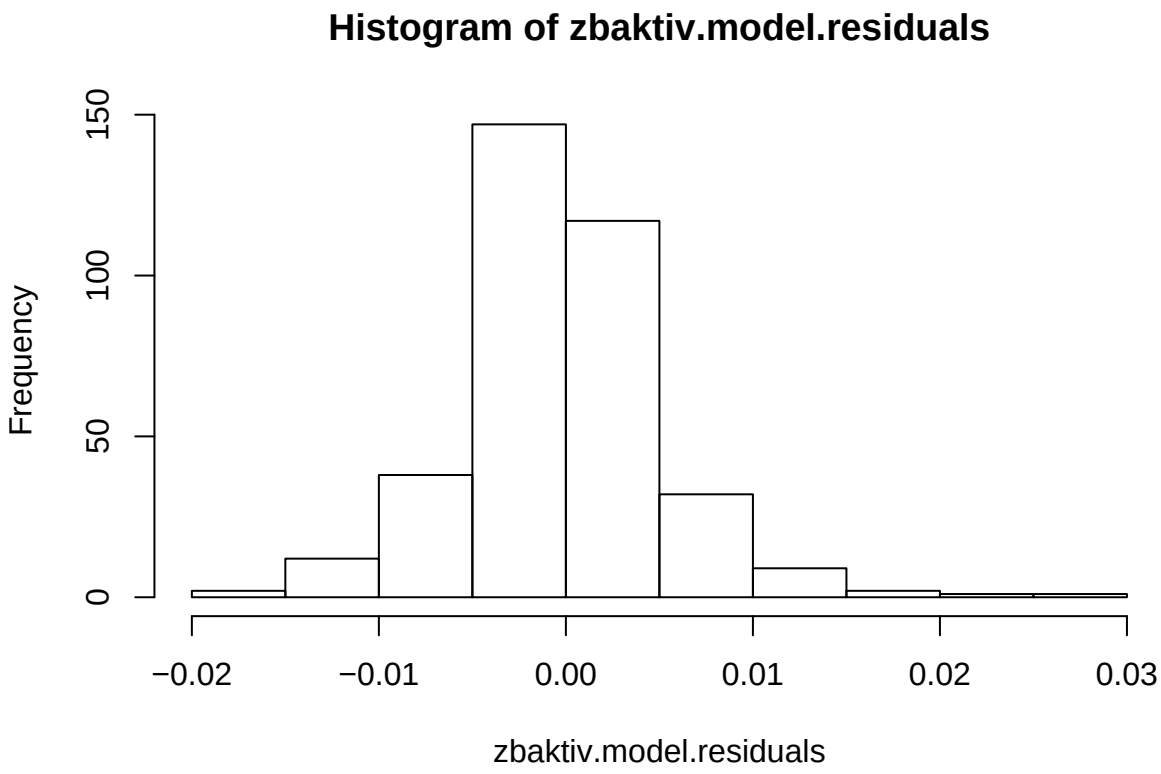
CAPM model

```
dates <- xs.returns$Date

year <- function(date) format(date, "%Y")
get_for_year <- function(df, dates, desired_year) df[year(dates) == desired_year, ]

xs.2010 <- get_for_year(xs.returns, xs.returns$Date, 2010)

zbaktiv.2010 <- xs.2010$ZBAktiv #xs.2010[c('Date', 'ZBAktiv')]
capm.market.2010 <- xs.2010$CROBEX #xs.2010[c('Date', 'CROBEX')]
capm.risk_free.2010 <- xs.2010$InterestRate.daily #[c('Date', 'InterestRate.daily')]
zbaktiv.model <- lm(formula = (zbaktiv.2010 - capm.risk_free.2010) ~ (capm.market.2010 - capm.risk_free
```

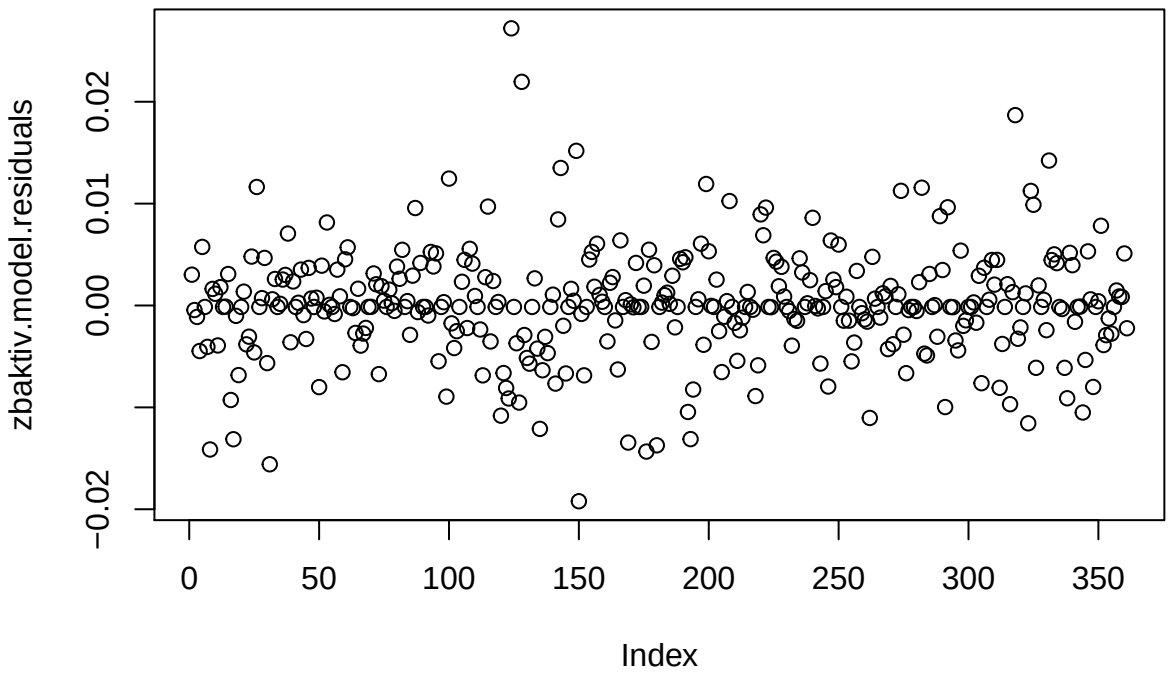
Provjera reziduala

TODO: regresija / vrijednosti i raspodjela reziduala

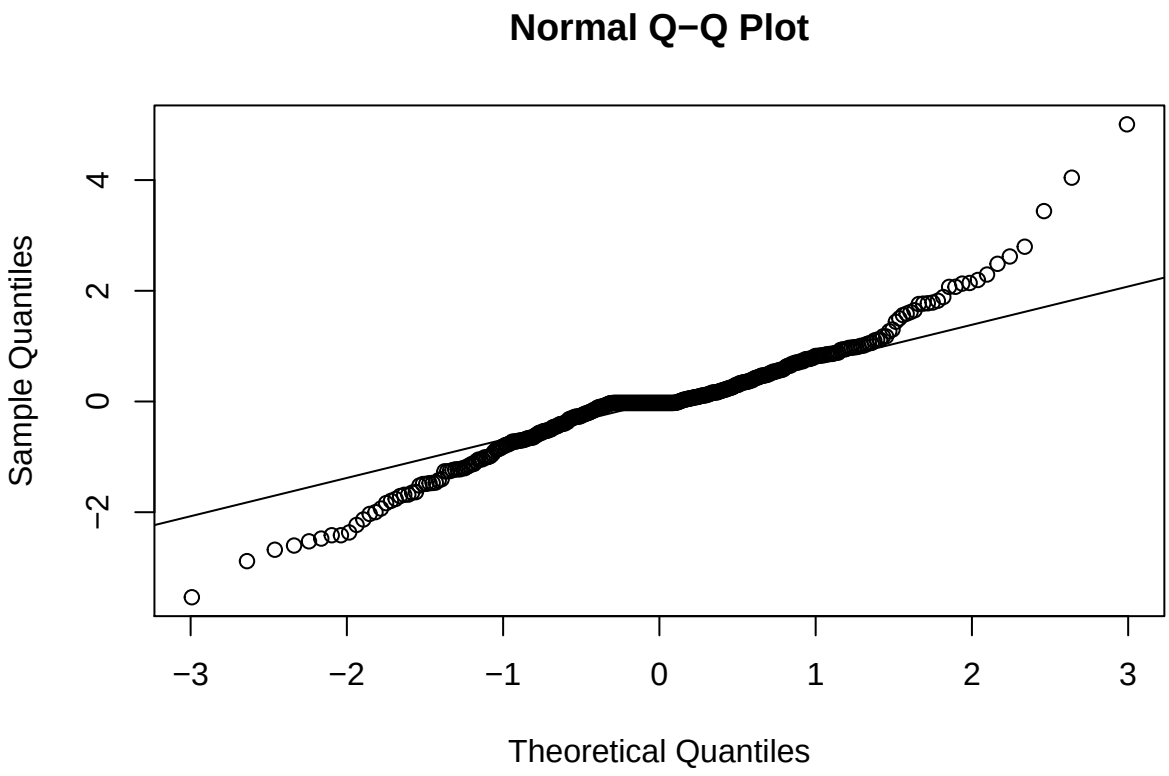
```
# https://www.r-bloggers.com/r-tutorial-series-simple-linear-regression/

zbaktiv.model.summary <- summary(zbaktiv.model)
zbaktiv.model.residuals <- zbaktiv.model.summary$residuals

hist(zbaktiv.model.residuals)
```




```
plot(zbaktiv.model.residuals)
```




```
qqnorm(rstandard(zbaktiv.model))
qqline(rstandard(zbaktiv.model))
```




```
ks.test(rstandard(zbaktiv.model), 'pnorm')
```

```
## Warning in ks.test(rstandard(zbaktiv.model), "pnorm"): ties should not be
## present for the Kolmogorov-Smirnov test
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(zbaktiv.model)
## D = 0.11279, p-value = 0.000205
## alternative hypothesis: two-sided
```

CAPM model 2

TODO: tablica modela (alpha / beta) <- VERIFY

```
require(quantmod)
```

```
## Loading required package: quantmod
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
```

```
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: TTR
```

```
## Version 0.4-0 included new data defaults. See ?getSymbols.
```

```
require(PerformanceAnalytics)
```

```
## Loading required package: PerformanceAnalytics
```

```
##
## Attaching package: 'PerformanceAnalytics'
```

```
## The following object is masked from 'package:graphics':
##
##     legend
```

```
library(xts)

get_capm_for_year <- function(df, fund, desired_year){
  xs.year = get_for_year(df, df$Date, desired_year)
  fund.year <- xs.year[c('Date', fund)]
  capm.market.year <- xs.year[c('Date', 'CROBEX')]
  capm.risk_free.year <- xs.year[c('Date', 'InterestRate.daily')]
  fund.ts <- xts(fund.year[, -1], order.by=fund.year$Date)


  capm.m.ts <-  xts(capm.market.year[, -1], order.by=capm.market.year$Date)
  capm.rf.year <- xts(capm.risk_free.year[, -1], order.by=capm.risk_free.year$Date)

  data.frame(sprintf('%s-%d', fund, desired_year), CAPM.alpha(fund.ts, capm.m.ts, capm.rf.year), CAPM.b
}

xs.years = seq(from = 2010, by = 1, length = 7)
xs.fund.names = c(investment_funds, pension_funds)
xs.capm <- data.frame(matrix(ncol = 3, nrow = 0))

for (i in 1:length(xs.fund.names)){
  for (j in 1:length(xs.years)){
    xs.capm <- rbind(xs.capm, get_capm_for_year(xs.returns, xs.fund.names[i], xs.years[j]))
  }
}
colnames(xs.capm) <- c("fond - godina", "alpha", "beta")
xs.capm
```

```
##               fond - godina         alpha         beta
## 1  ERSTEAdriaticEquity-2010 -1.363158e-04 0.5669352275
## 2  ERSTEAdriaticEquity-2011 -3.331016e-04 0.4543998614
## 3  ERSTEAdriaticEquity-2012 -1.467188e-04 0.2646270122
## 4  ERSTEAdriaticEquity-2013  1.072103e-04 0.3940627807
## 5  ERSTEAdriaticEquity-2014  1.520230e-04 0.3489534496
## 6  ERSTEAdriaticEquity-2015  2.024548e-04 0.4975787045
## 7  ERSTEAdriaticEquity-2016  1.429577e-04 0.7529119728
## 8        OTPMeridian20-2010 -1.401558e-05 0.4309319208
## 9        OTPMeridian20-2011 -4.044461e-04 0.5599034422
## 10       OTPMeridian20-2012  2.005561e-04 0.3908358348
```

```
## 11       OTPMeridian20-2013  2.280547e-04 0.2464292424
## 12       OTPMeridian20-2014  5.006249e-05 0.2761167134
## 13       OTPMeridian20-2015  1.400398e-04 0.4208172130
## 14       OTPMeridian20-2016 -1.026420e-05 0.4574313828
## 15             ZBAktiv-2010  9.544554e-05 0.2194612955
## 16             ZBAktiv-2011 -4.358250e-04 0.1381375343
## 17             ZBAktiv-2012  2.009252e-04 0.1336074631
## 18             ZBAktiv-2013  5.840394e-05 0.1116804387
## 19             ZBAktiv-2014  1.375125e-04 0.2024930920
## 20             ZBAktiv-2015  1.880294e-04 0.2632705419
## 21             ZBAktiv-2016  1.448745e-04 0.3620458129
## 22       RaiffeisenDMF-2010  1.378239e-04 0.1194627941
## 23       RaiffeisenDMF-2011 -7.635330e-05 0.1405371249
## 24       RaiffeisenDMF-2012  2.378826e-04 0.1359857205
## 25       RaiffeisenDMF-2013  9.345165e-05 0.1687797266
## 26       RaiffeisenDMF-2014  3.404221e-04 0.1610284601
## 27       RaiffeisenDMF-2015  1.803462e-04 0.1697165854
## 28       RaiffeisenDMF-2016  1.041926e-04 0.1389678904
## 29    ERSTEPlaviEXPERT-2010  1.580814e-04 0.1750763495
## 30    ERSTEPlaviEXPERT-2011 -2.905792e-05 0.2343404356
## 31    ERSTEPlaviEXPERT-2012  3.950473e-04 0.1491048287
## 32    ERSTEPlaviEXPERT-2013  5.594323e-05 0.1442715157
## 33    ERSTEPlaviEXPERT-2014  2.469191e-04 0.1700392710
## 34    ERSTEPlaviEXPERT-2015  1.991195e-04 0.2703175563
## 35    ERSTEPlaviEXPERT-2016  1.542028e-04 0.2781643675
## 36   ERSTEPlaviPROTECT-2010  1.528344e-04 0.0248670367
## 37   ERSTEPlaviPROTECT-2011  3.855290e-05 0.0355562101
## 38   ERSTEPlaviPROTECT-2012  3.418137e-04 0.0312794690
## 39   ERSTEPlaviPROTECT-2013  4.735975e-05 0.0220619941
## 40   ERSTEPlaviPROTECT-2014  2.035929e-04 0.0185440353
## 41   ERSTEPlaviPROTECT-2015  9.710402e-05 0.0358210528
## 42   ERSTEPlaviPROTECT-2016  1.639057e-04 0.0005997816
```

```
#zbaktiv.2010 <- xs.2010[c('Date', 'ZBAktiv')]
#capm.market.2010 <- xs.2010[c('Date', 'CROBEX')]
#capm.risk_free.2010 <- xs.2010[c('Date', 'InterestRate.daily')]

#zbaktiv.ts <- xts(zbaktiv.2010[, -1], order.by=zbaktiv.2010$Date)
#capm.m.ts <-  xts(capm.market.2010[, -1], order.by=capm.market.2010$Date)
#capm.rf.2010 <- xts(capm.risk_free.2010[, -1], order.by=capm.risk_free.2010$Date)

#CAPM.alpha(zbaktiv.ts, capm.m.ts, capm.rf.2010)
#CAPM.beta(zbaktiv.ts, capm.m.ts, capm.rf.2010)

anova(zbaktiv.model)
```

```
## Analysis of Variance Table
##
## Response: (zbaktiv.2010 - capm.risk_free.2010)
##                   Df    Sum Sq    Mean Sq F value    Pr(>F)
## capm.market.2010   1 0.0010622 0.00106222  35.877 5.107e-09 ***
## Residuals        359 0.0106290 0.00002961
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

TODO: ANOVA