SAPiens

Uloga izvoza i uvoza u gospodarstvu

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Uvod

Uvoz i izvoz dva su važna čimbenika gospodarskog rasta i ekonomske stabilnosti država. Izvozom novac "ulazi" u državu, dok uvozom on "izlazi". Shodno tome države većinom potiču izvoz kako bi povisile svoj standard. Cilj je ovoga projekta istražiti veze između uvoza, izvoza, odnosno rasta uvoza i izvoza s BDP-om analizirajući i uspoređujući istovremeno tri odabrane države: Luksemburg, Meskisko i Japan. Odabirom zemalja namjerno smo pokušali dobiti podatke što različitijih gospodarstava, ne bi li time usporedba bila zanimljivija.

Učitavanje podataka

Učitani su podaci uvoza i izvoza po državama na godišnjoj razini u milijunima US dolara za razdoblje od 1979. do 2019. godine. Izvor podataka jest stranica: https://data.oecd.org/trade/trade-in-goods-and-services.htm

U nastavku slijedi učitavanje podataka o uvozu, izvozu, BDP-u te BDP per capita za odabrane zemlje: Japan, Luksemburg te Meksiko.

```
df = read.table("trade/GDP_data.csv", sep = ",", header = TRUE)
df.percapita = read.table("trade/GDPpercapita_data.csv",
                          sep = ",",
                          header = TRUE)
df.export = read.table("trade/Export_data.csv", sep = ",", header = TRUE)
df.import = read.table("trade/Import_data.csv", sep = ",", header = TRUE)
lux_GDP = df[df$LOCATION == "LUX", c("FREQUENCY", "TIME", "Value")]
lux_GDP_percapita = df.percapita[df.percapita$LOCATION == "LUX",
                                 c("FREQUENCY", "TIME", "Value")]
lux_GDP_percapita$Value = lux_GDP_percapita$Value / 1000000
lux_export = df.export[df.export$LOCATION == "LUX",
                       c("FREQUENCY", "TIME", "Value")]
lux_import = df.import[df.import$LOCATION == "LUX",
                       c("FREQUENCY", "TIME", "Value")]
mex_GDP = df[df$LOCATION == "MEX", c("FREQUENCY", "TIME", "Value")]
mex_GDP_percapita = df.percapita[df.percapita$LOCATION == "MEX",
                                 c("FREQUENCY", "TIME", "Value")]
mex_GDP_percapita$Value = mex_GDP_percapita$Value / 1000000
mex_export = df.export[df.export$LOCATION == "MEX",
                       c("FREQUENCY", "TIME", "Value")]
mex_import = df.import[df.import$LOCATION == "MEX",
                       c("FREQUENCY", "TIME", "Value")]
```

```
jpn_GDP = df[df$LOCATION == "JPN", c("FREQUENCY", "TIME", "Value")]
jpn_GDP_percapita = df.percapita[df.percapita$LOCATION == "JPN",
                                 c("FREQUENCY", "TIME", "Value")]
jpn_GDP_percapita$Value = jpn_GDP_percapita$Value / 1000000
jpn_export = df.export[df.export$LOCATION == "JPN",
                       c("FREQUENCY", "TIME", "Value")]
jpn_import = df.import[df.import$LOCATION == "JPN",
                       c("FREQUENCY", "TIME", "Value")]
growth_lux_GDP = diff(lux_GDP$Value) / head(as.vector(lux_GDP['Value']),-1)
growth_mex_GDP = diff(mex_GDP$Value) / head(as.vector(mex_GDP['Value']),-1)
growth_jpn_GDP = diff(jpn_GDP$Value) / head(as.vector(jpn_GDP['Value']),-1)
growth_lux_GDP_percapita = diff(lux_GDP_percapita$Value) /
  head(as.vector(lux_GDP_percapita['Value']),-1)
growth_mex_GDP_percapita = diff(mex_GDP_percapita$Value) /
  head(as.vector(mex_GDP_percapita['Value']),-1)
growth_jpn_GDP_percapita = diff(jpn_GDP_percapita$Value) /
  head(as.vector(jpn_GDP_percapita['Value']),-1)
growth_lux_import = diff(lux_import$Value) / head(as.vector(lux_import['Value']),-1)
growth_mex_import = diff(mex_import$Value) / head(as.vector(mex_import['Value']),-1)
growth_jpn_import = diff(jpn_import$Value) / head(as.vector(jpn_import['Value']),-1)
growth_lux_export = diff(lux_export$Value) / head(as.vector(lux_export['Value']),-1)
growth_mex_export = diff(mex_export$Value) / head(as.vector(mex_export['Value']),-1)
growth_jpn_export = diff(jpn_export$Value) / head(as.vector(jpn_export['Value']),-1)
lux_GDP_dataframe = data.frame(GDP = lux_GDP$Value,
                               EXPORT = lux_export$Value,
                               IMPORT = lux_import$Value)
mex_GDP_dataframe = data.frame(GDP = mex_GDP$Value,
                               EXPORT = mex_export$Value,
                               IMPORT = mex_import$Value)
jpn_GDP_dataframe = data.frame(GDP = jpn_GDP$Value,
                               EXPORT = jpn_export$Value,
                               IMPORT = jpn_import$Value)
```

Metodom summary() dan je pregled učitanih podataka kako provođenja testova i donošenje zaključaka bilo što intuitivnije, nakon kratkog pogleda na učitane vrijednosti.

```
summary(lux_GDP)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 4218
##            1st Qu.:1989   1st Qu.:10044
##            Median :1998   Median :20325
##            Mean   :1998   Mean   :26633
##            3rd Qu.:2008   3rd Qu.:41332
##            Max.   :2018   Max.   :71000
```

```
summary(mex_GDP)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 294359
##            1st Qu.:1989   1st Qu.: 563620
##            Median :1998   Median : 997899
##            Mean   :1998   Mean   :1153493
##            3rd Qu.:2008   3rd Qu.:1641432
##            Max.   :2018   Max.   :2573848
```

```r
summary(jpn_GDP)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 918687
##            1st Qu.:1989   1st Qu.:2174991
##            Median :1998   Median :3188437
##            Mean   :1998   Mean   :3233187
##            3rd Qu.:2008   3rd Qu.:4426279
##            Max.   :2018   Max.   :5230147
```

```r
summary(lux_GDP_percapita)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   :0.01162
##            1st Qu.:1989   1st Qu.:0.02666
##            Median :1998   Median :0.04744
##            Mean   :1998   Mean   :0.05468
##            3rd Qu.:2008   3rd Qu.:0.08428
##            Max.   :2018   Max.   :0.11662
```

```r
summary(mex_GDP_percapita)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   :0.004314
##            1st Qu.:1989   1st Qu.:0.006631
##            Median :1998   Median :0.010069
##            Mean   :1998   Mean   :0.010997
##            3rd Qu.:2008   3rd Qu.:0.014621
##            Max.   :2018   Max.   :0.020660
```

```r
summary(jpn_GDP_percapita)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   :0.00791
##            1st Qu.:1989   1st Qu.:0.01767
##            Median :1998   Median :0.02524
##            Mean   :1998   Mean   :0.02565
##            3rd Qu.:2008   3rd Qu.:0.03458
##            Max.   :2018   Max.   :0.04136
```

```r
summary(lux_export)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 12868
##            1st Qu.:1989   1st Qu.: 22502
##            Median :1998   Median : 47560
##            Mean   :1998   Mean   : 58637
##            3rd Qu.:2008   3rd Qu.: 93338
##            Max.   :2018   Max.   :135743
```

```r
summary(mex_export)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 51942
##            1st Qu.:1989   1st Qu.:109506
##            Median :1998   Median :353253
##            Mean   :1998   Mean   :358604
```

```
##            3rd Qu.:2008   3rd Qu.:524688
##            Max.   :2018   Max.   :880275
```

```
summary(jpn_export)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 157275
##            1st Qu.:1989   1st Qu.: 293918
##            Median :1998   Median : 453482
##            Mean   :1998   Mean   : 521356
##            3rd Qu.:2008   3rd Qu.: 798070
##            Max.   :2018   Max.   :1016518
```

```
summary(lux_import)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 11894
##            1st Qu.:1989   1st Qu.: 18942
##            Median :1998   Median : 37899
##            Mean   :1998   Mean   : 48057
##            3rd Qu.:2008   3rd Qu.: 74048
##            Max.   :2018   Max.   :113112
```

```
summary(mex_import)
```

```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   : 56671
##            1st Qu.:1989   1st Qu.:132553
##            Median :1998   Median :377176
##            Mean   :1998   Mean   :397978
##            3rd Qu.:2008   3rd Qu.:631770
##            Max.   :2018   Max.   :944689
```

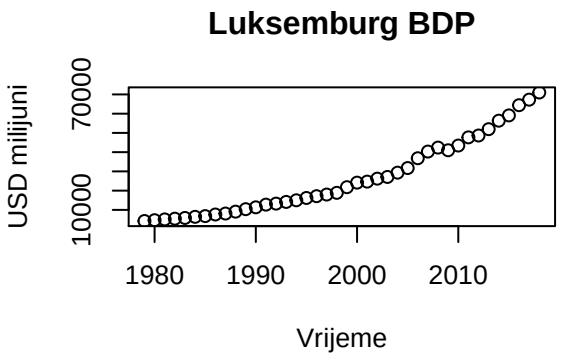
```
summary(jpn_import)
```

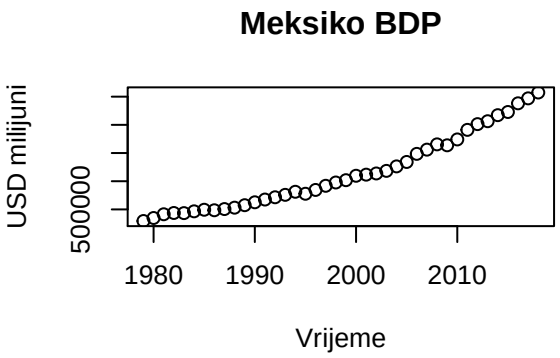
```
##  FREQUENCY      TIME          Value
##  A:40      Min.   :1979   Min.   :232512
##            1st Qu.:1989   1st Qu.:385417
##            Median :1998   Median :571513
##            Mean   :1998   Mean   :566113
##            3rd Qu.:2008   3rd Qu.:767861
##            Max.   :2018   Max.   :973561
```

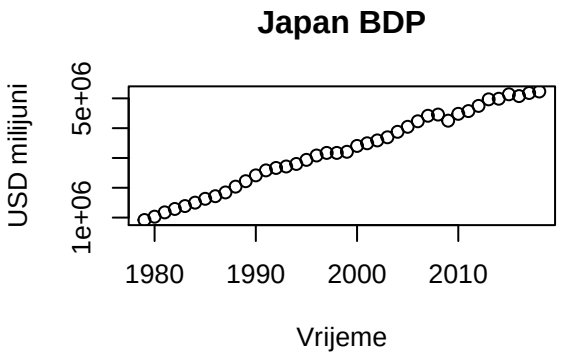
Sljedeći dio grafički prikazuje podatke koji se obrađuju u nastavku. Prikazani su grafovi BDP u ovisnosti o godinama za svaku zemlju zasebno. S obzirom na veliku razliku u godišnjem BDP-u među državama, podatke nije pregledno promatrati na istome grafu. Međutim korisno je promotriti istovremeno boxplot dijagrame zemalja za godišnji rast BDP-a. Iz njega su istovremeno vidljive i stršeće vrijednosti goidšnjeg rasta BDP-a za svaku zemlju.

```
par(mfrow = c(2, 2))
plot(
  lux_GDP$TIME,
  lux_GDP$Value,
  main = 'Luksemburg BDP',
  xlab = 'Vrijeme',
  ylab = 'USD milijuni'
)
```

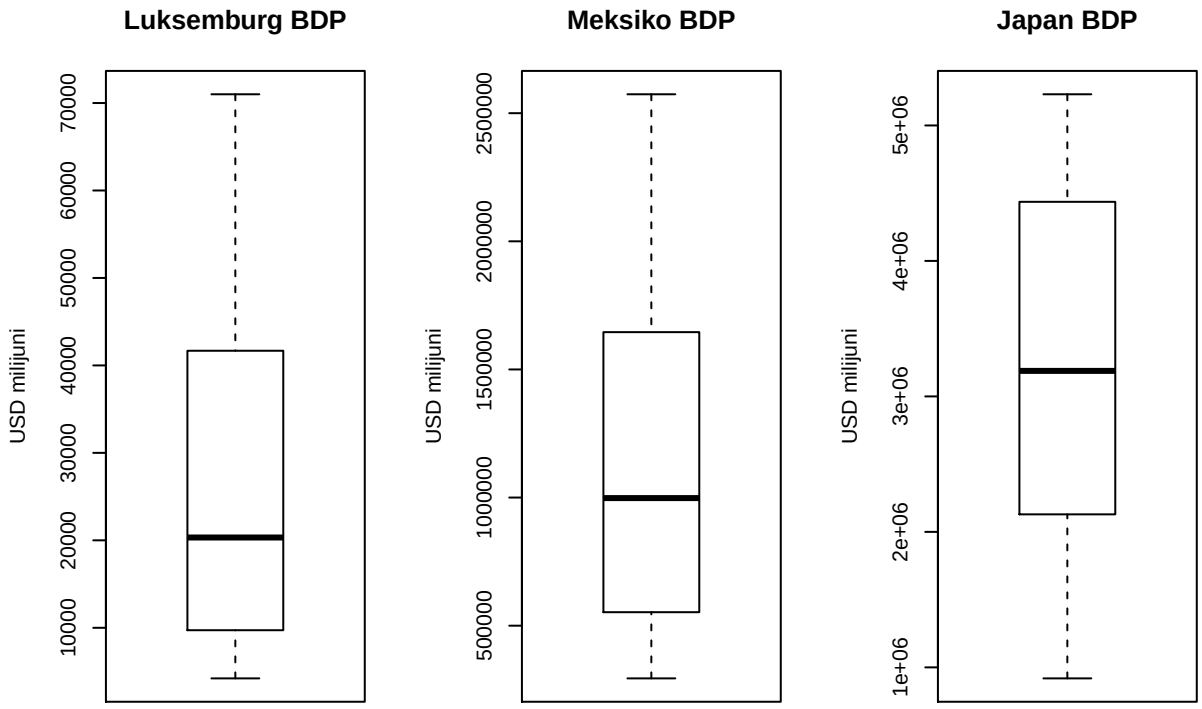
```r
plot(
  mex_GDP$TIME,
  mex_GDP$Value,
  main = 'Meksiko BDP',
  xlab = 'Vrijeme',
  ylab = 'USD milijuni'
)
plot(
  jpn_GDP$TIME,
  jpn_GDP$Value,
  main = 'Japan BDP',
  xlab = 'Vrijeme',
  ylab = 'USD milijuni'
)
par(mfrow = c(1, 1))
```







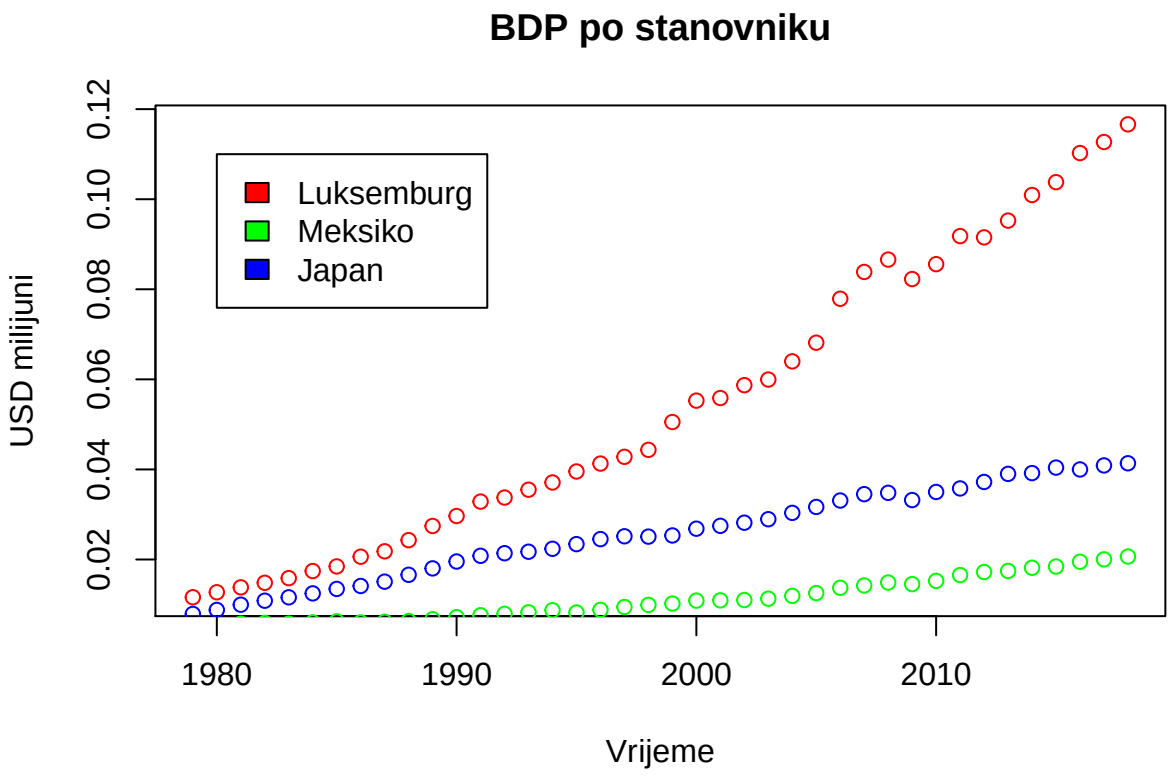

```r
par(mfrow = c(1, 3))
boxplot(lux_GDP$Value, main = 'Luksemburg BDP',
        ylab = 'USD milijuni')
boxplot(mex_GDP$Value, main = 'Meksiko BDP',
        ylab = 'USD milijuni')
boxplot(jpn_GDP$Value, main = 'Japan BDP',
        ylab = 'USD milijuni')
```



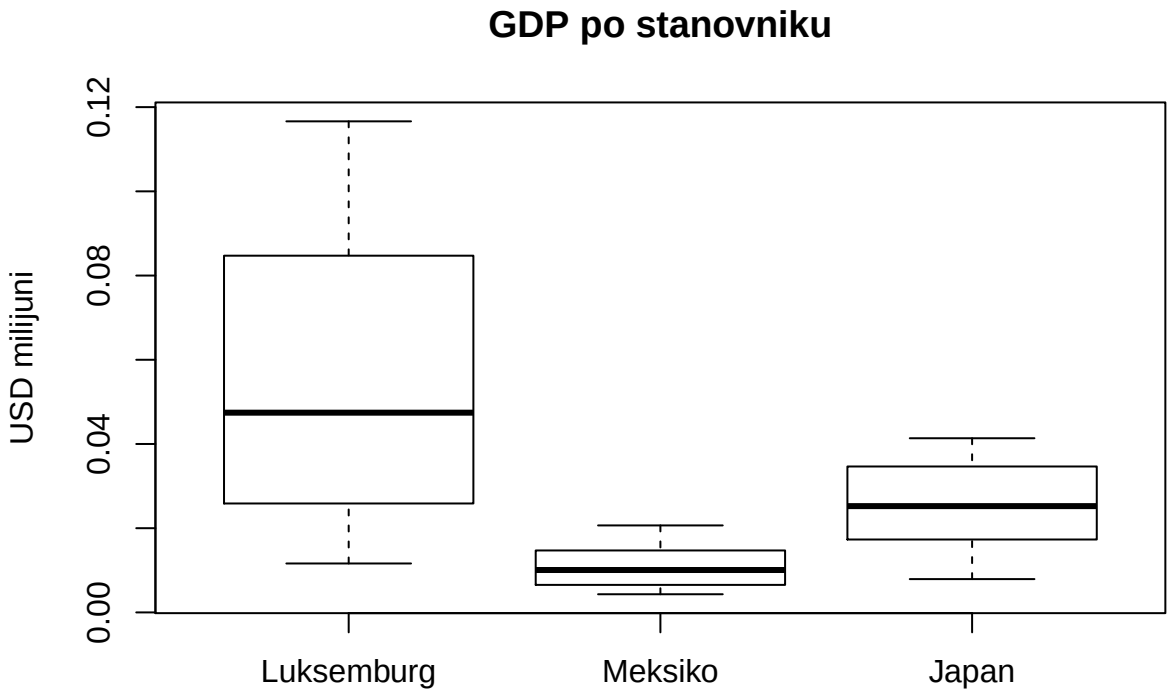

```
par(mfrow = c(1, 1))
```

Sljedećim grafovima prikazani su podaci o BDP-u po stanovniku za svaku zemlju, te su prikazani boxplot dijagrami za rast BDP-a per capita za svaku odabranu zemlju.

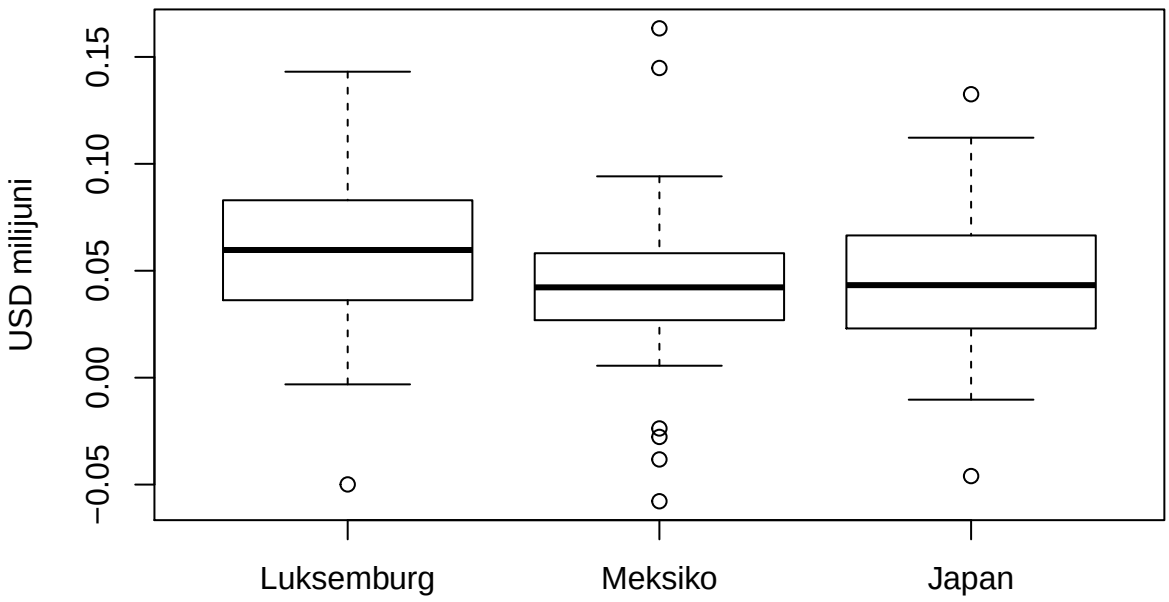
```
plot(
        lux_GDP_percapita$TIME,
        lux_GDP_percapita$Value,
        main = 'BDP po stanovniku',
        xlab = 'Vrijeme',
        ylab = 'USD milijuni',
        col = "red"
)
points(mex_GDP_percapita$TIME, mex_GDP_percapita$Value, col = "green")
points(jpn_GDP_percapita$TIME, jpn_GDP_percapita$Value, col = "blue")
legend(
        1980,
        0.11,
        legend = c("Luksemburg", "Meksiko", "Japan"),
        fill = c("red", "green", "blue")
)
```




```
boxplot(
        lux_GDP_percapita$Value,
        mex_GDP_percapita$Value,
        jpn_GDP_percapita$Value,
        main = 'GDP po stanovniku',
        ylab = 'USD milijuni',
        names = c("Luksemburg", "Meksiko", "Japan")
)
```

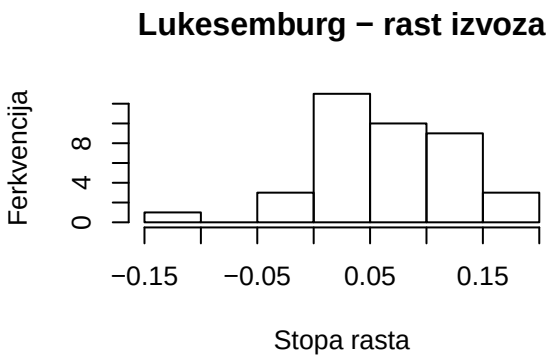


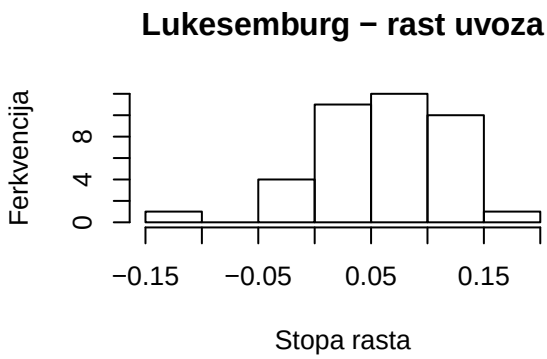

```
boxplot(
        growth_lux_GDP_percapita$Value,
        growth_mex_GDP_percapita$Value,
        growth_jpn_GDP_percapita$Value,
        main = 'Rast GDP-a po stanovniku',
        ylab = 'USD milijuni',
        names = c("Luksemburg", "Meksiko", "Japan")
)
```

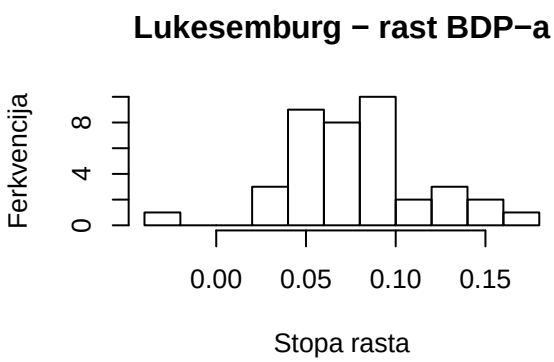

Rast GDP−a po stanovniku
USD milijuni
−0.05
0.00
0.05
0.10
0.15
Luksemburg
Meksiko
Japan

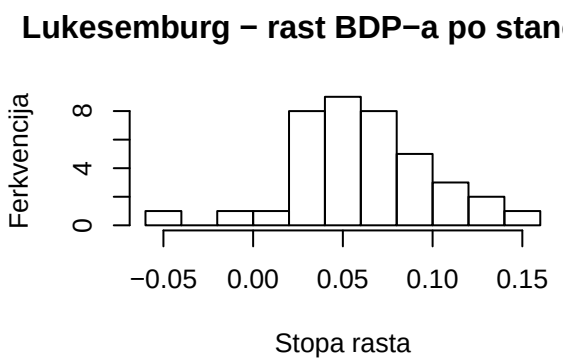
Provjera normalnosti podataka Prije nego li se u radu počne odgovarati na pitanja koristeći statističke testove potrebno je obaviti provjeru normalnosti podataka. Pretpostavkom normalnosti podataka moguće je koristit parametarsku statistiku te testove s većom snagom testa, nasuprot neparametarskim testovima s manjom snagom testa.

```
par(mfrow = c(2, 2))
hist(
        growth_lux_export$Value,
        main = 'Lukesemburg - rast izvoza',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
hist(
        growth_lux_import$Value,
        main = 'Lukesemburg - rast uvoza',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
hist(growth_lux_GDP$Value,
     main = 'Lukesemburg - rast BDP-a',
     xlab = 'Stopa rasta',
     ylab = 'Ferkvencija')
hist(
        growth_lux_GDP_percapita$Value,
        main = 'Lukesemburg - rast BDP-a po stanovniku',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
```

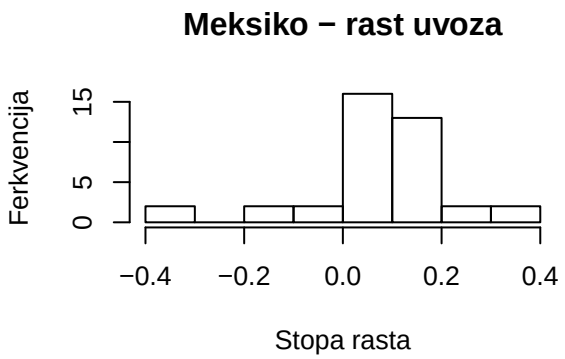


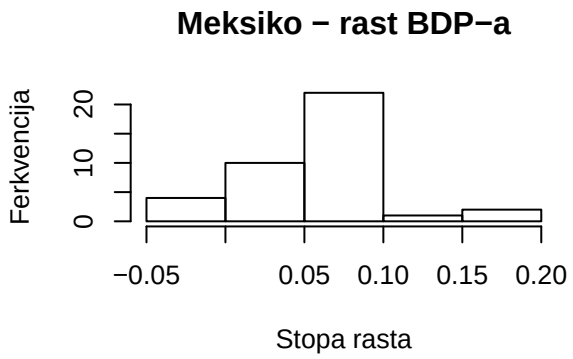


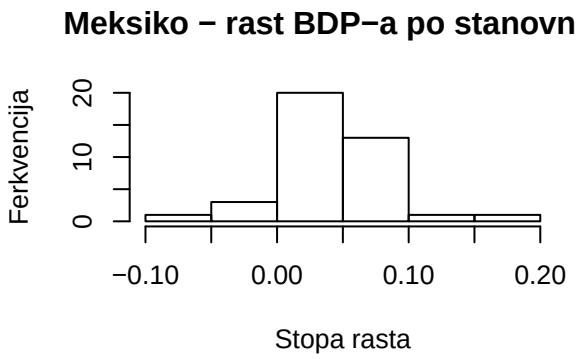




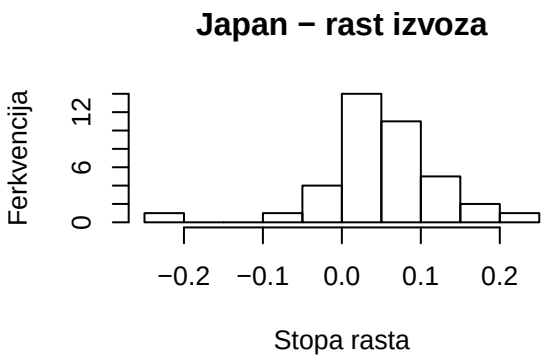

```r
hist(
        growth_mex_export$Value,
        main = 'Meksiko - rast izvoza',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
hist(
        growth_mex_import$Value,
        main = 'Meksiko - rast uvoza',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
hist(growth_mex_GDP$Value,
     main = 'Meksiko - rast BDP-a',
     xlab = 'Stopa rasta',
     ylab = 'Ferkvencija')
hist(
        growth_mex_GDP_percapita$Value,
        main = 'Meksiko - rast BDP-a po stanovniku',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
```

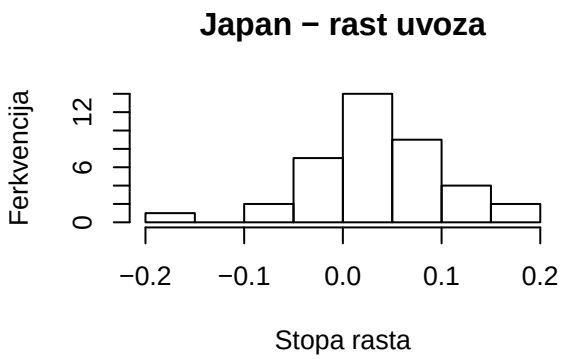


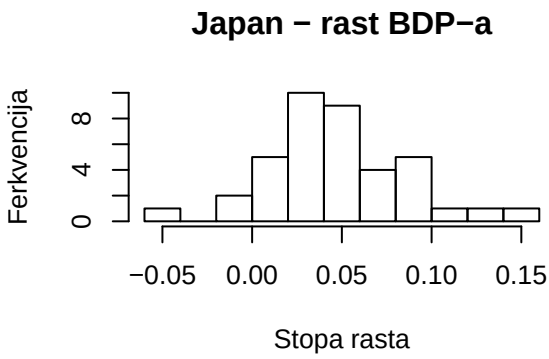


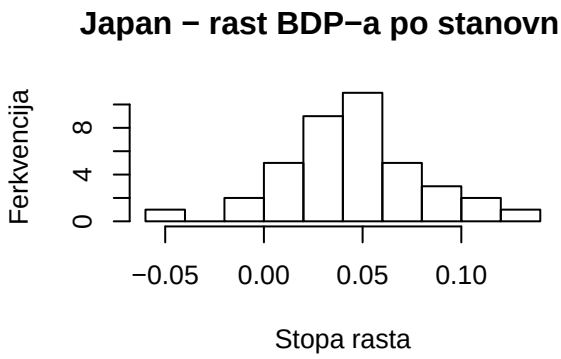



```r
hist(
        growth_jpn_export$Value,
        main = 'Japan - rast izvoza',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
hist(
        growth_jpn_import$Value,
        main = 'Japan - rast uvoza',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
hist(growth_jpn_GDP$Value,
     main = 'Japan - rast BDP-a',
     xlab = 'Stopa rasta',
     ylab = 'Ferkvencija')
hist(
        growth_jpn_GDP_percapita$Value,
        main = 'Japan - rast BDP-a po stanovniku',
        xlab = 'Stopa rasta',
        ylab = 'Ferkvencija'
)
```


Japan − rast izvoza
Ferkvencija
0
6
12
−0.2
−0.1
0.0
0.1
0.2
Stopa rasta


Japan − rast uvoza
Ferkvencija
0
6
12
−0.2
−0.1
0.0
0.1
0.2
Stopa rasta

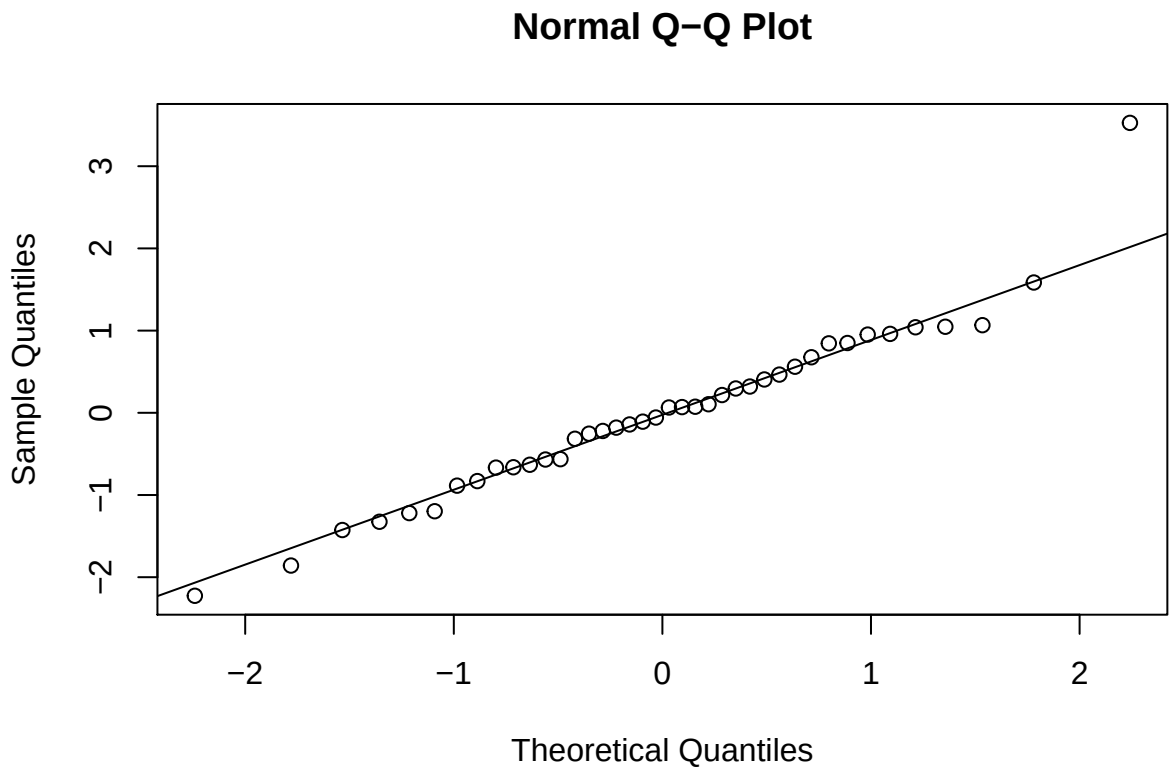

Japan − rast BDP−a
Ferkvencija
0
4
8
−0.05
0.00
0.05
0.10
0.15
Stopa rasta


Japan − rast BDP−a po stanovniku
Ferkvencija
0
4
8
−0.05
0.00
0.05
0.10
Stopa rasta

Linearna regresija

Koristeći linearnu regresiju kao moćni alat, provjerava se veza između BDP-a te uvoza i izvoza. Ispituje se normalnost reziduala grafički, koristeći kvantil-kvantil graf te statistički, Kolmogorov-Smirnovljevim testom.

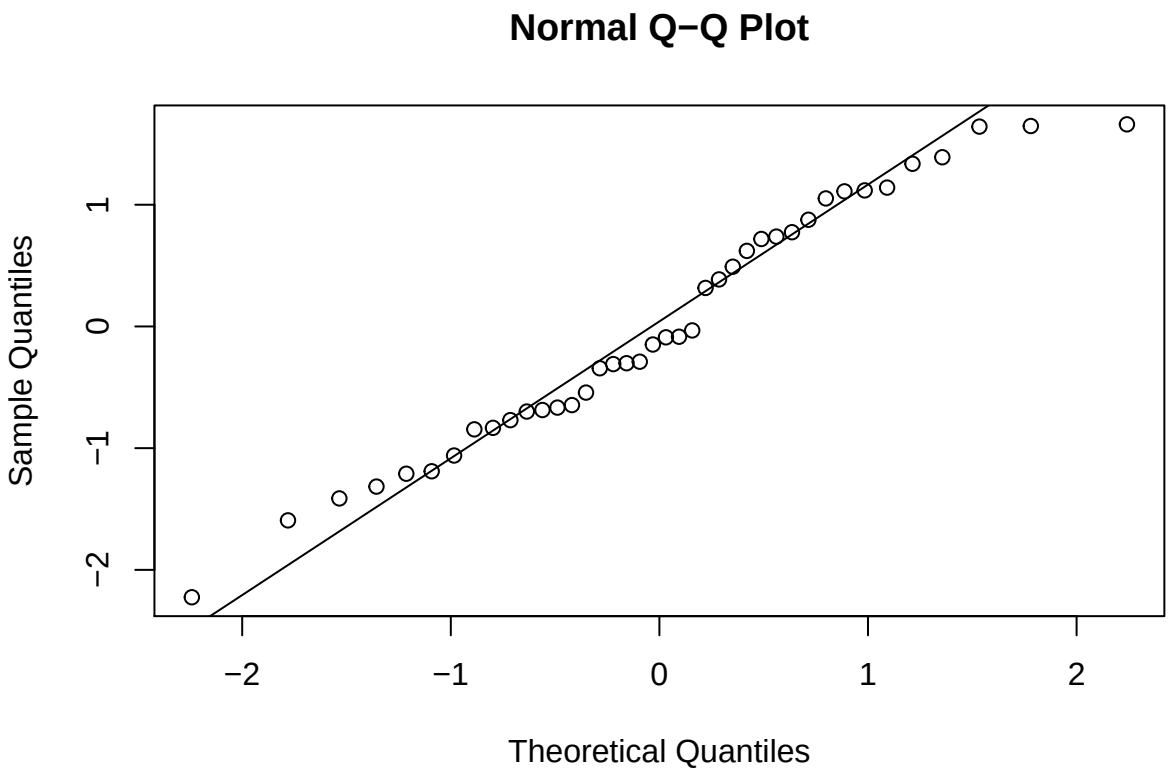
```
fit_lux = lm(lux_GDP$Value ~ lux_export$Value + lux_import$Value)
fit_lux_percapita = lm(lux_GDP_percapita$Value ~ lux_export$Value + lux_import$Value)
#plot(fit_lux$residuals)
#plot(fit_lux_percapita$residuals)
qqnorm(rstandard(fit_lux))
qqline(rstandard(fit_lux))
```




```
ks.test(rstandard(fit_lux), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_lux)
## D = 0.09316, p-value = 0.8465
## alternative hypothesis: two-sided
```

```
qqnorm(rstandard(fit_lux_percapita))
qqline(rstandard(fit_lux_percapita))
```




```
ks.test(rstandard(fit_lux_percapita), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_lux_percapita)
## D = 0.090944, p-value = 0.8656
## alternative hypothesis: two-sided
```

```
summary(fit_lux)
```

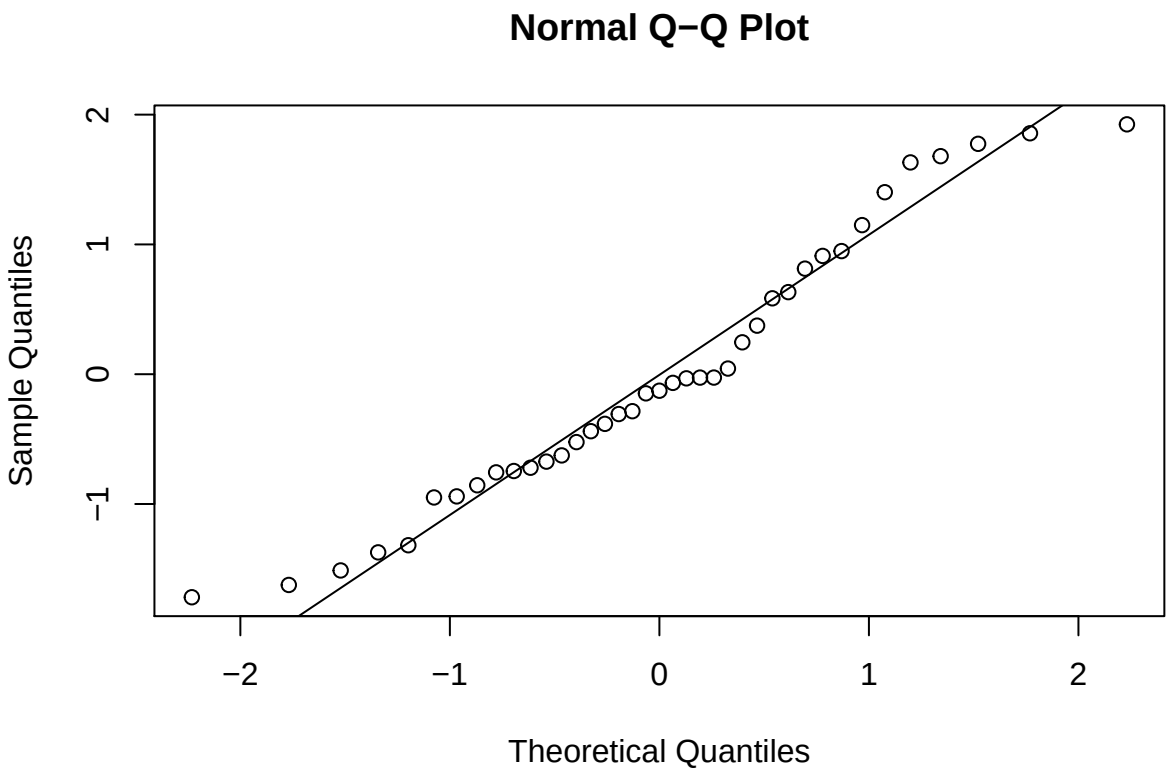
```
##
## Call:
## lm(formula = lux_GDP$Value ~ lux_export$Value + lux_import$Value)
##
## Residuals:
##    Min     1Q Median     3Q    Max
##  -4057  -1297      8   1204   6944
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       -1.280e+03  5.980e+02  -2.140   0.0390 *
## lux_export$Value   7.805e-02  1.724e-01   0.453   0.6534
## lux_import$Value   4.856e-01  2.075e-01   2.340   0.0248 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 2100 on 37 degrees of freedom
## Multiple R-squared:  0.9893, Adjusted R-squared:  0.9888
## F-statistic:  1717 on 2 and 37 DF,  p-value: < 2.2e-16
```

```
summary(fit_lux_percapita)
```

```
##
## Call:
## lm(formula = lux_GDP_percapita$Value ~ lux_export$Value + lux_import$Value)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0059125 -0.0018905 -0.0002913  0.0021345  0.0044491
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       7.326e-03  7.836e-04   9.349 2.78e-11 ***
## lux_export$Value  2.018e-06  2.259e-07   8.936 8.97e-11 ***
## lux_import$Value -1.477e-06  2.719e-07  -5.434 3.67e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.002751 on 37 degrees of freedom
## Multiple R-squared:  0.9933, Adjusted R-squared:  0.9929
## F-statistic:  2725 on 2 and 37 DF,  p-value: < 2.2e-16
```

```
dat_lux_growth = data.frame(
  BDP_GROWTH = growth_lux_GDP$Value,
  EXPORT = growth_lux_export$Value,
  IMPORT = growth_lux_import$Value
)
fit_lux_growth = lm(BDP_GROWTH ~ EXPORT + IMPORT, data = dat_lux_growth)
qqnorm(rstandard(fit_lux_growth))
qqline(rstandard(fit_lux_growth))
```




```
ks.test(rstandard(fit_lux_growth), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_lux_growth)
## D = 0.12566, p-value = 0.5281
## alternative hypothesis: two-sided
```

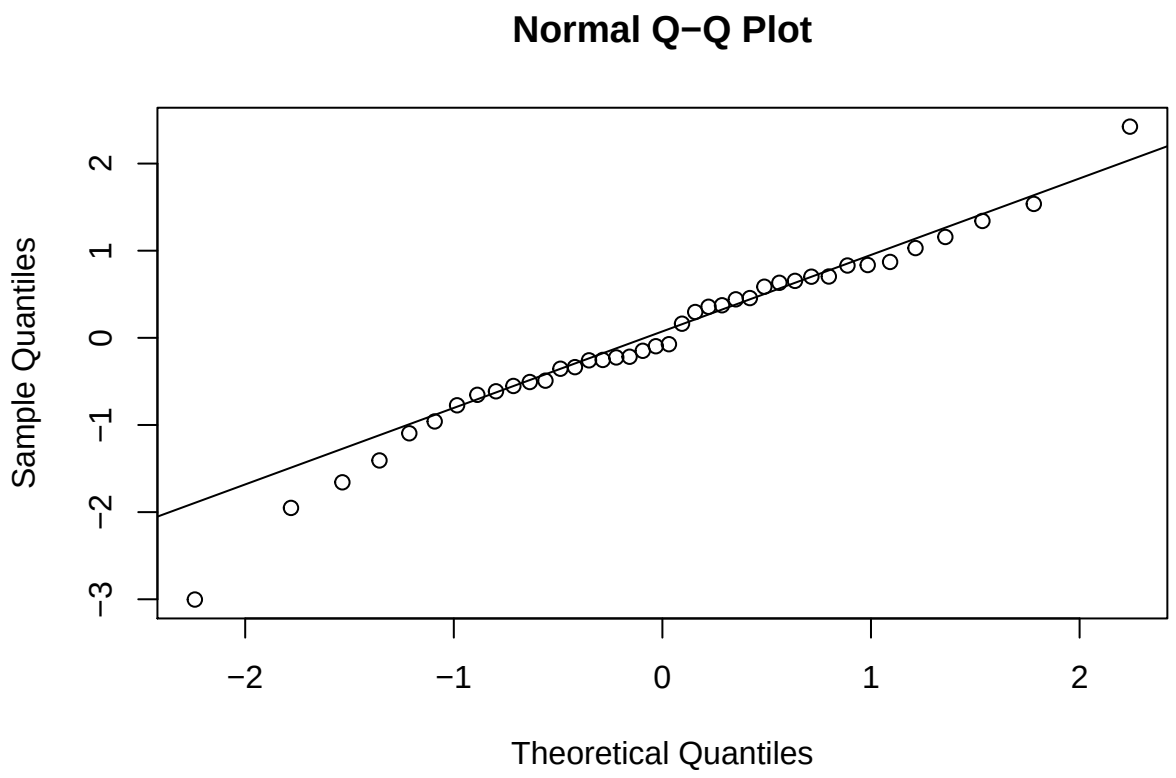
```
summary(fit_lux_growth)
```

```
##
## Call:
## lm(formula = BDP_GROWTH ~ EXPORT + IMPORT, data = dat_lux_growth)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.052807 -0.022289 -0.004139  0.023286  0.061563
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.054590   0.007726   7.066 2.69e-08 ***
## EXPORT      0.333167   0.246020   1.354    0.184
## IMPORT      0.007474   0.240701   0.031    0.975
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.03302 on 36 degrees of freedom
## Multiple R-squared:  0.2825, Adjusted R-squared:  0.2427
## F-statistic: 7.089 on 2 and 36 DF,  p-value: 0.002537
```

Zadovoljena je normalnost reziduala. Ovisnost BDP o uvozu i izvozu je potvrđena, koeficijenit uz sve članove potvrđeni su kao značajni. Točnije rečeno za svaku je koeficijent odbačena nulta hipoteza da taj koeficijent iznosi 0. Danim testovima vidljivije je iz koeficijent determinacije R^2, da uvoz i izvoz bolje modeliraju BDP po stanovniku. Na primjeru Luksemburga promatrana je ovisnost rasta BDP-a o rastu izvoza i rastu uvoza. Koeficijent determinacije značajno je manji od prethodno promatranih modela, to jest znatno manja varijabilnost je objašnjena ovim modelom. Iz čega slijedi da ime više smisla promatrati modele BDP-a, a ne rasta BDP-a. Na primjeru Luksemburga pokazano da nije korisno modelirati linearnog regresijom BDP o rastu izvoza i uvoza, kao jedini značajni koeficijent t-testom pokazuje se interakcijski član.

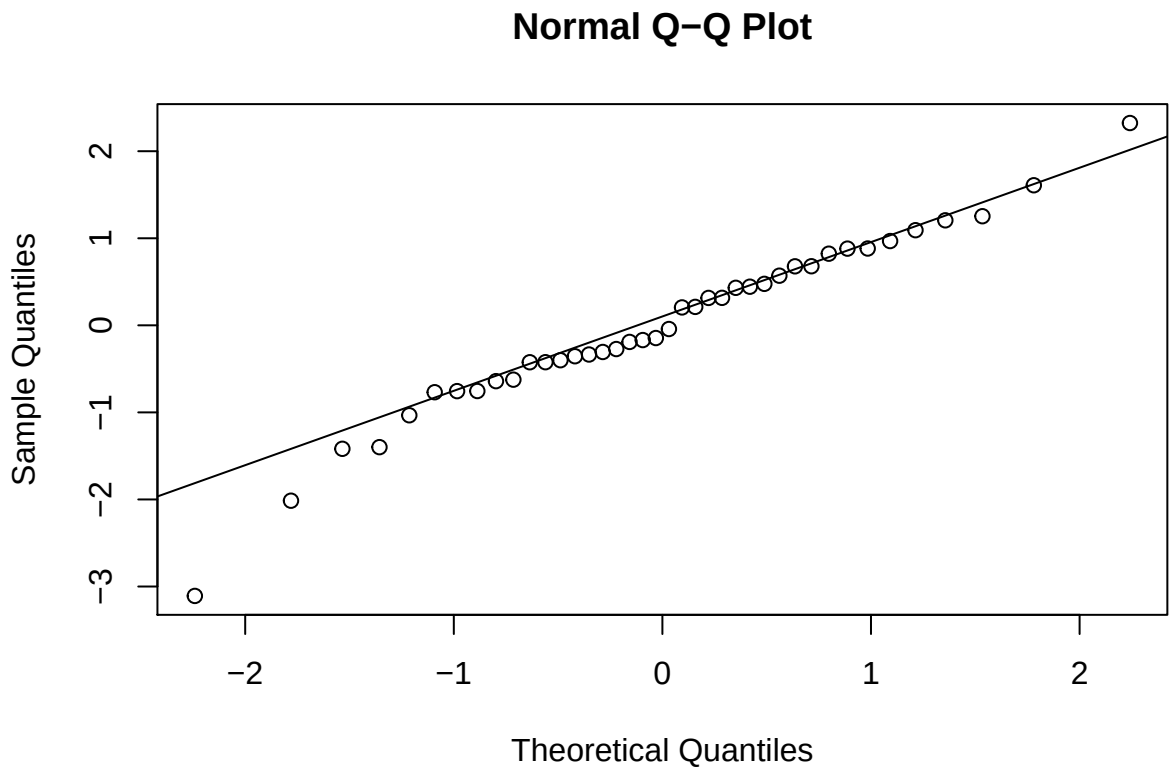
```
#dataframe
jpn_growth_dataframe = data.frame(
        GDP_GROWTH = growth_jpn_GDP$Value,
        EXPORT = growth_jpn_export$Value,
        IMPORT = growth_jpn_import$Value
)
fit_jpn = lm(jpn_GDP$Value ~ jpn_export$Value + jpn_import$Value)
fit_jpn_percapita = lm(jpn_GDP_percapita$Value ~ jpn_export$Value + jpn_import$Value)
#plot(fit_jpn$residuals)
#plot(fit_jpn_percapita$residuals)
qqnorm(rstandard(fit_jpn))
qqline(rstandard(fit_jpn))
```




```
ks.test(rstandard(fit_jpn), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_jpn)
## D = 0.081589, p-value = 0.933
## alternative hypothesis: two-sided
```

```
qqnorm(rstandard(fit_jpn_percapita))
qqline(rstandard(fit_jpn_percapita))
```




```
ks.test(rstandard(fit_jpn_percapita), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_jpn_percapita)
## D = 0.096102, p-value = 0.8196
## alternative hypothesis: two-sided
```

```
summary(fit_jpn)
```

```
##
## Call:
## lm(formula = jpn_GDP$Value ~ jpn_export$Value + jpn_import$Value)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -567996  -97584  -16033  127124  469769
```

```
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)      1.156e+05  9.709e+04   1.190    0.241
## jpn_export$Value 4.798e-01  5.922e-01   0.810    0.423
## jpn_import$Value 5.065e+00  6.512e-01   7.778 2.68e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 197000 on 37 degrees of freedom
## Multiple R-squared:  0.9792, Adjusted R-squared:  0.978
## F-statistic: 868.8 on 2 and 37 DF,  p-value: < 2.2e-16
```

```
summary(fit_jpn_percapita)
```

```
##
## Call:
## lm(formula = jpn_GDP_percapita$Value ~ jpn_export$Value + jpn_import$Value)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0043747 -0.0006563 -0.0001329  0.0009335  0.0033515
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)      1.845e-03  7.225e-04   2.553   0.0149 *
## jpn_export$Value 4.057e-09  4.407e-09   0.921   0.3632
## jpn_import$Value 3.832e-08  4.846e-09   7.907 1.82e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.001466 on 37 degrees of freedom
## Multiple R-squared:  0.9802, Adjusted R-squared:  0.9792
## F-statistic: 917.8 on 2 and 37 DF,  p-value: < 2.2e-16
```

Kao i u prethodnome primjeru zadovoljena je normalnost reziduala oba promatrana modela. Međutim, za razliku od modela Luksemburga kod Japana je koeficijent modela uz varijablu izvoza neznačajan, kao i njihova interakcija. Kod modela gdje se ispituje kako BDP per capita ovisi o uvozu i izvozu, značajan je jedino koeficijent u varijablu uvoza i interakcijski član uvoza i izvoza.

```
fit_jpn_only_import = lm(jpn_GDP_percapita$Value~jpn_import$Value)
ks.test(rstandard(fit_jpn_only_import),'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_jpn_only_import)
## D = 0.092198, p-value = 0.855
## alternative hypothesis: two-sided
```

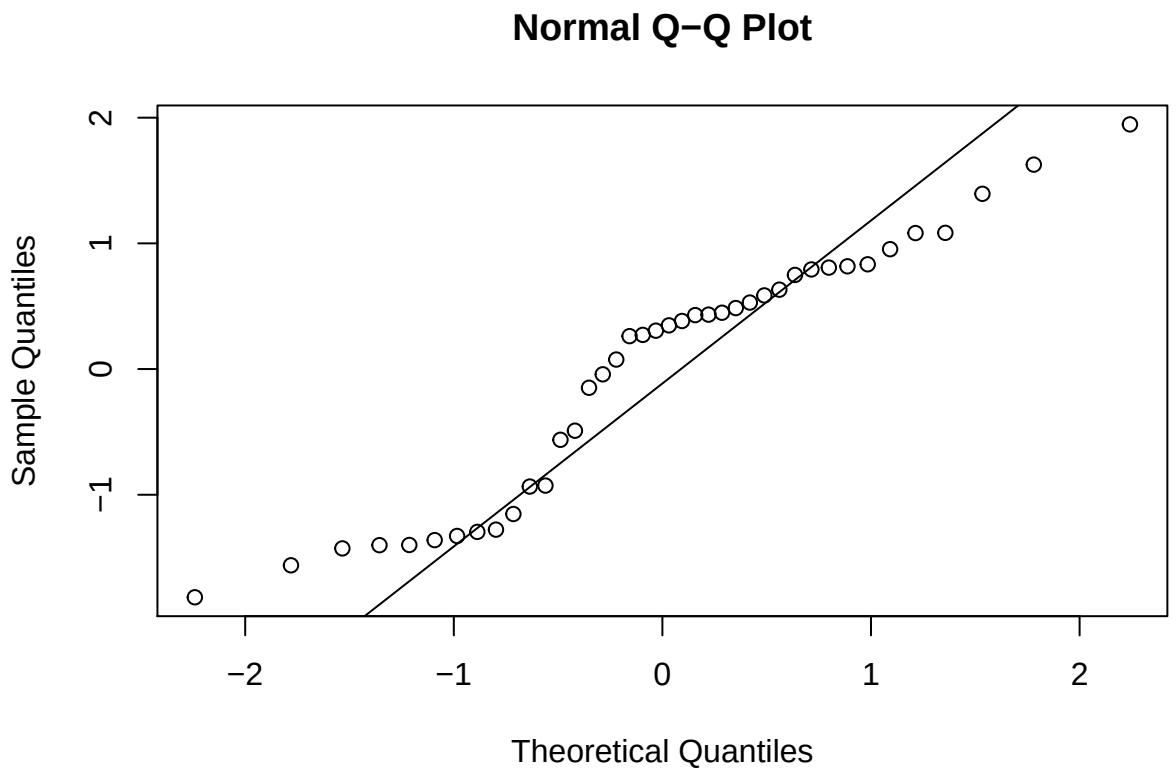
```
summary(fit_jpn_only_import)
```

```
##
## Call:
## lm(formula = jpn_GDP_percapita$Value ~ jpn_import$Value)
##
## Residuals:
```

```
##        Min         1Q     Median         3Q        Max
## -0.0044968 -0.0007796 -0.0000497  0.0010108  0.0034136
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)      1.488e-03  6.087e-04   2.445   0.0192 *
## jpn_import$Value 4.269e-08  9.946e-10  42.920   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.001463 on 38 degrees of freedom
## Multiple R-squared:  0.9798, Adjusted R-squared:  0.9793
## F-statistic:  1842 on 1 and 38 DF,  p-value: < 2.2e-16
```

Prethodno je napravljen model gospodarstva Japana o značajnim varijablama, to jest uvozu.

```
fit_mex = lm(mex_GDP$Value ~ mex_export$Value + mex_import$Value)
fit_mex_percapita = lm(mex_GDP_percapita$Value ~ mex_export$Value + mex_import$Value)
#plot(fit_mex$residuals)
#plot(fit_mex_percapita$residuals)
qqnorm(rstandard(fit_mex))
qqline(rstandard(fit_mex))
```

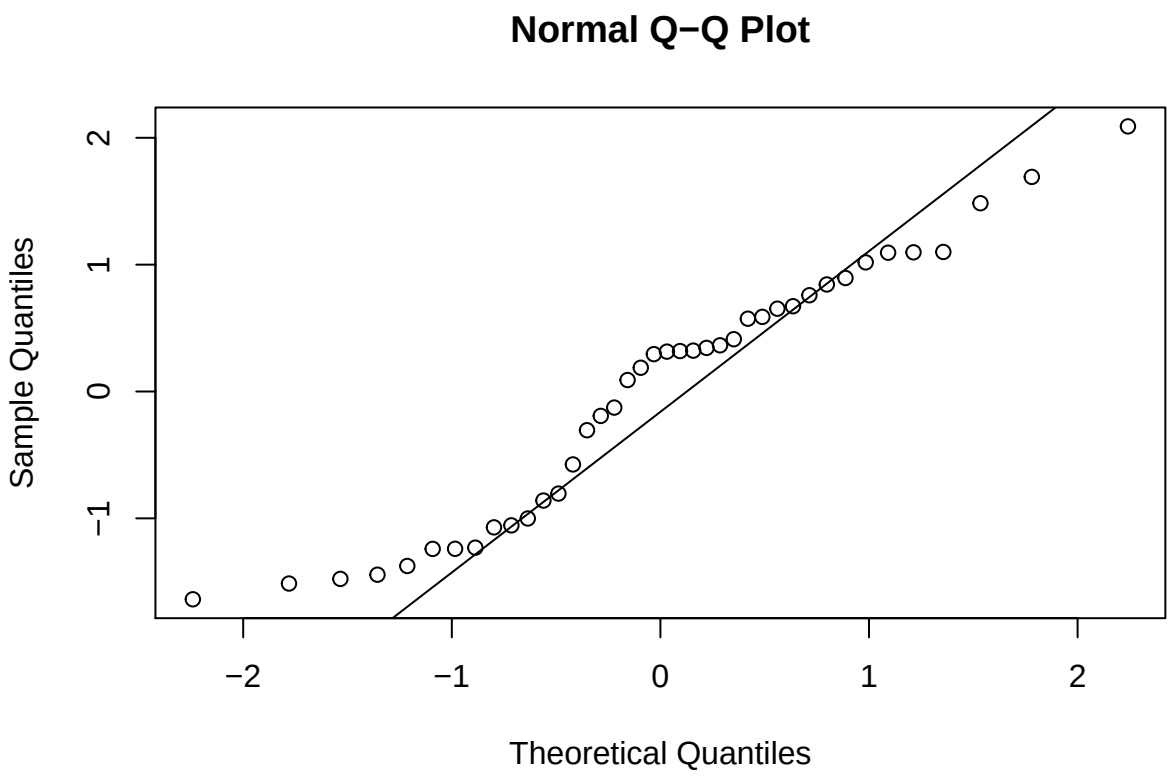



```
ks.test(rstandard(fit_mex), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
```

```
## data:  rstandard(fit_mex)
## D = 0.17833, p-value = 0.1388
## alternative hypothesis: two-sided
```

```
qqnorm(rstandard(fit_mex_percapita))
qqline(rstandard(fit_mex_percapita))
```




```
ks.test(rstandard(fit_mex_percapita), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_mex_percapita)
## D = 0.14086, p-value = 0.3707
## alternative hypothesis: two-sided
```

```
summary(fit_mex)
```

```
##
## Call:
## lm(formula = mex_GDP$Value ~ mex_export$Value + mex_import$Value)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -182260  -98931   31753   75189  194959
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)      2.083e+05  2.873e+04   7.251 1.32e-08 ***
## mex_export$Value 2.466e+00  5.115e-01   4.822 2.44e-05 ***
## mex_import$Value 1.525e-01  4.661e-01   0.327    0.745
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 102700 on 37 degrees of freedom
## Multiple R-squared:  0.9777, Adjusted R-squared:  0.9765
## F-statistic: 812.2 on 2 and 37 DF,  p-value: < 2.2e-16
```

```
summary(fit_mex_percapita)
```

```
##
## Call:
## lm(formula = mex_GDP_percapita$Value ~ mex_export$Value + mex_import$Value)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0010971 -0.0006670  0.0002005  0.0004640  0.0013969
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)      4.221e-03  1.917e-04  22.021  < 2e-16 ***
## mex_export$Value 1.501e-08  3.414e-09   4.397 8.91e-05 ***
## mex_import$Value 3.498e-09  3.111e-09   1.125    0.268
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0006854 on 37 degrees of freedom
## Multiple R-squared:  0.9805, Adjusted R-squared:  0.9795
## F-statistic: 932.5 on 2 and 37 DF,  p-value: < 2.2e-16
```

Prilikom izrade modela BDP-a Meksika o uvozu i izvozu zanimljivo je primjetiti da hipotezu da je koeficijent uz varijablu uvoza jednak 0 nije moguće odbaciti uz nivo signifikantnosti od 25%. Oba promatrana modela su jednako dobra gledajući R^2, uz malu prednost prema modelu koji promatra BDP po stanovniku. U nastavku je dan model bez uvoza za Meksiko.

```
dat_mex = data.frame(GDP = mex_GDP_percapita$Value,
                     EXPORT = mex_export$Value,
                     IMPORT = mex_import$Value)
fit_mex_only_export = lm(GDP ~ . - IMPORT, data = dat_mex)
ks.test(rstandard(fit_mex_only_export), 'pnorm')
```

```
##
##  One-sample Kolmogorov-Smirnov test
##
## data:  rstandard(fit_mex_only_export)
## D = 0.14654, p-value = 0.3245
## alternative hypothesis: two-sided
```

```
summary(fit_mex_only_export)
```

```
##
## Call:
## lm(formula = GDP ~ . - IMPORT, data = dat_mex)
##
## Residuals:
```

```
##        Min         1Q     Median         3Q        Max
## -9.906e-04 -7.668e-04  8.997e-05  4.341e-04  1.505e-03
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 4.248e-03  1.909e-04   22.26   <2e-16 ***
## EXPORT      1.882e-08  4.374e-10   43.02   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0006878 on 38 degrees of freedom
## Multiple R-squared:  0.9799, Adjusted R-squared:  0.9794
## F-statistic:  1851 on 1 and 38 DF,  p-value: < 2.2e-16
```

Promatranje transformiranih varijabli

Unatoč velikom prostoru mogućnosti transformiranih varijabli, promatrana je transformacija logaritmiranjem.

```
lux_log = lm(GDP ~ log(EXPORT) + log(IMPORT) , data = lux_GDP_dataframe)
summary(lux_log)
```

```
##
## Call:
## lm(formula = GDP ~ log(EXPORT) + log(IMPORT), data = lux_GDP_dataframe)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6663.4 -2997.6  -391.5  2462.5 13505.7
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -237752       9624 -24.703  < 2e-16 ***
## log(EXPORT)   -95194      15952  -5.968 6.94e-07 ***
## log(IMPORT)   122095      16398   7.446 7.28e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4374 on 37 degrees of freedom
## Multiple R-squared:  0.9537, Adjusted R-squared:  0.9512
## F-statistic: 381.4 on 2 and 37 DF,  p-value: < 2.2e-16
```

```
mex_log = lm(GDP ~ log(EXPORT) + log(IMPORT) , data = mex_GDP_dataframe)
summary(mex_log)
```

```
##
## Call:
## lm(formula = GDP ~ log(EXPORT) + log(IMPORT), data = mex_GDP_dataframe)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -379407 -259195   31113  157613  572072
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -7597445     614439 -12.365 1.04e-14 ***
## log(EXPORT)   505858     181068   2.794   0.0082 **
## log(IMPORT)   194426     179234   1.085   0.2850
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 269500 on 37 degrees of freedom
## Multiple R-squared:  0.8467, Adjusted R-squared:  0.8384
## F-statistic: 102.2 on 2 and 37 DF,  p-value: 8.541e-16
```

```
jpn_log = lm(GDP ~ log(EXPORT) + log(IMPORT) , data = jpn_GDP_dataframe)
summary(jpn_log)
```

```
##
## Call:
## lm(formula = GDP ~ log(EXPORT) + log(IMPORT), data = jpn_GDP_dataframe)
```

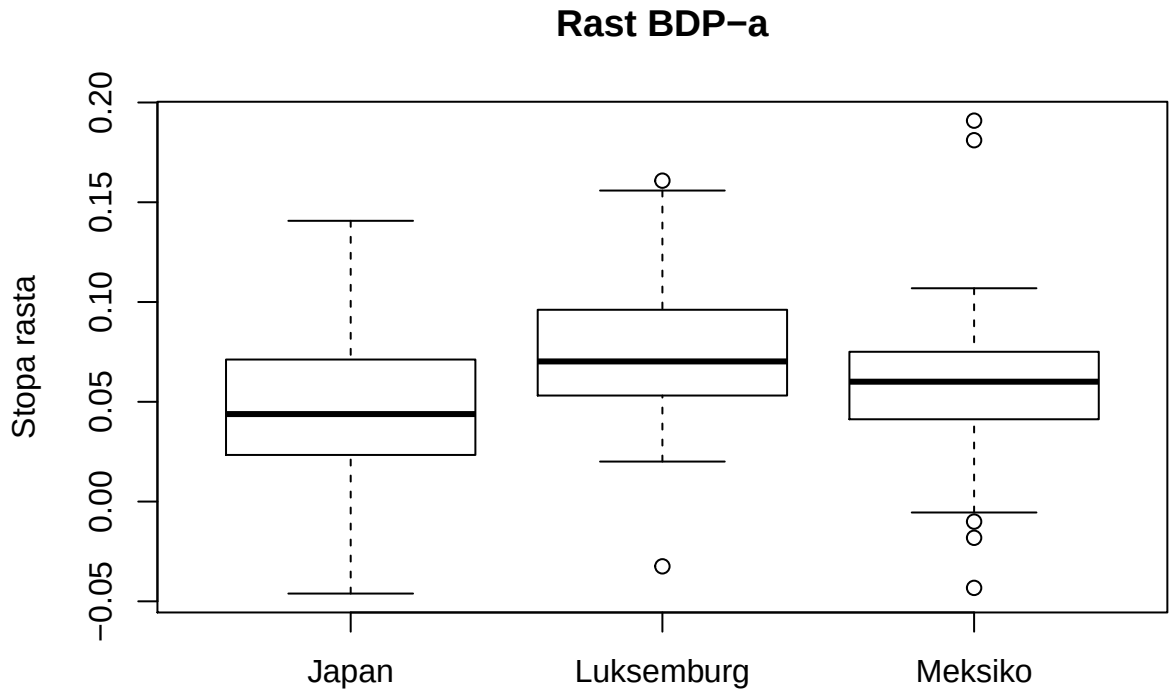
```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -222113  -74643   13121   78824  320251
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -30767134     640273 -48.053  < 2e-16 ***
## log(EXPORT)   1707744     171518   9.957 5.16e-12 ***
## log(IMPORT)    893161     195352   4.572 5.25e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 129500 on 37 degrees of freedom
## Multiple R-squared:  0.991,  Adjusted R-squared:  0.9905
## F-statistic:  2034 on 2 and 37 DF,  p-value: < 2.2e-16
```

Promatranjem transformiranih modela vidljivo je da su logaritmirani modeli Meksika i Luksemburga lošiji. Imaju manji koeficijent determinacije, a nema razlike u testiranju značajnosti koeficijenata. Nasuprot tome,model Japana s logaritmiranim varijablama je bolji od netransformiranog modela.

Usporedba prosječnog rasta gospodarstva država

Kako bismo ispitali razlikuje li se prosječni rast gospodarstva neke države u odnosu na prosječni rast gospodarstva neke druge države koristili smo analizu varijanci, ANOVA-u. Njezina je pretpostavka nezavisnost i normalna distribuiranost podataka te homogenost varijanci među populacijama. Kako bismo provjerili homogenost varijanci među populacijama koristimo Bartletov test.

```
data_growth_gdp = c(growth_jpn_GDP$Value,
                    growth_lux_GDP$Value,
                    growth_mex_GDP$Value)
tmp = factor(rep(c('Japan', 'Luksemburg', 'Meksiko'), c(39, 39, 39)))
boxplot(data_growth_gdp ~ tmp,
        main = "Rast BDP-a",
        ylab = "Stopa rasta",
        xlab = "")
```




```
bartlett.test(data_growth_gdp ~ tmp)
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  data_growth_gdp by tmp
## Bartlett's K-squared = 1.1723, df = 2, p-value = 0.5565
```

```
# ANOVA
model = lm(data_growth_gdp ~ tmp)
anova(model)
```

```
## Analysis of Variance Table
##
## Response: data_growth_gdp
##            Df   Sum Sq   Mean Sq F value   Pr(>F)
## tmp         2 0.017165 0.0085827   5.391 0.005793 **
## Residuals 114 0.181494 0.0015921
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#bartlett.test(dat$TIME, dat$VALUE.Value)
t.test(growth_lux_GDP,
       growth_mex_GDP,
       alt = "greater",
       var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  growth_lux_GDP and growth_mex_GDP
## t = 1.904, df = 76, p-value = 0.03035
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.002218435         Inf
## sample estimates:
##  mean of x  mean of y
## 0.07573277 0.05804665
```

```
t.test(growth_lux_GDP,
       growth_jpn_GDP,
       alt = "greater",
       var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  growth_lux_GDP and growth_jpn_GDP
## t = 3.4475, df = 76, p-value = 0.0004627
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.01523752        Inf
## sample estimates:
##  mean of x  mean of y
## 0.07573277 0.04625945
```

```
t.test(growth_mex_GDP,
       growth_jpn_GDP,
       alt = "two.sided",
       var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  growth_mex_GDP and growth_jpn_GDP
## t = 1.2743, df = 76, p-value = 0.2064
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
```

```
##  -0.006634931  0.030209328
## sample estimates:
##  mean of x  mean of y
## 0.05804665 0.04625945
```

Iz dobivenih rezultata Bartletovog testa možemo zaključiti da su varijance jednake, no prosječni rast gospodarstva nije jednak. Pravokutni dijagram bi dao naslutiti da je rast gospodarstva Meksika i Luksemburga veći od rasta gospodarstva Japana. Uz nivo signifikatnosti od 5% možemo odbaciti hipotezu da je rast BDP-a Luksemburga jednak Meksiku u korist hipoteze da je rast BDP-a Luksemburga veći od Meksika. Jednako tako možemo zaključiti da je rast BDP-a veći od rasta Japana. Dok uz nivo signifikantnosti od 20% ne možemo odbaciti hipotezu da je rast BDP-a različit od rasta BDP-a Meksika.

Usporedba prosječnog rasta uvoza i izvoza

Koristeći dvostrani t-test kao snažni alat provjeravali smo je li prosječni rast izvoza veći od prosječnog rasta uvoza neke države. Kao jedan od parametara t-testu trebamo postaviti jesu li varijance prosječnog rasta uvoza i izvoza jednake. Tu provjeru izvršili smo metodom var.test()

```
var.test(growth_lux_import$Value, growth_lux_export$Value)
```

```
##
##  F test to compare two variances
##
## data:  growth_lux_import$Value and growth_lux_export$Value
## F = 1.0447, num df = 38, denom df = 38, p-value = 0.8935
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.547813 1.992211
## sample estimates:
## ratio of variances
##           1.044681
```

```
var.test(growth_mex_import$Value, growth_mex_export$Value)
```

```
##
##  F test to compare two variances
##
## data:  growth_mex_import$Value and growth_mex_export$Value
## F = 2.4289, num df = 38, denom df = 38, p-value = 0.007474
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  1.273686 4.631968
## sample estimates:
## ratio of variances
##           2.428925
```

```
var.test(growth_jpn_import$Value, growth_jpn_export$Value)
```

```
##
##  F test to compare two variances
##
## data:  growth_jpn_import$Value and growth_jpn_export$Value
## F = 0.74142, num df = 38, denom df = 38, p-value = 0.3605
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.3887904 1.4138998
## sample estimates:
## ratio of variances
##          0.7414248
```

```
t.test(growth_lux_import,
       growth_lux_export,
       alt = "two.sided",
       var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  growth_lux_import and growth_lux_export
```

```
## t = -0.073157, df = 76, p-value = 0.9419
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.02802038  0.02603487
## sample estimates:
##  mean of x  mean of y
## 0.06109758 0.06209034
```

```
t.test(growth_mex_import,
       growth_mex_export,
       alt = "two.sided",
       var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  growth_mex_import and growth_mex_export
## t = -0.17516, df = 64.755, p-value = 0.8615
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.06097412  0.05114186
## sample estimates:
##  mean of x  mean of y
## 0.07398704 0.07890317
```

```
t.test(growth_jpn_import,
       growth_jpn_export,
       alt = "two.sided",
       var.equal = TRUE)
```

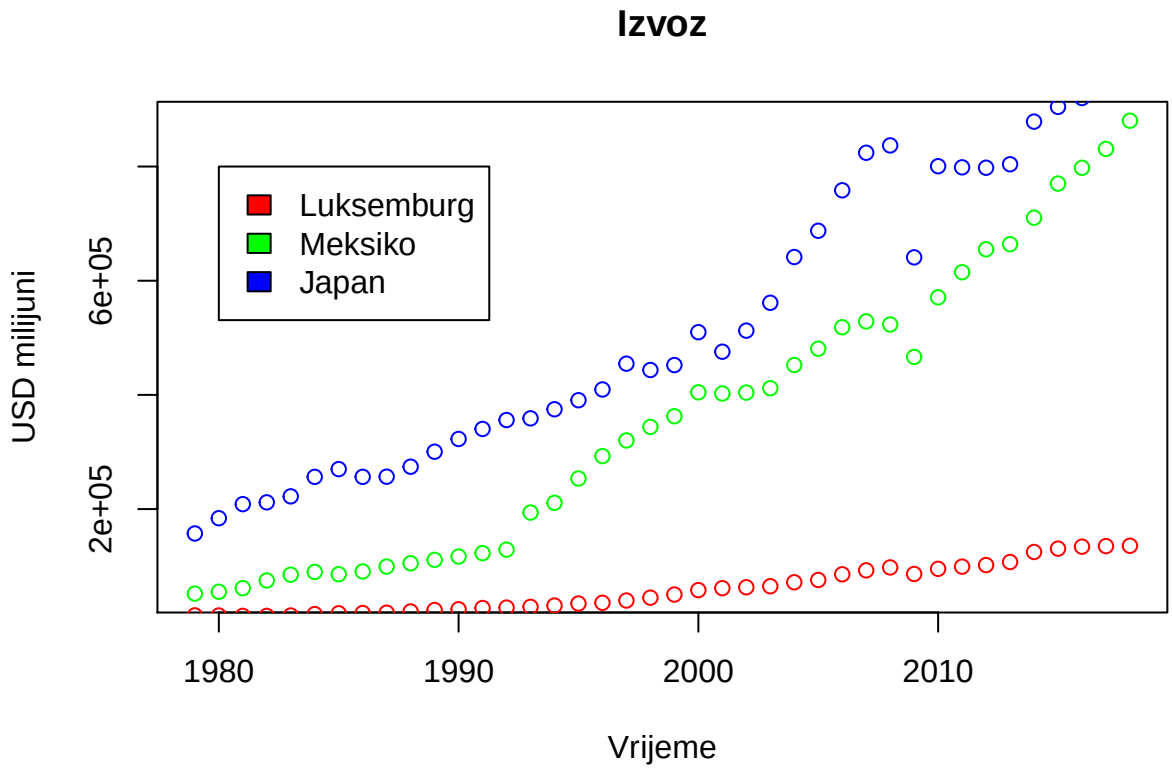
```
##
##  Two Sample t-test
##
## data:  growth_jpn_import and growth_jpn_export
## t = -0.91281, df = 76, p-value = 0.3642
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.04765403  0.01770097
## sample estimates:
##  mean of x  mean of y
## 0.03699730 0.05197383
```

Iz rezultata vidimo da vrijednosti varijanci nisu jednake kod Meksika. Također rast uvoza nije značajno veći od rasta izvoza niti kod Meksika, Luksemburga niti Japana, iz čega bi mogli protumačiti da te države i dalje granice održavaju otvorenim za uvoz, razvijajući pri tome gospodarstvo izvozom.

Ispitivanje stršećih vrijednosti rasta izvoza

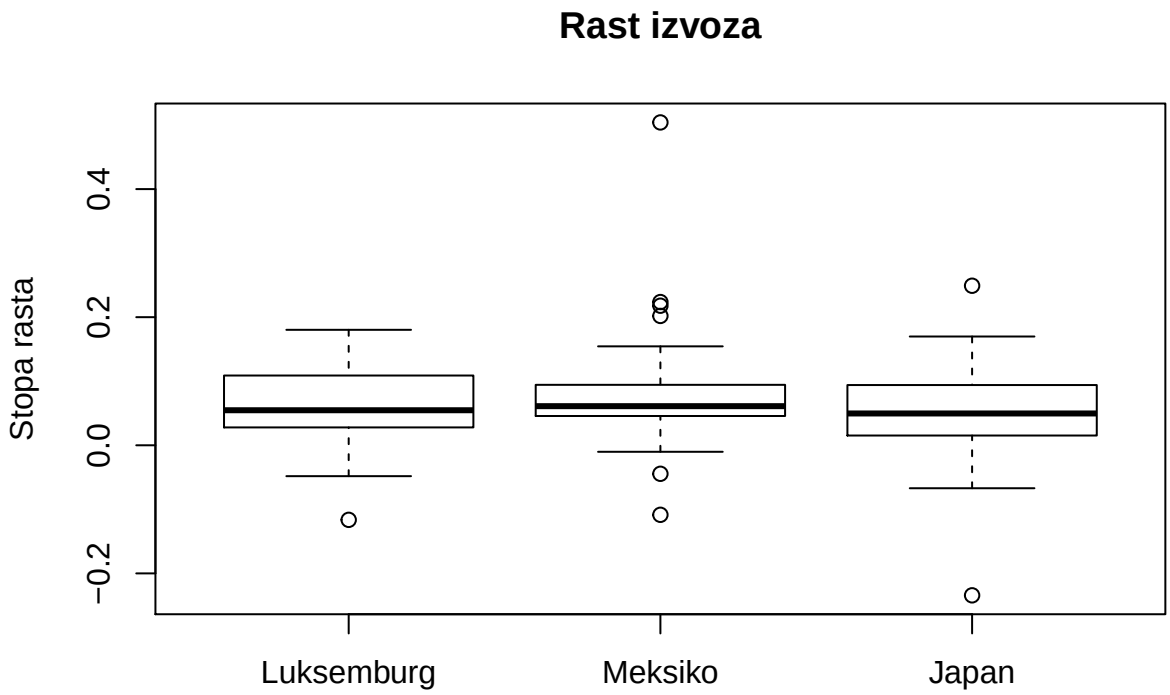
Stršeće su vrijednosti (eng. outliers) one koje bitno odudaraju od većine vrijednosti podataka. Jedan od načina detekcije stršećih vrijednosti je prikazom podataka pravokutnim dijagramom. Sve vrijednosti koje su veće od gornjeg ili manje od donjeg izdanka su stršeće. U nastavku su prikazana tri pravokutna dijagrama godišnjeg rasta izvoza.

```
plot(
  lux_GDP$TIME,
  mex_export$Value,
  main = 'Izvoz',
  xlab = 'Vrijeme',
  ylab = 'USD milijuni',
  col = "green"
)
points(lux_GDP$TIME, lux_export$Value, col = "red")
points(lux_GDP$TIME, jpn_export$Value, col = "blue")
legend(
        1980,
        8e+05,
        legend = c("Luksemburg", "Meksiko", "Japan"),
        fill = c("red", "green", "blue")
)
```




```
boxplot(
  growth_lux_export$Value,
  growth_mex_export$Value,
```

```
  growth_jpn_export$Value,
  main = 'Rast izvoza',
  ylab = 'Stopa rasta',
  names = c("Luksemburg", "Meksiko", "Japan")
)
```



Na pravokutnim dijagramima može se uočiti da sve tri zemlje imaju jednu stršeću vrijednost ispod donjeg izdanka. Ta vrijednost posljedica je svjetske financijske krize 2008. godine. Nakon tog pada države su se oporavile te se dogodio nagli rast izvoza Japana i Meskiska. Taj nagli rast prikazan je kao stršeća vrijednost iznad gornjeg izdanka na dijagramu. Uz te dvije vrijednosti Meksiko ima još stršećih vrijednosti zbog visoke stope kriminala te nestabilnosti ekonomije.

Usporedba rasta BDP-a te rasta BDP-a po stanovniku

Koristeći dvostrani t-test ispituje se značajnost razlike prosječnog rasta BDP-a i prosječnog rasta BDP-a po stanovniku. Prije t-testa potrebno je napraviti test jednakosti varijanci.

```
t.test(growth_lux_GDP$Value,
       growth_lux_GDP_percapita$Value,
       paired = TRUE,
       alt = "two.sided",
       var.equal = TRUE)
```

```
##
##  Paired t-test
##
## data:  growth_lux_GDP$Value and growth_lux_GDP_percapita$Value
## t = 12.032, df = 38, p-value = 1.574e-14
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.01171917 0.01646049
## sample estimates:
## mean of the differences
##              0.01408983
```

```
t.test(growth_mex_GDP$Value,
       growth_mex_GDP_percapita$Value,
       paired = TRUE,
       alt = "two.sided",
       var.equal = TRUE)
```

```
##
##  Paired t-test
##
## data:  growth_mex_GDP$Value and growth_mex_GDP_percapita$Value
## t = 18.227, df = 38, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.01445727 0.01806982
## sample estimates:
## mean of the differences
##              0.01626355
```

```
t.test(growth_jpn_GDP$Value,
       growth_jpn_GDP_percapita$Value,
       paired = TRUE,
       alt = "two.sided",
       var.equal = TRUE)
```

```
##
##  Paired t-test
##
## data:  growth_jpn_GDP$Value and growth_jpn_GDP_percapita$Value
## t = 4.8086, df = 38, p-value = 2.409e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.001360125 0.003337997
## sample estimates:
```

```
## mean of the differences
##             0.002349061
```

```
wilcox.test(
        growth_lux_GDP$Value,
        growth_lux_GDP_percapita$Value,
        paired = TRUE,
        alternative = "two.sided"
)
```

```
##
##  Wilcoxon signed rank test
##
## data:  growth_lux_GDP$Value and growth_lux_GDP_percapita$Value
## V = 780, p-value = 3.638e-12
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(
        growth_mex_GDP$Value,
        growth_mex_GDP_percapita$Value,
        paired = TRUE,
        alternative = "two.sided"
)
```

```
##
##  Wilcoxon signed rank test
##
## data:  growth_mex_GDP$Value and growth_mex_GDP_percapita$Value
## V = 780, p-value = 3.638e-12
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(
        growth_jpn_GDP$Value,
        growth_jpn_GDP_percapita$Value,
        paired = TRUE,
        alternative = "two.sided"
)
```

```
##
##  Wilcoxon signed rank test
##
## data:  growth_jpn_GDP$Value and growth_jpn_GDP_percapita$Value
## V = 677, p-value = 2.031e-05
## alternative hypothesis: true location shift is not equal to 0
```

Testiranjem jednakosti srednjih vrijednosti uparenih podataka rasta BDP-a i rasta BDP-a po stanovniku utvrđeno je da se srednje vrijednosti razlikuju značajno. Iako je pokazana normalnost podataka, jednakost rasta BDP-a i rasta BDP-a po stanovniku provjerena je neparametarskim testom. Neparametarski test ima manju snagu testa, te je njime donesena jednaka odluka u svim slučajevima.

Zaključak

U ovom radu pokušali smo provjeriti utjecaj uvoza i izvoza na gospodarstvo odabranih država. Rezultati koje smo dobili pokazuju da se ovisnost ne može generalizirati, već ovisi individualno o svakoj državi.

Statisički značajnije rezultate mogli bismo dobiti da smo imali još veći broj podataka.