World Happiness Report

Opis

Podaci kojima se bavimo u ovom projektu su dobiveni kroz ankete koje provode Gallup i Lloyd's Register Foundation. Proučavat ćemo podatke iz 2020. godine koji su sadžani u 9 varijabli te podatke iz 2021. godine koji su sadržani u 11 varijabli. Temeljna varijabla je osjećaj sreće prema Cantrilovoj ljestvici gdje su ispitanici ocjenjivali zadovoljstvo vlastitog života na skali od 0 do 10. Vrijednost varijable je prosjek reprezentativnog uzorka pojedine zemlje. Uz to projekt zadrži varijable kao što su BDP po stanovniku, životni vijek, socijalna podrška, percepcija korupcije, doniranje novca u dobrotvorne svrhe, nejednakost dohotha i slično.

```
## [1] 153   9
```

```
## [1] 149  11
```

Summary podataka:

```
## [1] "2020: "
```

```
##        V3              V4               V5               V6
##  Min.   :2.567   Min.   : 6.493   Min.   :0.3190   Min.   :45.20
##  1st Qu.:4.724   1st Qu.: 8.351   1st Qu.:0.7370   1st Qu.:58.96
##  Median :5.515   Median : 9.456   Median :0.8290   Median :66.31
##  Mean   :5.473   Mean   : 9.296   Mean   :0.8087   Mean   :64.45
##  3rd Qu.:6.228   3rd Qu.:10.265   3rd Qu.:0.9070   3rd Qu.:69.29
##  Max.   :7.809   Max.   :11.451   Max.   :0.9750   Max.   :76.81
##        V7               V8                V9
##  Min.   :0.3970   Min.   :-0.30100   Min.   :0.1100
##  1st Qu.:0.7150   1st Qu.:-0.12700   1st Qu.:0.6830
##  Median :0.8000   Median :-0.03400   Median :0.7830
##  Mean   :0.7834   Mean   :-0.01454   Mean   :0.7331
##  3rd Qu.:0.8780   3rd Qu.: 0.08500   3rd Qu.:0.8490
##  Max.   :0.9750   Max.   : 0.56100   Max.   :0.9360
```

```
## [1] "2021: "
```

```
##        V3              V4               V5               V6
##  Min.   :2.523   Min.   : 6.635   Min.   :0.4630   Min.   :48.48
##  1st Qu.:4.852   1st Qu.: 8.541   1st Qu.:0.7500   1st Qu.:59.80
##  Median :5.534   Median : 9.569   Median :0.8320   Median :66.60
##  Mean   :5.533   Mean   : 9.432   Mean   :0.8147   Mean   :64.99
##  3rd Qu.:6.255   3rd Qu.:10.421   3rd Qu.:0.9050   3rd Qu.:69.60
##  Max.   :7.842   Max.   :11.647   Max.   :0.9830   Max.   :76.95
##        V7               V8                V9
##  Min.   :0.3820   Min.   :-0.28800   Min.   :0.0820
##  1st Qu.:0.7180   1st Qu.:-0.12600   1st Qu.:0.6670
##  Median :0.8040   Median :-0.03600   Median :0.7810
##  Mean   :0.7916   Mean   :-0.01513   Mean   :0.7274
##  3rd Qu.:0.8770   3rd Qu.: 0.07900   3rd Qu.:0.8450
##  Max.   :0.9700   Max.   : 0.54200   Max.   :0.9390
```

```
## [1] "Country name"                "Regional indicator"
```

```
## [3] "Ladder score"                 "Logged GDP per capita"
## [5] "Social support"               "Healthy life expectancy"
## [7] "Freedom to make life choices" "Generosity"
## [9] "Perceptions of corruption"
```

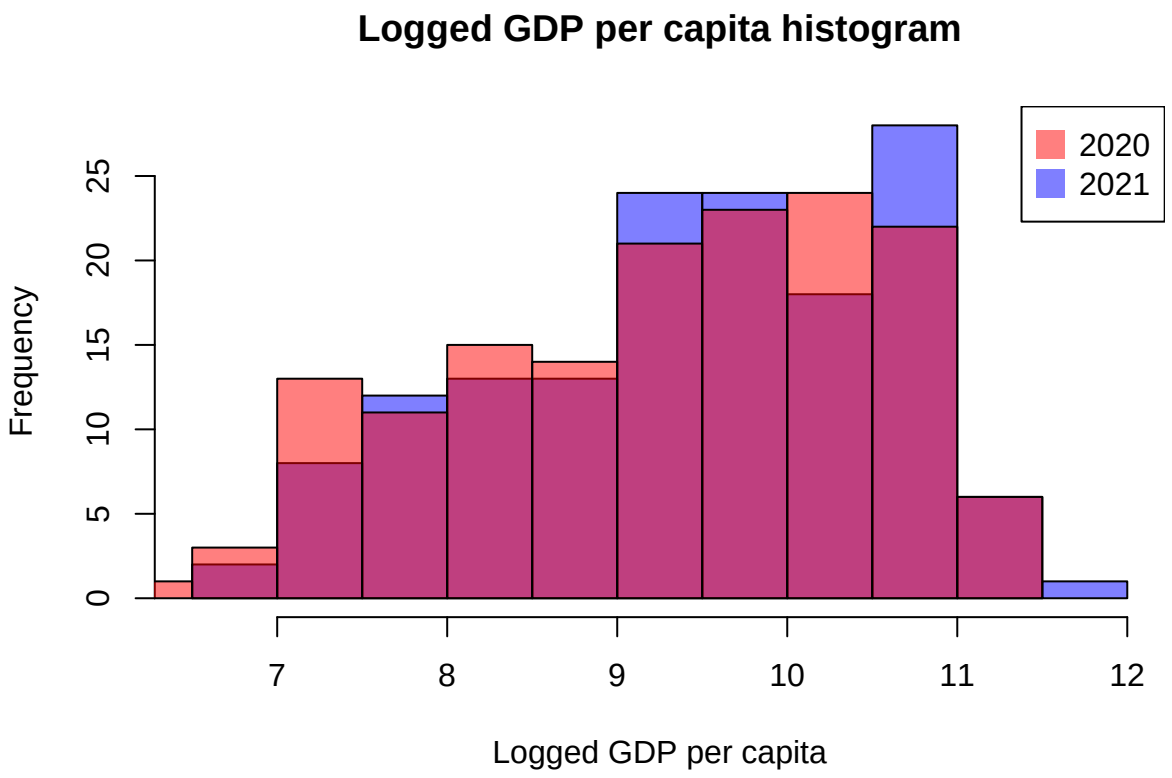
```
##  [1] "Country name"                 "Regional indicator"
##  [3] "Ladder score"                 "Logged GDP per capita"
##  [5] "Social support"               "Healthy life expectancy"
##  [7] "Freedom to make life choices" "Generosity"
##  [9] "Perceptions of corruption"    "Income Gini"
## [11] "Wealth Gini"
```

Deskriptivna statistika

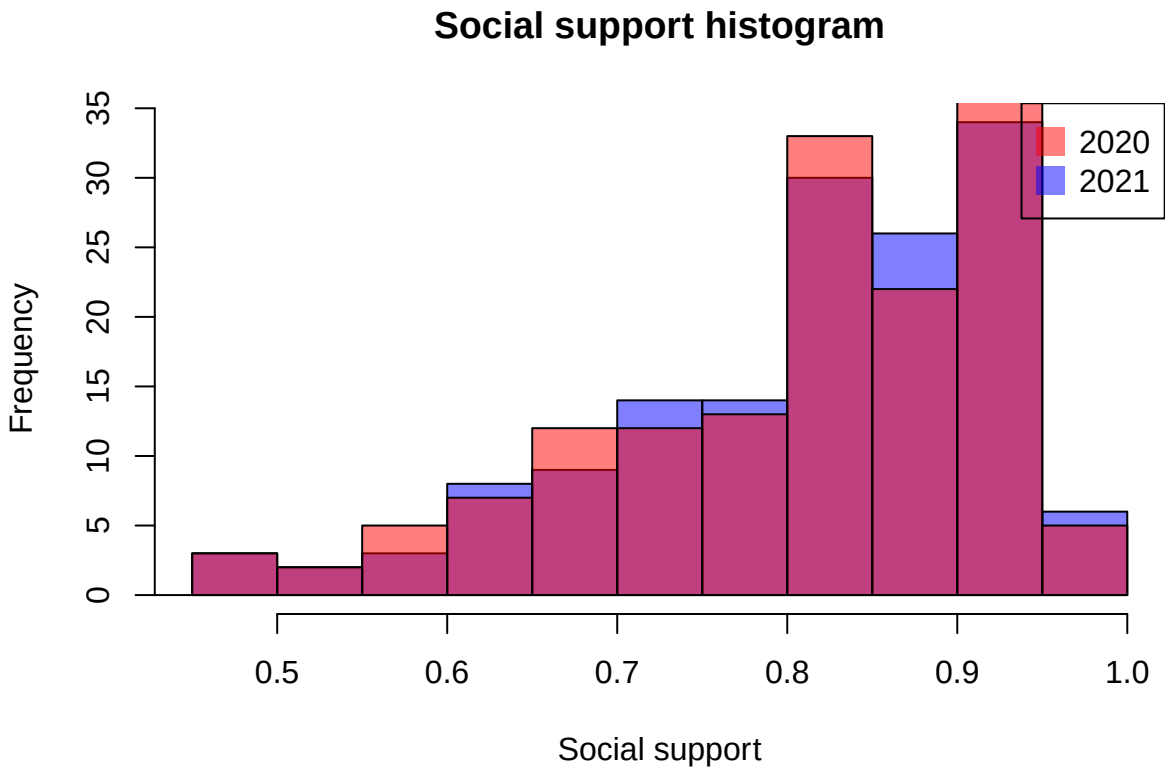
Prikažimo sada histograme usporedbe varijabli za različite godine.

```
#histogrami varijable s obzirom na godine
plot_by_years <- function(column, main) {
  hist(whr2021[[column]], breaks=15, main=main, xlab=column, ylab="Frequency",col=rgb(0,0,1,0.5))
  hist(whr2020[[column]], breaks=15, main=main, xlab=column, ylab="Frequency", col=rgb(1,0,0,0.5), add=
  legend(x="topright", c("2020", "2021"), col=c(rgb(1,0,0,0.5), rgb(0,0,1,0.5)), pt.cex = 2, pch = 15)
}
plot_by_years("Ladder score", "Ladder score histogram")
```

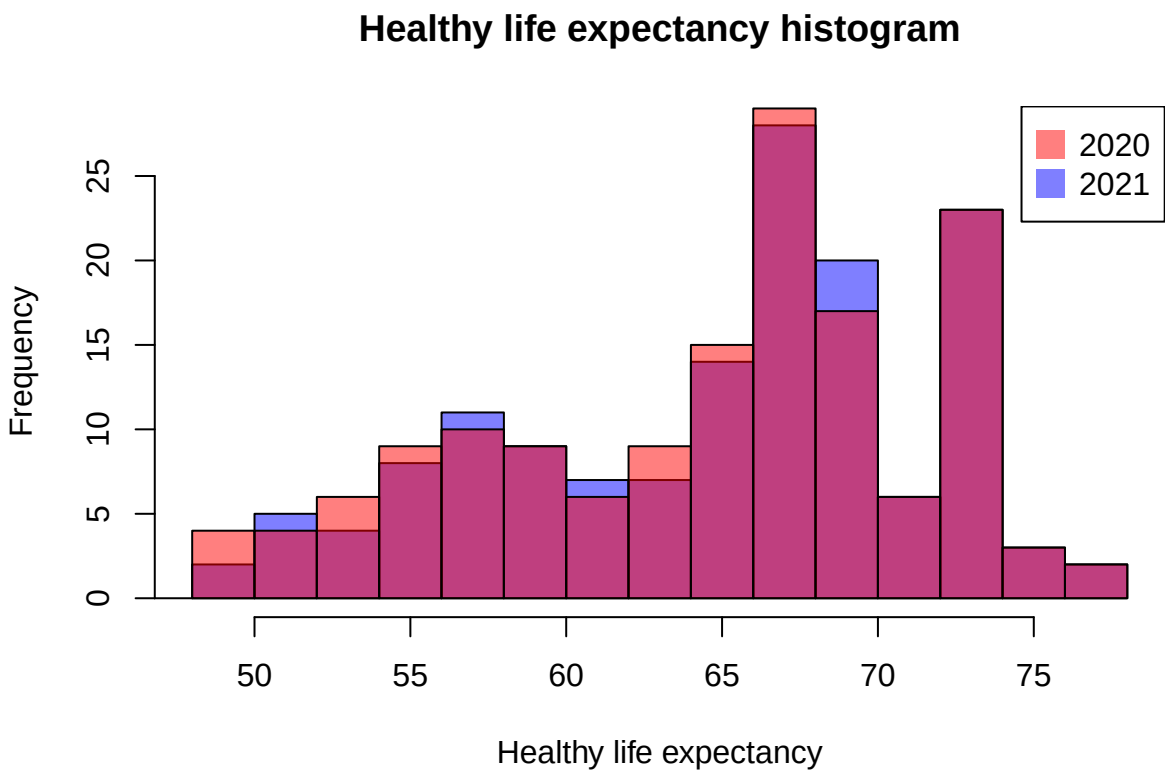

```
plot_by_years("Logged GDP per capita", "Logged GDP per capita histogram")
```



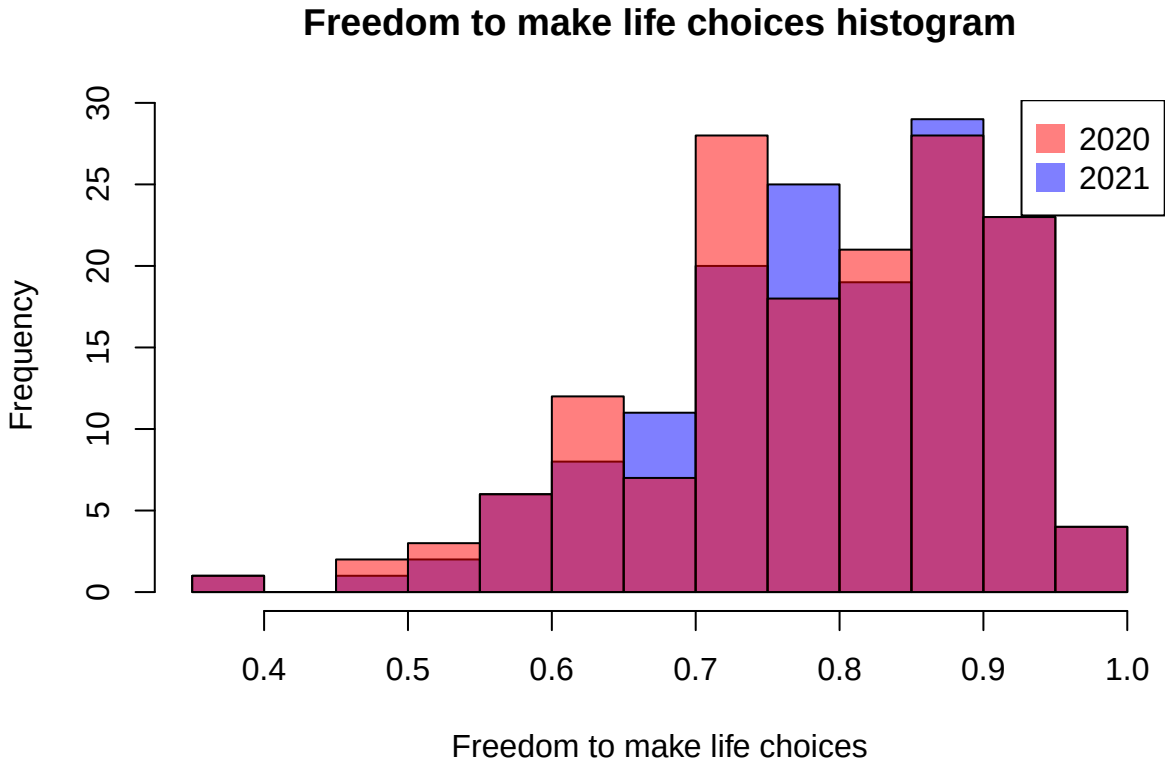

```
plot_by_years("Social support", "Social support histogram")
```



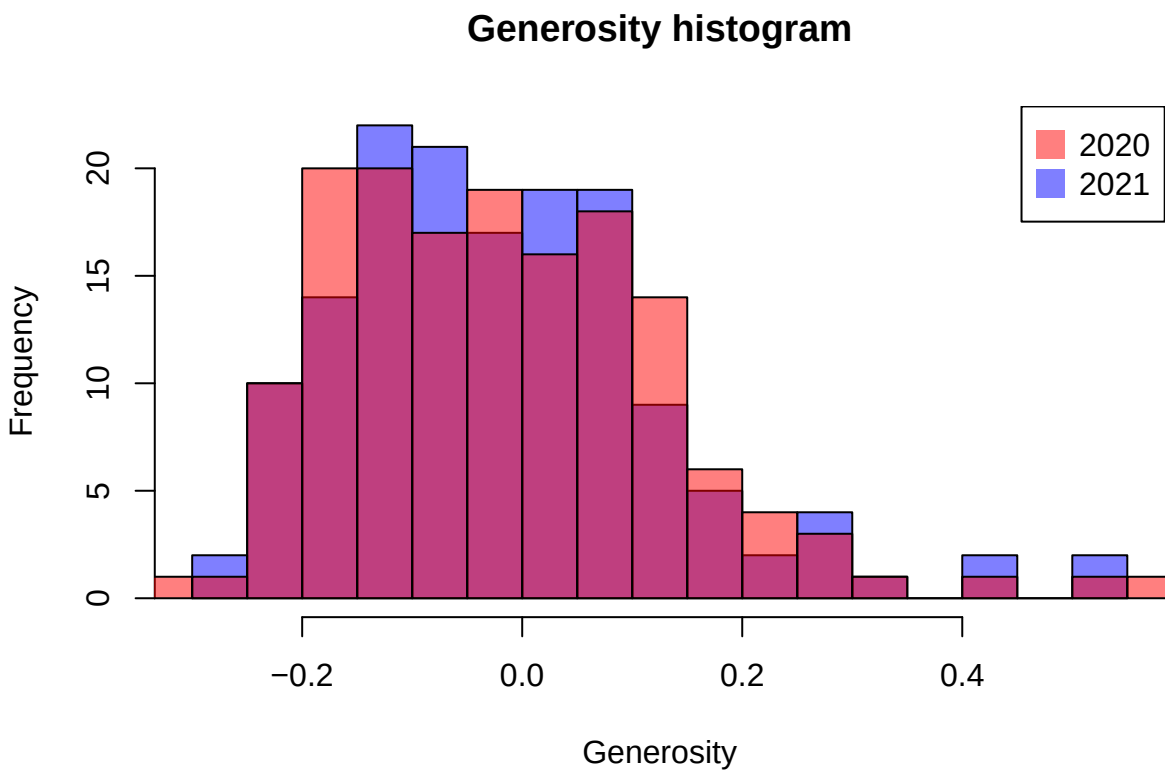

```
plot_by_years("Healthy life expectancy", "Healthy life expectancy histogram")
```



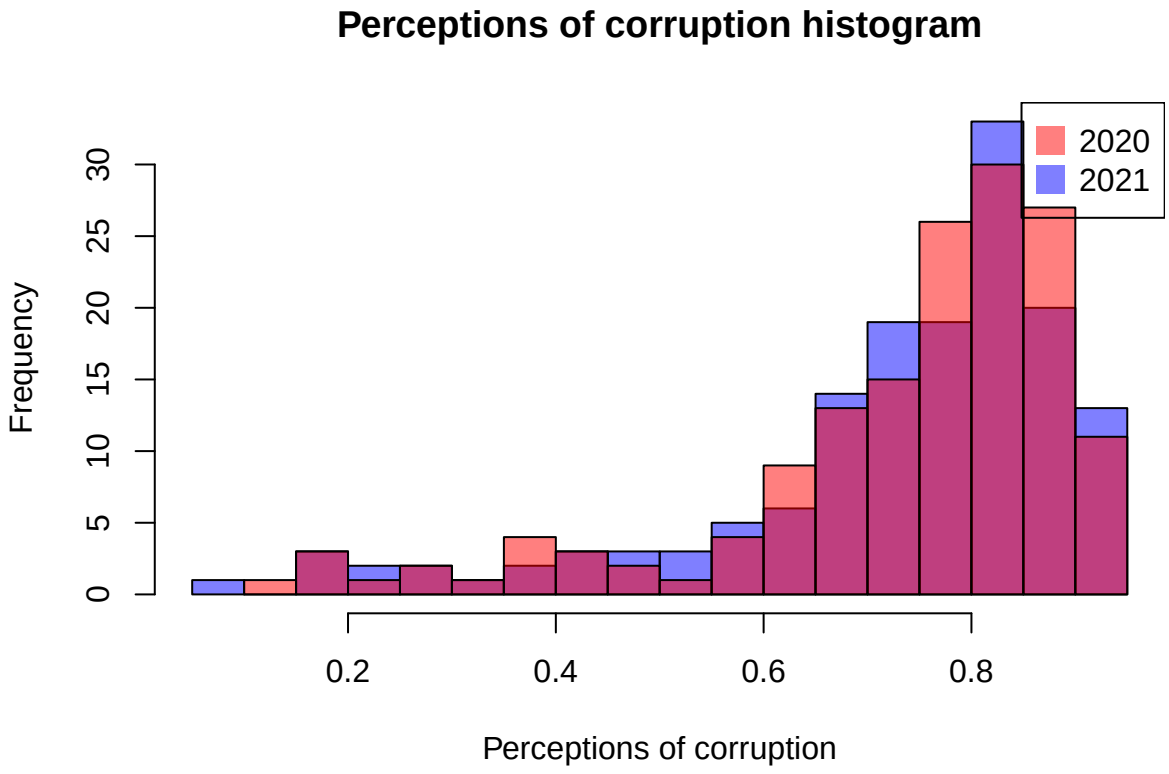

```
plot_by_years("Freedom to make life choices", "Freedom to make life choices histogram")
```



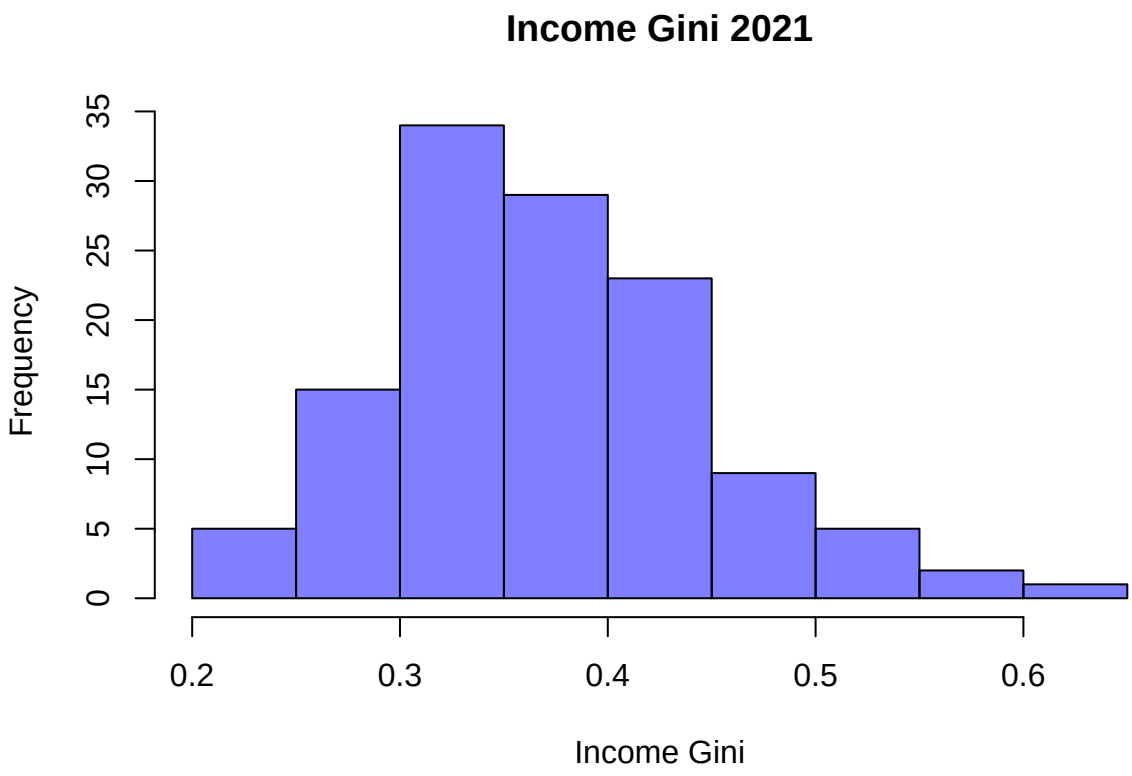

```
plot_by_years("Generosity", "Generosity histogram")
```



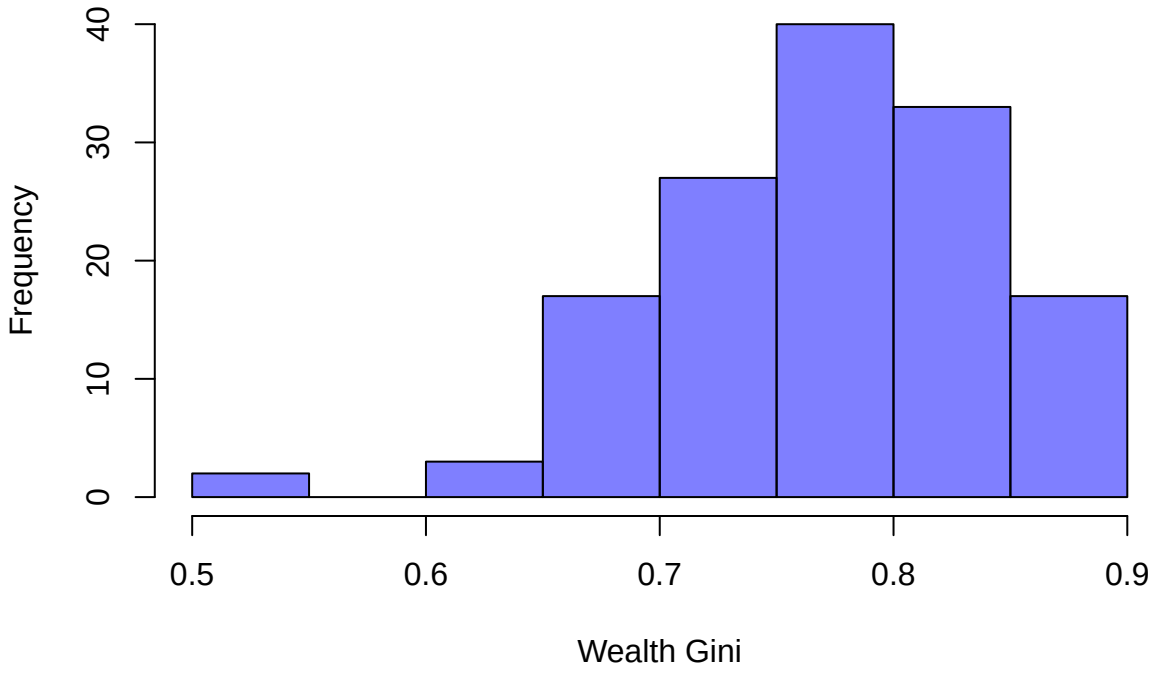

```
plot_by_years("Perceptions of corruption", "Perceptions of corruption histogram")
```




```
hist(whr2021$`Income Gini`, breaks=10, main="Income Gini 2021", xlab="Income Gini", ylab="Frequency",co
```




```
hist(whr2021$`Wealth Gini`, breaks=10, main="Wealth Gini 2021", xlab="Wealth Gini", ylab="Frequency",co
```



Iz dobivenih histograma vidljivo je da postoje promjene u varijablama za različite godine, no raspodjela podataka je veoma slična za obje godine. Također se može naslutiti da većina podataka nije normalno distribuirana.

Izračunajmo srednje vrijednosti i medijane Ladder score-ova po regijama.

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.5     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.0.2     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
whr2021 %>% group_by(`Regional indicator`) %>% summarise(
          Mean.LadderScore = mean(`Ladder score`),
          Mean.GDP = mean(`Logged GDP per capita`),
          Mean.SocialSupport = mean(`Social support`),
          Mean.LifeExp = mean(`Healthy life expectancy`),
          Mean.Freedom = mean(`Freedom to make life choices`),
          Mean.Generosity = mean(Generosity),
          Mean.Corruption = mean(`Perceptions of corruption`)
           #Mean.IncomeGini = mean(`Income Gini`),
           #Mean.WealthGini = mean(`Wealth Gini`)
            ) -> summary.result1
summary.result1
```

```
## # A tibble: 10 x 8
##    `Regional indicator`  Mean.LadderScore Mean.GDP Mean.SocialSupp~ Mean.LifeExp
##    <fct>                            <dbl>    <dbl>            <dbl>        <dbl>
##  1 Central and Eastern ~             5.98    10.1             0.887         68.3
##  2 Commonwealth of Inde~             5.47     9.40            0.872         65.0
##  3 East Asia                         5.81    10.4             0.860         71.3
##  4 Latin America and Ca~             5.91     9.37            0.840         67.1
##  5 Middle East and Nort~             5.22     9.67            0.798         65.6
##  6 North America and ANZ             7.13    10.8             0.934         72.3
##  7 South Asia                        4.44     8.68            0.703         62.7
##  8 Southeast Asia                    5.41     9.42            0.820         64.9
##  9 Sub-Saharan Africa                4.49     8.08            0.697         55.9
## 10 Western Europe                    6.91    10.8             0.914         73.0
## # ... with 3 more variables: Mean.Freedom <dbl>, Mean.Generosity <dbl>,
## #   Mean.Corruption <dbl>
```

```
whr2021 %>% group_by(`Regional indicator`) %>% summarise(
          Med.LadderScore = median(`Ladder score`),
          Med.GDP = median(`Logged GDP per capita`),
          Med.SocialSupport = median(`Social support`),
          Med.LifeExp = median(`Healthy life expectancy`),
          Med.Freedom = median(`Freedom to make life choices`),
          Med.Generosity = median(Generosity),
          Med.Corruption = median(`Perceptions of corruption`)
            ) -> summary.result2
summary.result2
```

```
## # A tibble: 10 x 8
##    `Regional indicator`     Med.LadderScore Med.GDP Med.SocialSuppo~ Med.LifeExp
```

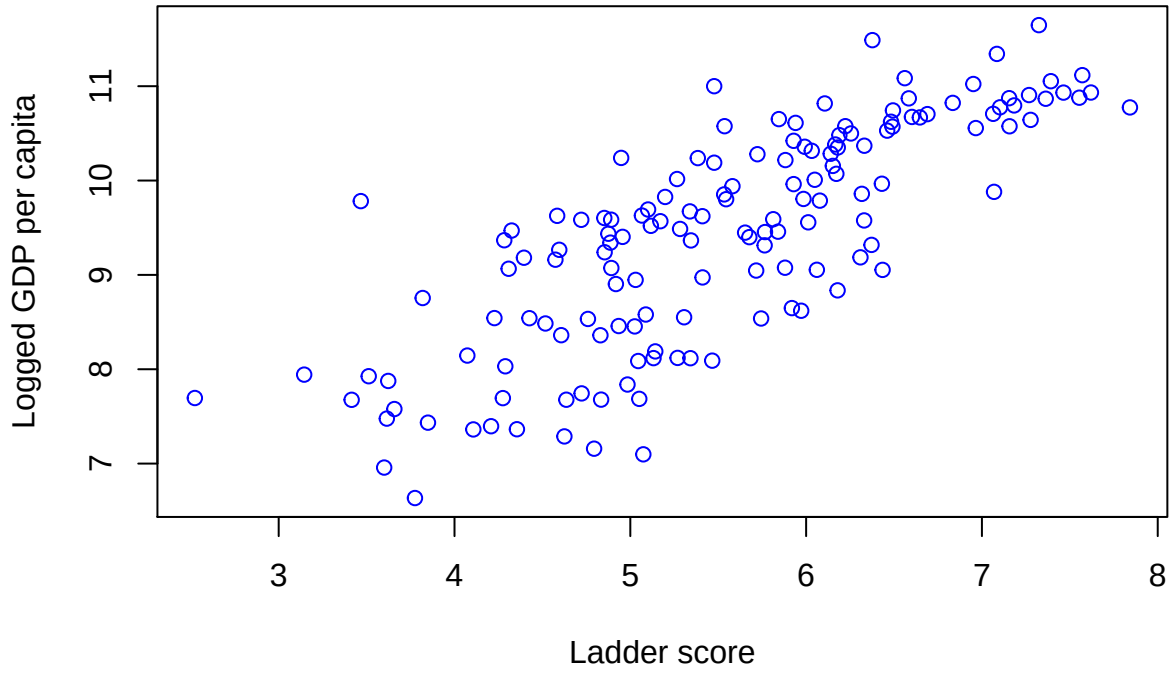
```
##    <fct>                          <dbl>   <dbl>           <dbl>       <dbl>
##  1 Central and Eastern Eur~        6.08   10.3            0.924        68.6
##  2 Commonwealth of Indepen~        5.47    9.53           0.891        65.1
##  3 East Asia                       5.76   10.6            0.86         71.8
##  4 Latin America and Carib~        5.99    9.45           0.857        67.6
##  5 Middle East and North A~        4.89    9.58           0.826        66.6
##  6 North America and ANZ           7.14   10.8            0.933        73.6
##  7 South Asia                      4.93    8.46           0.693        64.2
##  8 Southeast Asia                  5.38    9.08           0.817        62.2
##  9 Sub-Saharan Africa              4.62    7.93           0.709        56.2
## 10 Western Europe                  7.08   10.8            0.934        72.7
## # ... with 3 more variables: Med.Freedom <dbl>, Med.Generosity <dbl>,
## #   Med.Corruption <dbl>
```

Promatrajući varijable u 2021. godini vidimo da su vrijednosti podataka u svim varijablama (osim kod varijable za percepciju korupcije") veće za Zapadnu Europu u usporedbi s Centralnom i Istočnom Europom.

Povezanost između Ladder score i Logged GDP per capita

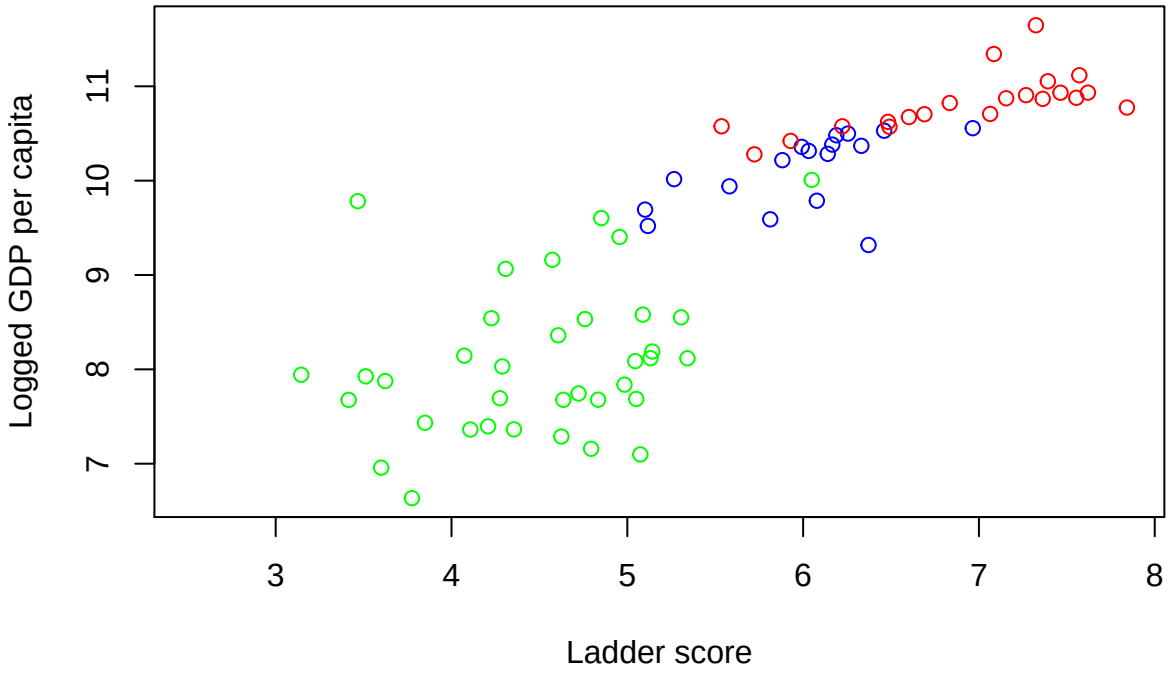
Možemo li iz dijagrama raspršenja možda naslutiti kakvu vezu između Ladder score i GDP per capita? Posebno ćemo istaknuti 3 regije na dijagramu (Zapadnu Europu, Srednju i Istočnu Europu i Sub-Saharsku Afriku).

```
# Ne razlikujemo vrste regija:
plot(whr2021$`Ladder score`,whr2021$`Logged GDP per capita`,
     col="blue",
     xlab='Ladder score',
     ylab='Logged GDP per capita')
```




```
# Razlikujemo vrste regija:
plot(whr2021$`Ladder score`[whr2021$`Regional indicator`=='Central and Eastern Europe'],
     whr2021$`Logged GDP per capita`[whr2021$`Regional indicator`=='Central and Eastern Europe'],
     col='blue',
```

```
     xlim=c(min(whr2021$`Ladder score`),max(whr2021$`Ladder score`)),
     ylim=c(min(whr2021$`Logged GDP per capita`),max(whr2021$`Logged GDP per capita`)),
     xlab='Ladder score',
     ylab='Logged GDP per capita')

points(whr2021$`Ladder score`[whr2021$`Regional indicator`=='Western Europe'],
     whr2021$`Logged GDP per capita`[whr2021$`Regional indicator`=='Western Europe'],col='red')
points(whr2021$`Ladder score`[whr2021$`Regional indicator`=='Sub-Saharan Africa'],
     whr2021$`Logged GDP per capita`[whr2021$`Regional indicator`=='Sub-Saharan Africa'],col='green')
```



Iz dijagrama raspršenja vidljiva je moguća povezanosti Ladder score s GDP per capita. Vidi se da što je veći GDP per capita, to je i razina sreće veća iskazana s Ladder score.Također vidimo da se na dijagramu razlikuju vrijednosti Zapadne, Srednje i Istočne Europe, te Sub-Saharske Afrike.

Jesu li ljudi u Zapadnoj Europi sretniji od ljudi u Srednjoj i Istočnoj Europi?

```
western_europe = whr2021[whr2021$`Regional indicator` == "Western Europe",]
central_eastern_europe = whr2021[whr2021$`Regional indicator` == "Central and Eastern Europe",]
```

```
cat('Prosječan Ladder score zemalja iz Zapadne Europe ', mean(western_europe$`Ladder score`),'\n')
```

```
## Prosječan Ladder score zemalja iz Zapadne Europe  6.914905
```

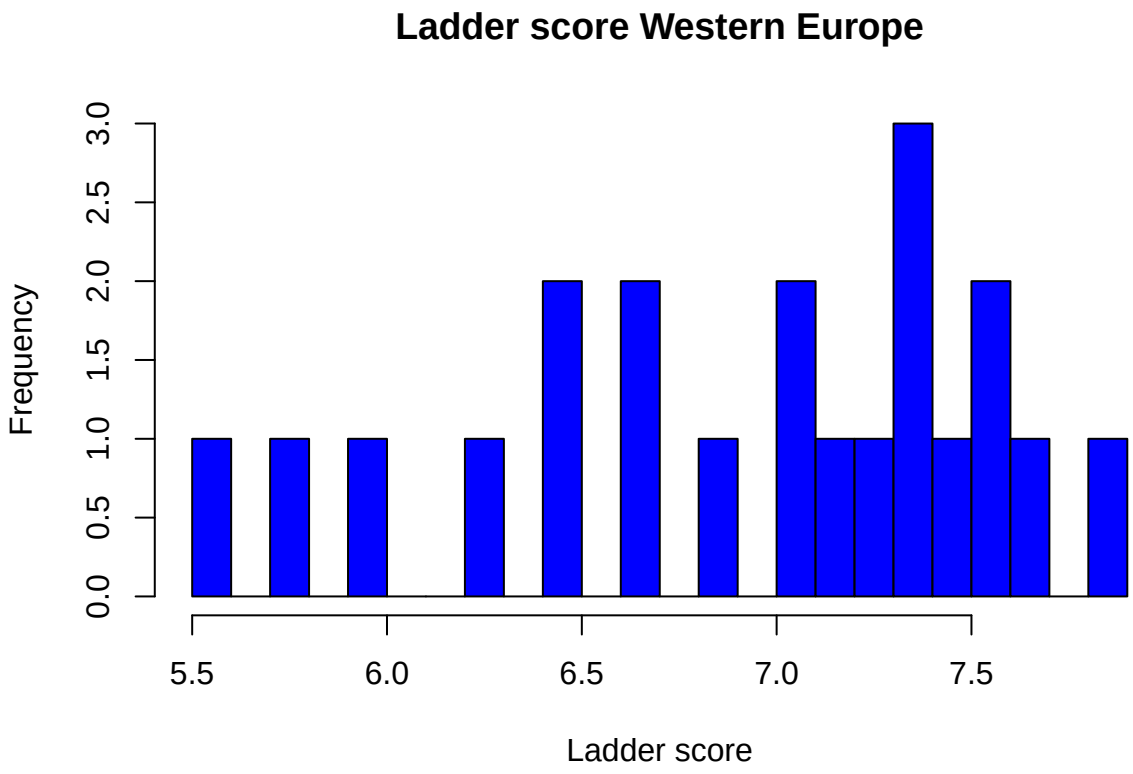
```
cat('Prosječan Ladder score zemalja iz Srednje i Istočne Europe', mean(central_eastern_europe$`Ladder s
```

```
## Prosječan Ladder score zemalja iz Srednje i Istočne Europe 5.984765
```

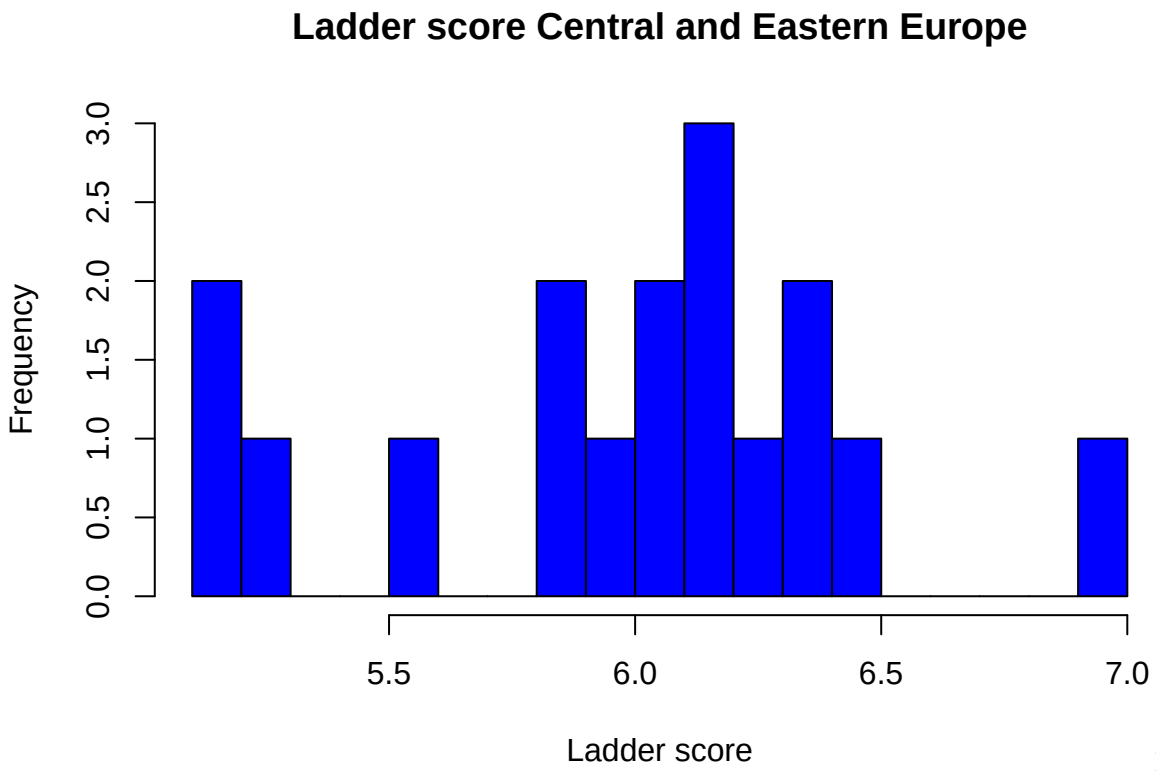
Histogrami za za Zapadnu i Centralnu/Istočnu Europu:

```
h = hist(western_europe$`Ladder score`,
         main="Ladder score Western Europe",
         xlab="Ladder score",
         ylab='Frequency',
         col="blue",
```

```
        breaks = 20
        )
```

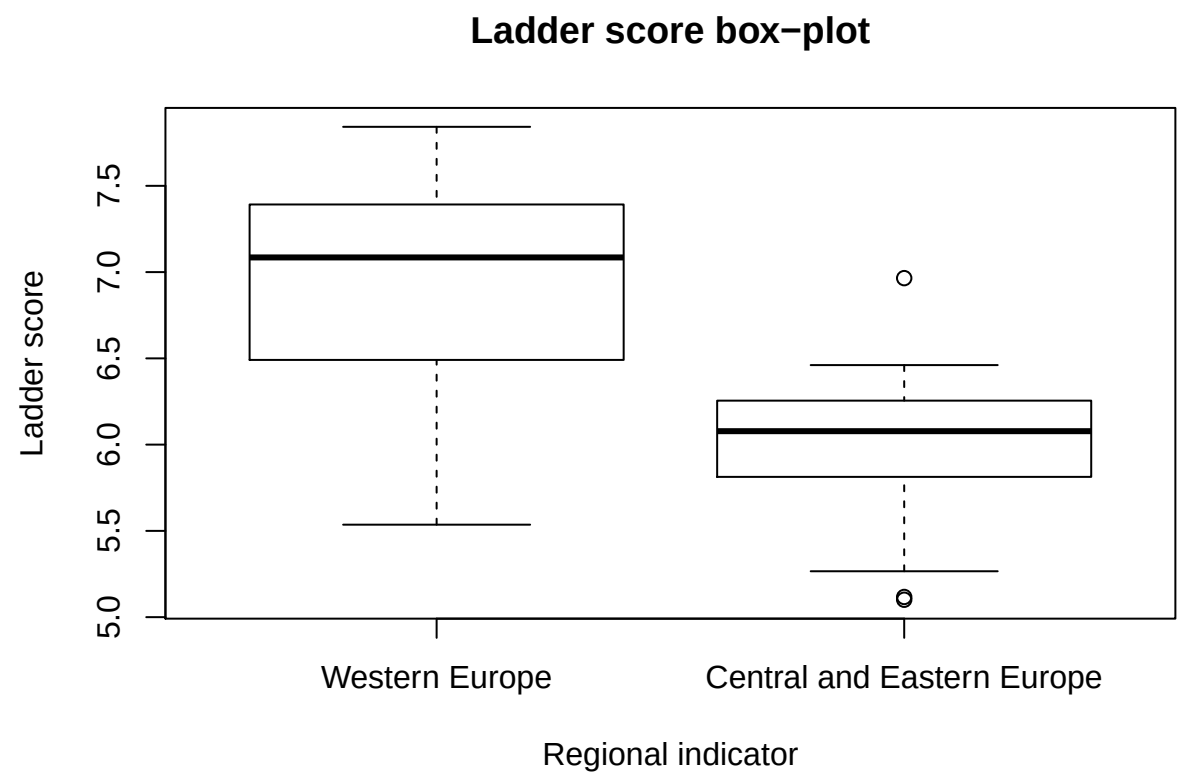



```
h = hist(central_eastern_europe$`Ladder score`,
         main="Ladder score Central and Eastern Europe",
         xlab="Ladder score",
         ylab='Frequency',
         col="blue",
         breaks = 20
         )
```



Pravokutni dijagram za Zapadnu i Centralnu/Istočnu Europu:

```
boxplot(western_europe$`Ladder score`,central_eastern_europe$`Ladder score`,
        main='Ladder score box-plot',
        ylab='Ladder score', xlab="Regional indicator", names = c("Western Europe", "Central and Eastern
```



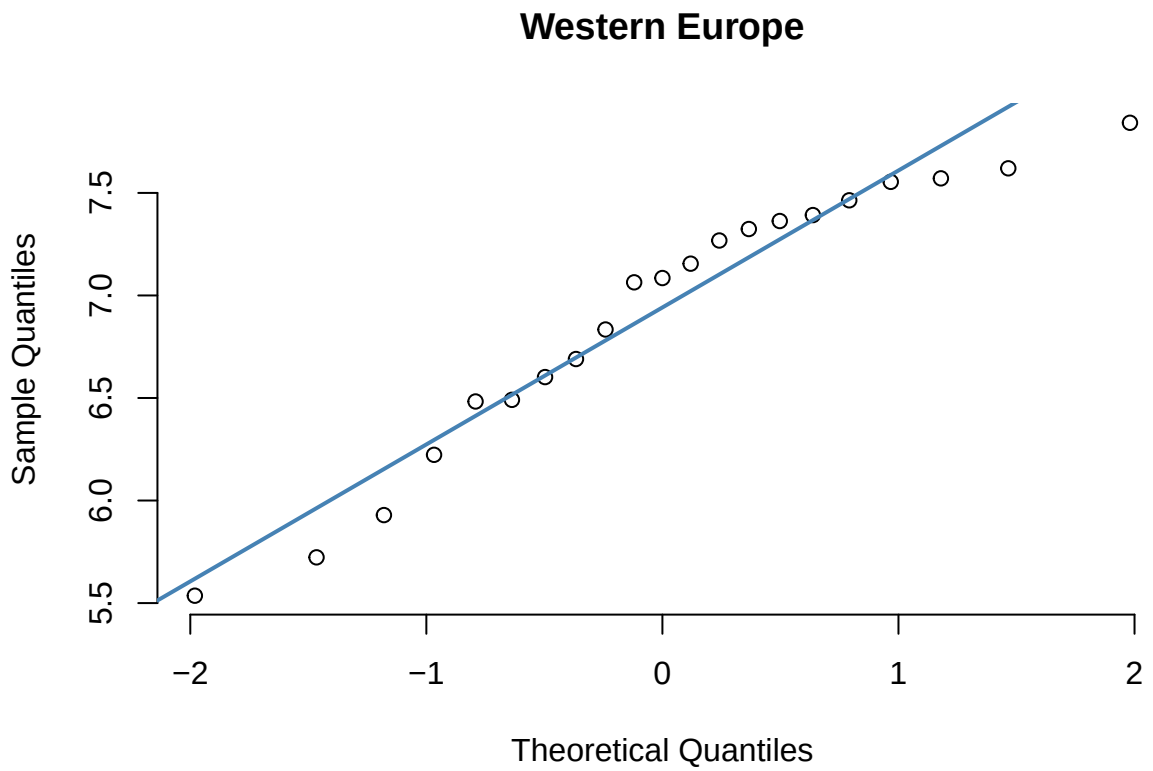
Postoje indikacije da bi ljudi iz zemalja Zapadne Europe trebali biti sretniji od ljudi iz zemalja Srednje i

Istočne Europe.

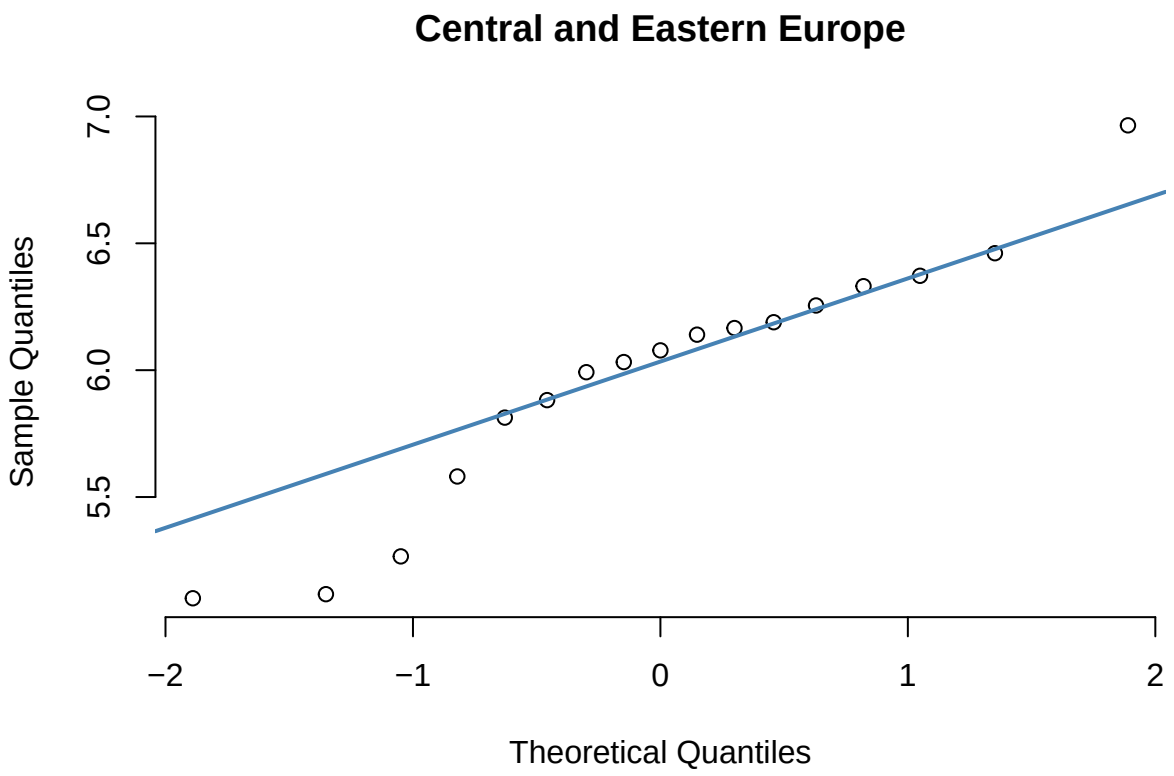
Postavimo sljedeće hipoteze: H_0: Ladder score je jednak za Zapadnu i Srednju i Istočnu Europu H_1: Ladder score je veći u Zapadnoj Europi od onog u Srednjoj i Istočnoj Europi

Ovakvo ispitivanje možemo provesti t-testom. Kako bi mogli provesti test, moramo najprije provjeriti pretpostavke normalnosti i nezavisnosti uzorka. Obzirom da razmatramo dva uzoraka iz dvije različite regije, možemo pretpostaviti njihovu nezavisnost. Sljedeći korak je provjeriti normalnost podataka koju ćemo provjeriti qq-plotom i KS testom.

```
qqnorm(western_europe$`Ladder score`, pch = 1, frame = FALSE,main='Western Europe')
qqline(western_europe$`Ladder score`, col = "steelblue", lwd = 2)
```




```
qqnorm(central_eastern_europe$`Ladder score`, pch = 1, frame = FALSE,main='Central and Eastern Europe')
qqline(central_eastern_europe$`Ladder score`, col = "steelblue", lwd = 2)
```



Koristimo Lillieforsovu inačicu testa normalnosti jer srednju vrijednost i varijancu računamo iz uzorka.

```
library(nortest)
lillie.test(western_europe$`Ladder score`)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  western_europe$`Ladder score`
## D = 0.16126, p-value = 0.1645
```

```
lillie.test(central_eastern_europe$`Ladder score`)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  central_eastern_europe$`Ladder score`
## D = 0.15291, p-value = 0.3622
```

Iz qq-plota ne možemo zaključiti normalnost podataka. Velika p-vrijednost kod Lillieforsovog testa govori kako ne možemo odbaciti hipotezu da podaci dolaze iz normalne distribucije.

Pogledajmo vrijednost varijanci oba uzorka.

```
var(western_europe$`Ladder score`)
```

```
## [1] 0.4310178
```

```
var(central_eastern_europe$`Ladder score`)
```

```
## [1] 0.2433699
```

```r
#Jesu li varijance značajno različite
var.test(western_europe$`Ladder score`, central_eastern_europe$`Ladder score`)
```

```
##
##  F test to compare two variances
##
## data:  western_europe$`Ladder score` and central_eastern_europe$`Ladder score`
## F = 1.771, num df = 20, denom df = 16, p-value = 0.2498
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.6606402 4.5100231
## sample estimates:
## ratio of variances
##            1.77104
```

p-vrijednost od 0.2498 nam govori da ne odbacujemo hipotezu da su varijance uzoraka jednake.

Provedimo sada t-test uz pretpostavku jednakosti varijanci.

```r
t.test(western_europe$`Ladder score`, central_eastern_europe$`Ladder score`, alt = "greater", var.equal
```

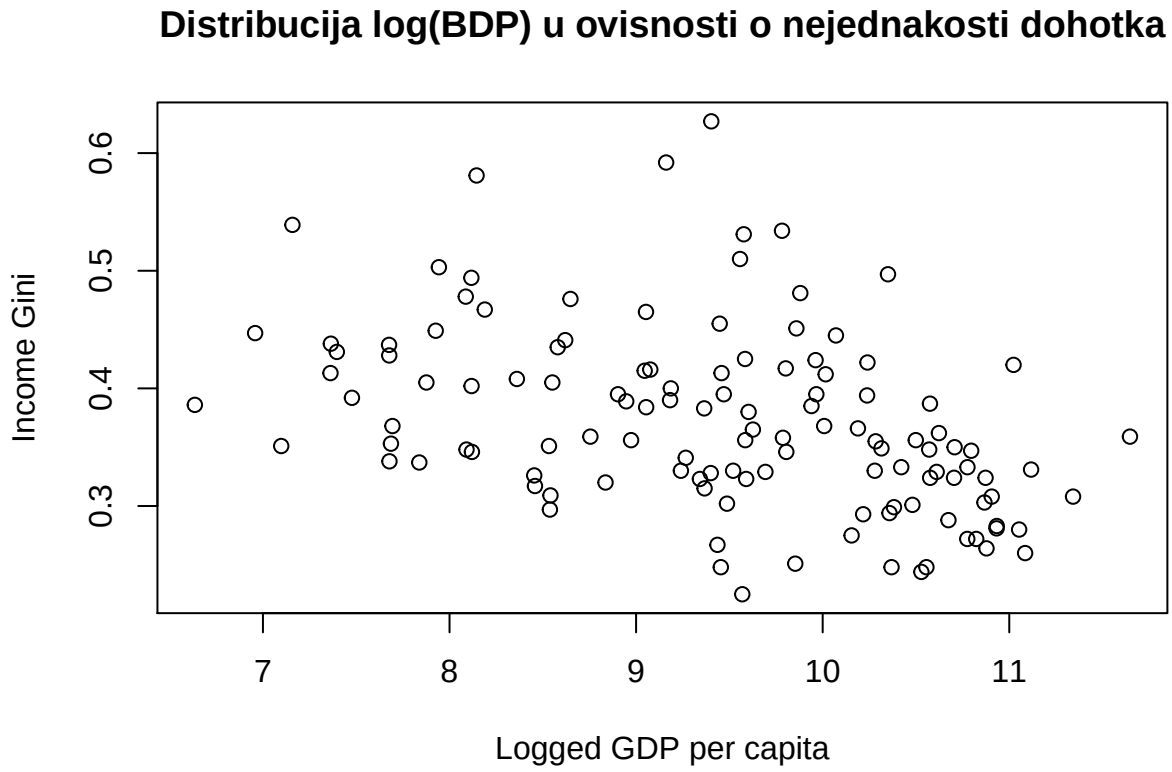
```
##
##  Two Sample t-test
##
## data:  western_europe$`Ladder score` and central_eastern_europe$`Ladder score`
## t = 4.8355, df = 36, p-value = 1.241e-05
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.6053832       Inf
## sample estimates:
## mean of x mean of y
##  6.914905  5.984765
```

Zbog male p-vrijednosti možemo odbaciti hipotezu H_0 u korist alternative da je Ladder score veći u Zapadnoj Europi od onog u Srednjoj i Istočnoj Europi.

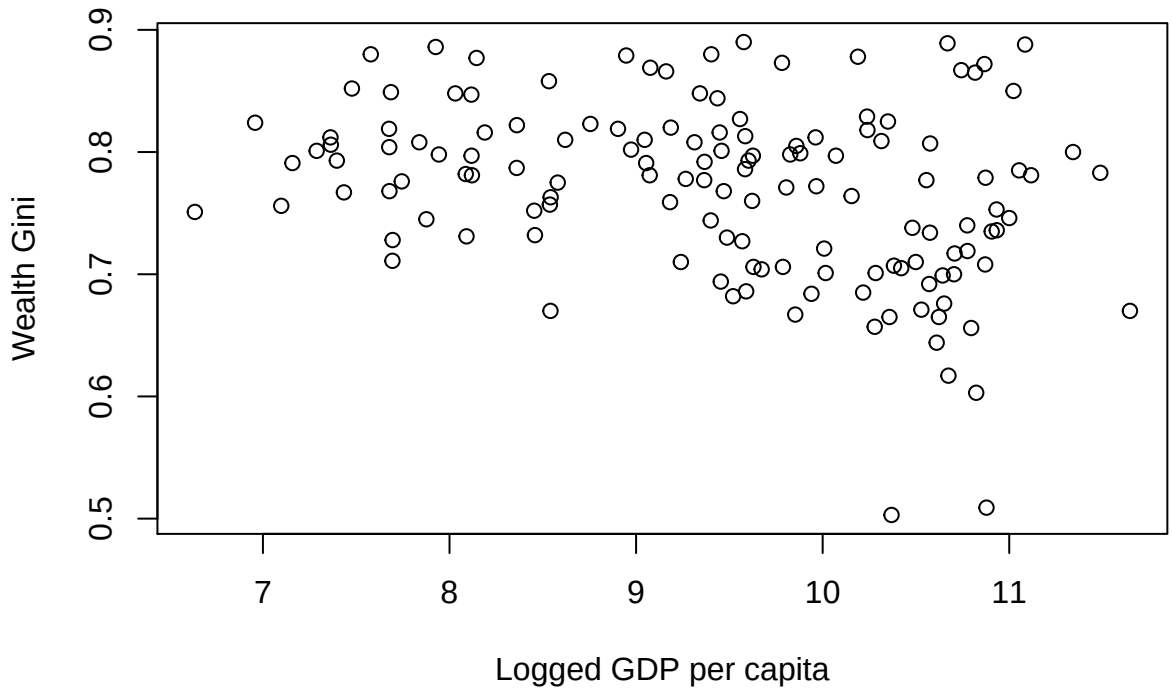
Povezanost između Logged GDP per capita i Gini koeficijenata

Pogledajmo distribuciju prirodnog logaritma bruto domaćeg proizvoda po stanovniku prema paritetu kupovne moći za nejednakost dohotka i nejednakost bogatstva.

```r
plot(whr2021$`Logged GDP per capita`, whr2021$`Income Gini`, xlab = "Logged GDP per capita", ylab = "In
     main = "Distribucija log(BDP) u ovisnosti o nejednakosti dohotka")
```




```
plot(whr2021$`Logged GDP per capita`, whr2021$`Wealth Gini`, xlab = "Logged GDP per capita", ylab = "Wea
     main = "Distribucija log(BDP) u ovisnosti o nejednakosti bogatstva")
```



Iz grafova vidimo da podaci ne slijede lijepi linerarni trend te bi mogli pretpostaviti da ne postoji značajna zavisnost između prirodnog logaritma bruto domaćeg proizvoda po stanovniku s nejednakostima dohotka i bogatstva.

Izračunajmo sada srednje vrijednosti i medijane za nejednokost bogatstva po regijama:

```
library(tidyverse)

whr2021 %>% group_by(`Regional indicator`) %>% summarise(
          Mean.WealthGini = mean(`Wealth Gini`),
          Median.WealthGini = median(`Wealth Gini`)
            ) -> summary.WealthGiniRegion
summary.WealthGiniRegion
```

```
## # A tibble: 10 x 3
##    `Regional indicator`               Mean.WealthGini Median.WealthGini
##    <fct>                                        <dbl>             <dbl>
##  1 Central and Eastern Europe                  NA                NA
##  2 Commonwealth of Independent States          NA                NA
##  3 East Asia                                    0.704             0.706
##  4 Latin America and Caribbean                 NA                NA
##  5 Middle East and North Africa                NA                NA
##  6 North America and ANZ                        0.731             0.709
##  7 South Asia                                   0.769             0.768
##  8 Southeast Asia                               0.796             0.787
##  9 Sub-Saharan Africa                          NA                NA
## 10 Western Europe                              NA                NA
```

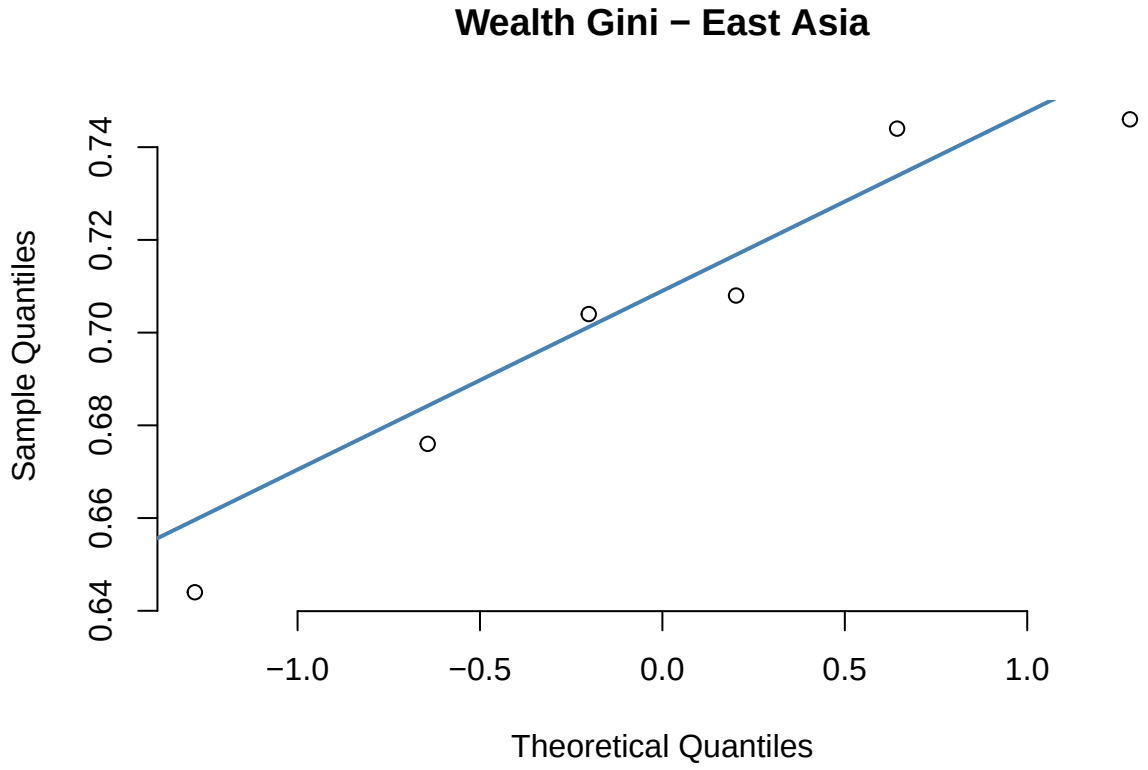
!Primjećujemo da nedostaju podaci za neke države te zbog toga nisu prikazani rezultati za sve regije.!

Najveća razlika srednje vrijednosti i medijana vidljiva je između Istočne Azije i Jugoistočne Azije. Postoje indikacije da je nejednakost bogatstva veća u Jugoistočnoj Aziji u odnosu na Istočnu Aziju.

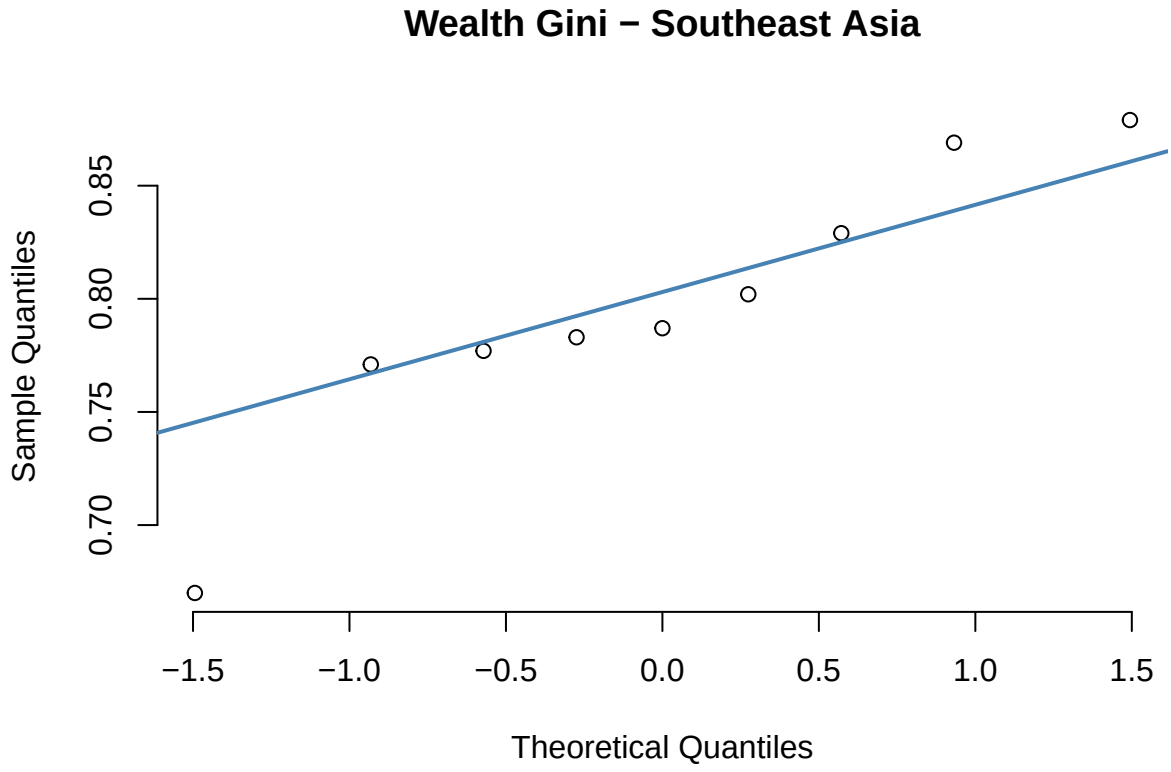
##Nejednakost bogatstva Istočna Azija vs Jugoistočna Azija Postavimo sljedeće hipoteze: H_0: Nejednakost bogatstva je jednaka u Istočnoj i Jugoistočnoj Aziji H_1: Nejednakost bogatstva je veća u Jugoistočnoj Aziji u odnosu na Istočnu Aziju

Ovakvo ispitivanje možemo provesti t-testom. Kako bi mogli provesti test, moramo najprije provjeriti pretpostavke normalnosti i nezavisnosti uzorka. Obzirom da razmatramo uzorke država različitih regija, možemo pretpostaviti njihovu nezavisnost. Sljedeći korak je provjeriti normalnost podataka koju ćemo provjeriti qq-plotom i Lillieforsovim testom.

```
library(nortest)
southeast_asia = whr2021[whr2021$`Regional indicator` == "Southeast Asia",]
east_asia = whr2021[whr2021$`Regional indicator` == "East Asia",]

qqnorm(east_asia$`Wealth Gini`, pch = 1, frame = FALSE,main='Wealth Gini - East Asia')
qqline(east_asia$`Wealth Gini`, col = "steelblue", lwd = 2)
```




```
qqnorm(southeast_asia$`Wealth Gini`, pch = 1, frame = FALSE,main='Wealth Gini - Southeast Asia')
qqline(southeast_asia$`Wealth Gini`, col = "steelblue", lwd = 2)
```



```
lillie.test(east_asia$`Wealth Gini`)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  east_asia$`Wealth Gini`
## D = 0.18032, p-value = 0.783
```

```
lillie.test(southeast_asia$`Wealth Gini`)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  southeast_asia$`Wealth Gini`
## D = 0.22957, p-value = 0.1867
```

Iz qq-plota ne možemo pretpostaviti normalnost podataka. Velika p-vrijednost kod Lillieforsovog testa govori kako ne možemo odbaciti hipotezu da podaci dolaze iz normalne distribucije.

Pogledajmo vrijednost varijanci oba uzorka.

```
var(east_asia$`Wealth Gini`)
```

```
## [1] 0.001552667
```

```
var(southeast_asia$`Wealth Gini`)
```

```
## [1] 0.00380675
```

```
#Jesu li varijance značajno različite
var.test(east_asia$`Wealth Gini`, southeast_asia$`Wealth Gini`)
```

```
##
##  F test to compare two variances
##
## data:  east_asia$`Wealth Gini` and southeast_asia$`Wealth Gini`
## F = 0.40787, num df = 5, denom df = 8, p-value = 0.3381
## alternative hypothesis: true ratio of variances is not equal to 1
## 95 percent confidence interval:
##  0.0846686 2.7560611
## sample estimates:
## ratio of variances
##           0.407872
```

p-vrijednost od 0.3381 nam govori da ne odbacujemo hipotezu da su varijance uzoraka jednake.

Provedimo sada t-test uz pretpostavku jednakosti varijanci.

```
t.test(southeast_asia$`Wealth Gini`, east_asia$`Wealth Gini`, alt = "greater", var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  southeast_asia$`Wealth Gini` and east_asia$`Wealth Gini`
## t = 3.2428, df = 13, p-value = 0.003208
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.0420598       Inf
## sample estimates:
## mean of x mean of y
```

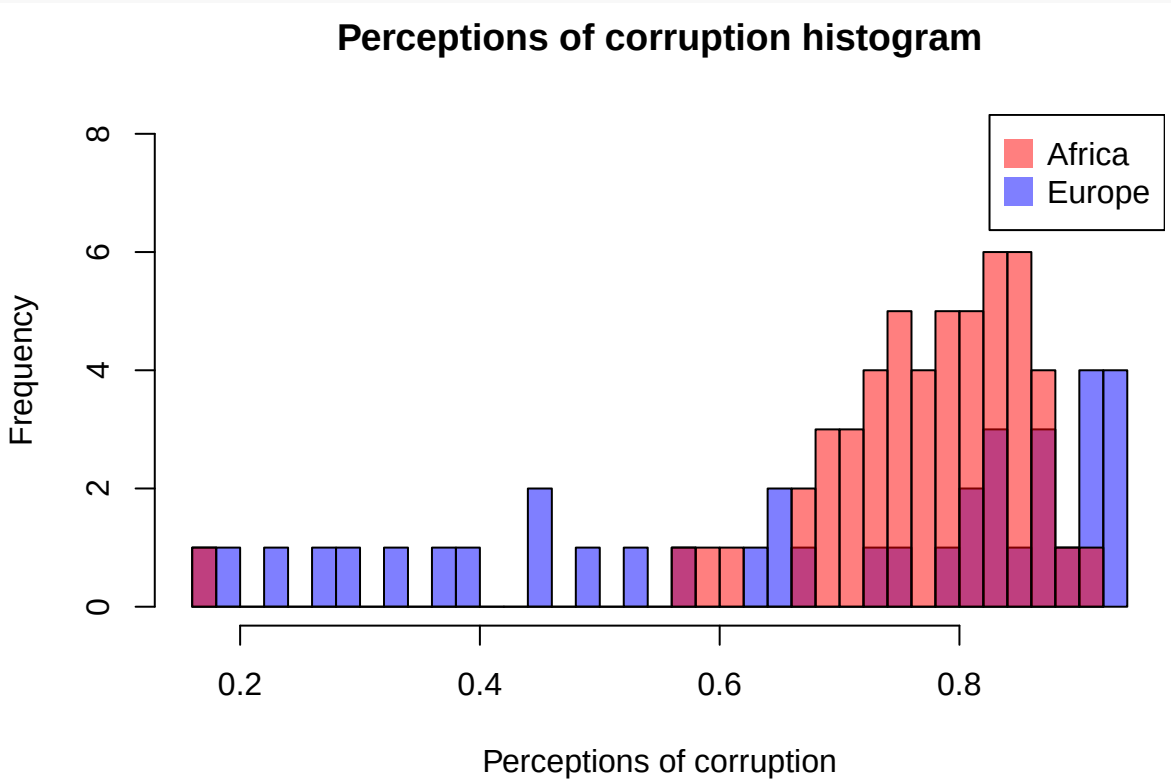
```
## 0.7963333 0.7036667
```

Zbog male p-vrijednosti možemo odbaciti hipotezu H_0 u korist alternative da je nejednakost bogatstva u Jugoistočnoj Aziji u prosjeku veća od nejednakosti bogatstva u Istočnoj Aziji.

Zastupljenost korupcije u zemljama Europe i Afrike

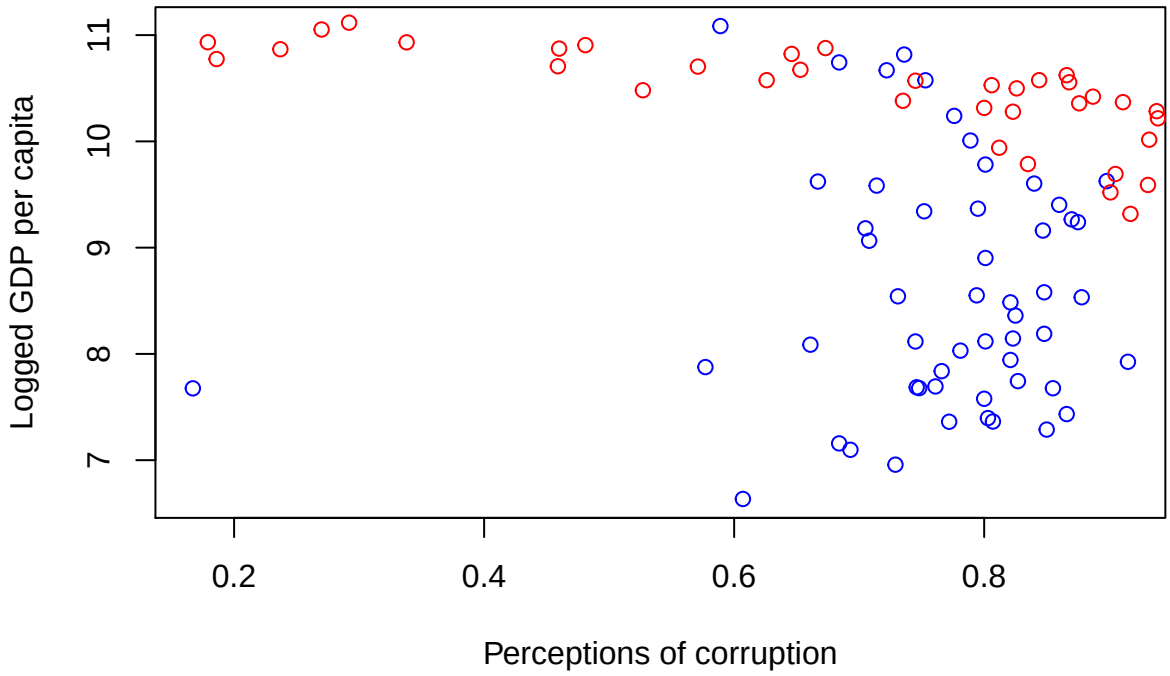
Pokušajmo sada zaključiti nešto o korupciji. Promatrat ćemo zemlje Europe i Afrike te želimo saznati gdje je korupcija zastupljenija. Ispitat ćemo zavosnost percepcije korupcije o logaritmu BDP-a po stanovniku.

```
ce_europe = whr2021[whr2021$`Regional indicator` == "Central and Eastern Europe",]
w_europe = whr2021[whr2021$`Regional indicator` == "Western Europe",]
men_africa = whr2021[whr2021$`Regional indicator` == "Middle East and North Africa",]
ss_africa = whr2021[whr2021$`Regional indicator` == "Sub-Saharan Africa",]

europe <- rbind(ce_europe, w_europe)
africa <- rbind(men_africa, ss_africa)

plot_by_gini <- function(column, main) {
  hist(europe[[column]], breaks=30, main=main, xlab=column, ylab="Frequency", ylim = c(0,8),col=rgb(0,0
  hist(africa[[column]], breaks=30, main=main, xlab=column, ylab="Frequency", col=rgb(1,0,0,0.5), add=T
  legend(x="topright", c("Africa", "Europe"), col=c(rgb(1,0,0,0.5), rgb(0,0,1,0.5)), pt.cex = 2, pch =
}
plot_by_gini("Perceptions of corruption", "Perceptions of corruption histogram")
```

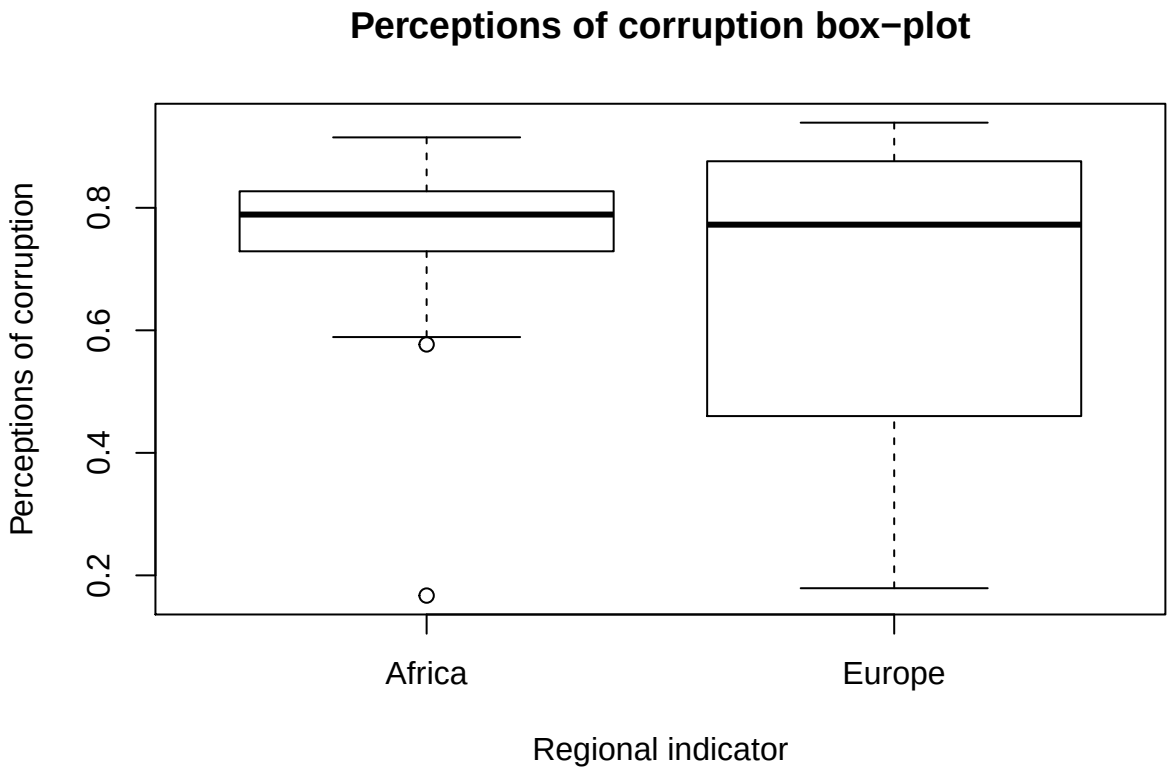



```
plot(africa$`Perceptions of corruption`,
     africa$`Logged GDP per capita`,
     col='blue',
     ylab='Logged GDP per capita',
     xlab='Perceptions of corruption')
```

```
points(europe$`Perceptions of corruption`,
     europe$`Logged GDP per capita`,col='red')
```




```
boxplot(africa$`Perceptions of corruption`,europe$`Perceptions of corruption`,
        main='Perceptions of corruption box-plot',
        ylab='Perceptions of corruption', xlab="Regional indicator", names = c("Africa", "Europe"))
```



Iz histograma vidimo da je percepcija korupcije u Africi bitno veća nego u Europi. Iz drugog grafa vidimo da je

logaritam BDP-a po stanovniku relativno visok za sve države Europe te neovisno o njemu ljudi različito percipiraju korupciju. Za države Afrike prevladava visok stupanj percepcije korupcije neovisno o BDP-u. Iz box-plota vidimo veliki rang podataka za Europu, no medijan je otprilike jednak za oba kontinenta. Izračunajmo sada srednju vrijednost percepcije korupcije za Europu i Afriku.

```
mean_europe = mean(europe$`Perceptions of corruption`)
mean_africa = mean(africa$`Perceptions of corruption`)
print(mean_europe)
```

```
## [1] 0.6695789
```

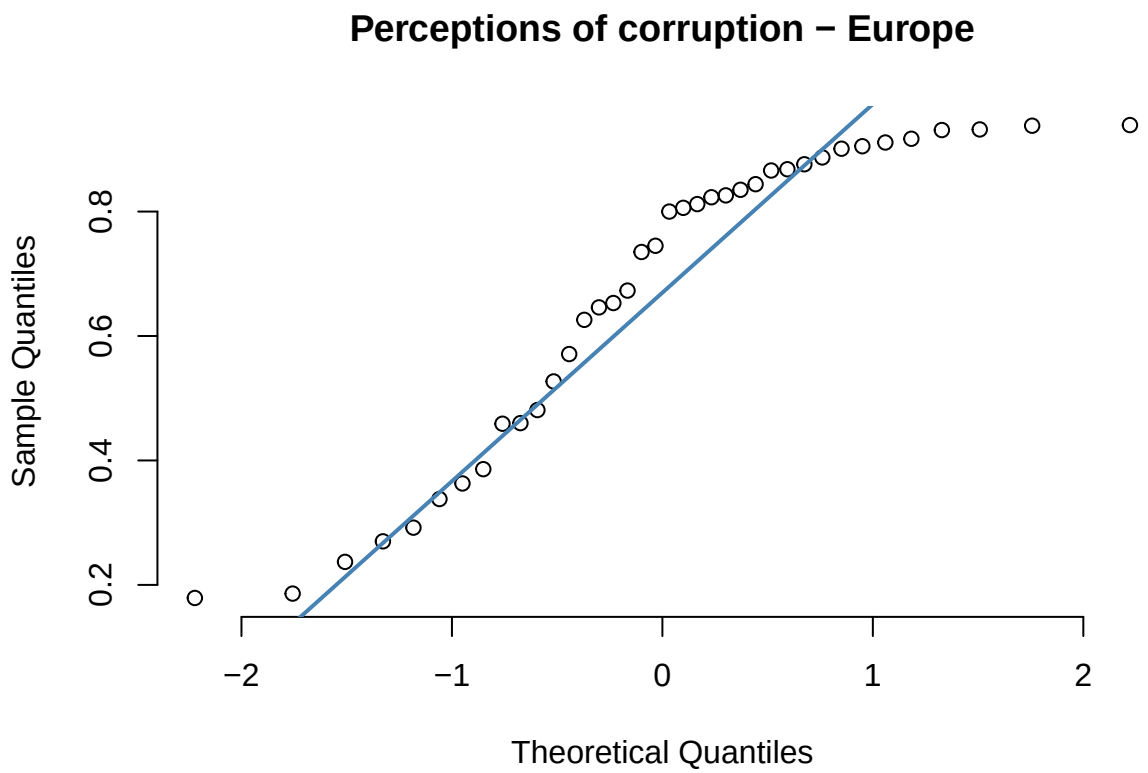
```
print(mean_africa)
```

```
## [1] 0.7647547
```

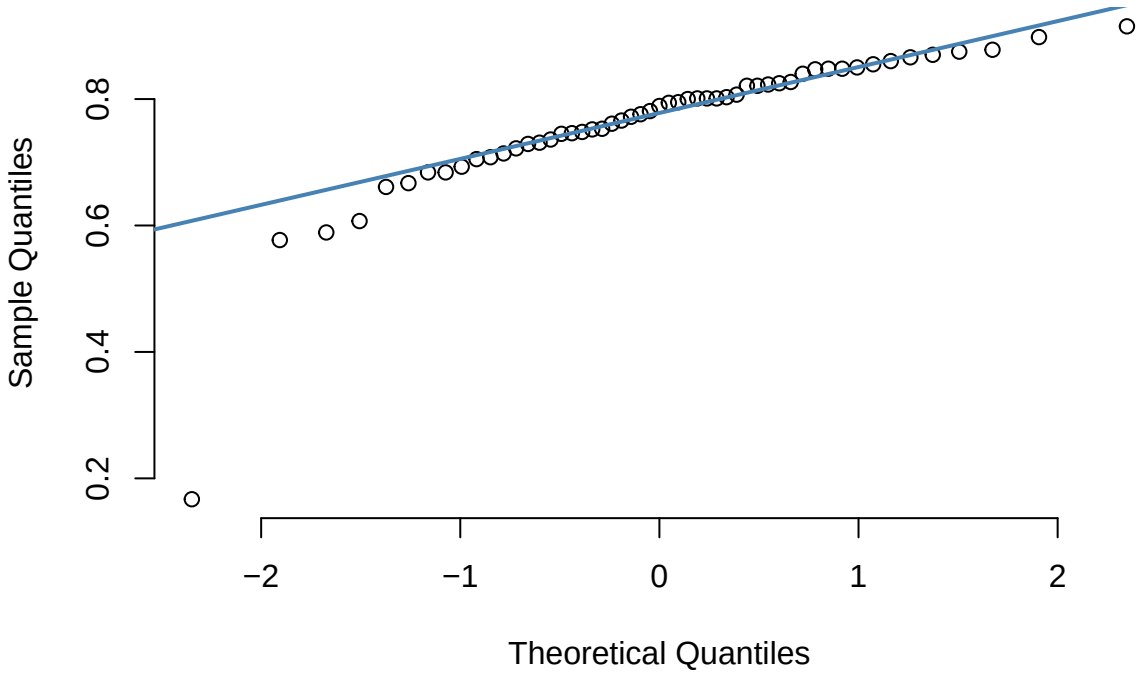
Možemo li na temelju analiza zaključiti da je percepcija korupcije manja u Europi?

Postavimo hipoteze: H_0: srednja vrijednost percepcije korupcije za Europu i Afriku je jednaka H_1: srednja vrijednost percepcije korupcije za Europu je manja od srednje vrijednosti za Afriku Ovakvo ispitivanje možemo provesti t-testom. Kako bi mogli provesti test, moramo najprije provjeriti pretpostavke normalnosti i nezavisnosti uzorka. Obzirom da razmatramo uzorke država različitih kontinenta, možemo pretpostaviti njihovu nezavisnost. Sljedeći korak je provjeriti normalnost podataka koju ćemo provjeriti qq-plotom.

```
qqnorm(europe$`Perceptions of corruption`, pch = 1, frame = FALSE,main='Perceptions of corruption - Eur
qqline(europe$`Perceptions of corruption`, col = "steelblue", lwd = 2)
```




```
qqnorm(africa$`Perceptions of corruption`, pch = 1, frame = FALSE,main='Perceptions of corruption - Afr
qqline(africa$`Perceptions of corruption`, col = "steelblue", lwd = 2)
```



Iz dobivenih grafova možemo naslutiti normalnost podataka za Afiku uz male izuzetke na repovima dok normalnost podataka za Europu nije vidljiva pa ne možemo provesti t-test. Već iz prethodnog histograma se dalo naslutiti da podaci za Europu ne slijede normalnu distibuciju.

Testirajmo li podatke Lillieforsovim testom dolazimo do istog zaključka.

```
lillie.test(africa$`Perceptions of corruption`)
```

```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  africa$`Perceptions of corruption`
## D = 0.13097, p-value = 0.02386
```

```
lillie.test(europe$`Perceptions of corruption`)
```

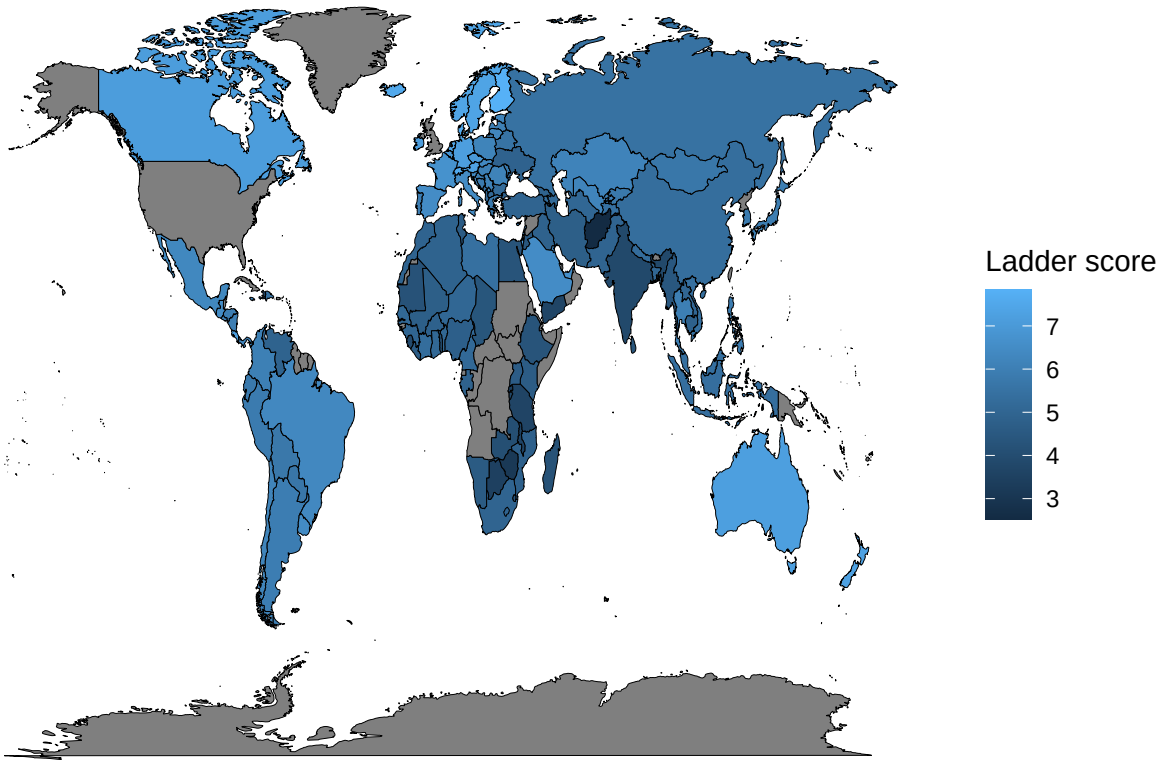
```
##
##  Lilliefors (Kolmogorov-Smirnov) normality test
##
## data:  europe$`Perceptions of corruption`
## D = 0.20137, p-value = 0.0004698
```

Zbog male p-vijednosti možemo odbaciti hiptezu H_0 da podaci dolaze iz normalne distibucije. Ne možemo provesti t-test. Jedan od mogućih rješenja je transformirati podatke i provesti jackknife.

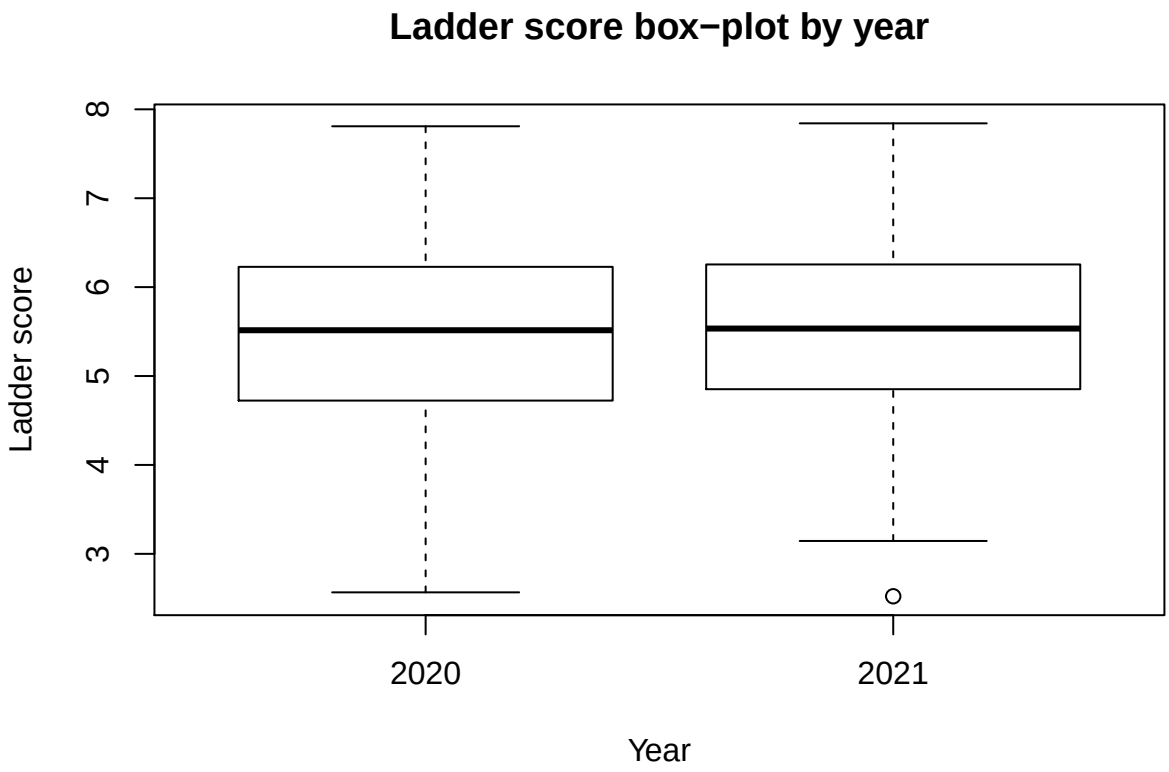
Usporedba razina sreće u 2020. i 2021. godini.

```
library(ggplot2)

data2021 = whr2021[c("Country name", "Ladder score")]
names(data2021)[names(data2021) == "Country name"] = "region"
```

```
mapdata2021 = map_data("world")
mapdata2021 = left_join(mapdata2021, data2021, by = "region")

map2021 = ggplot(mapdata2021, aes(x = long, y = lat, group = group)) +
  geom_polygon(aes(fill = `Ladder score`), color = "black", size = 0.1) + theme(axis.text.x = element_bl
                            axis.text.y = element_blank(),
                            axis.ticks = element_blank(),
                            axis.title.y = element_blank(),
                            axis.title.x = element_blank(),
                            rect = element_blank())

map2021
```



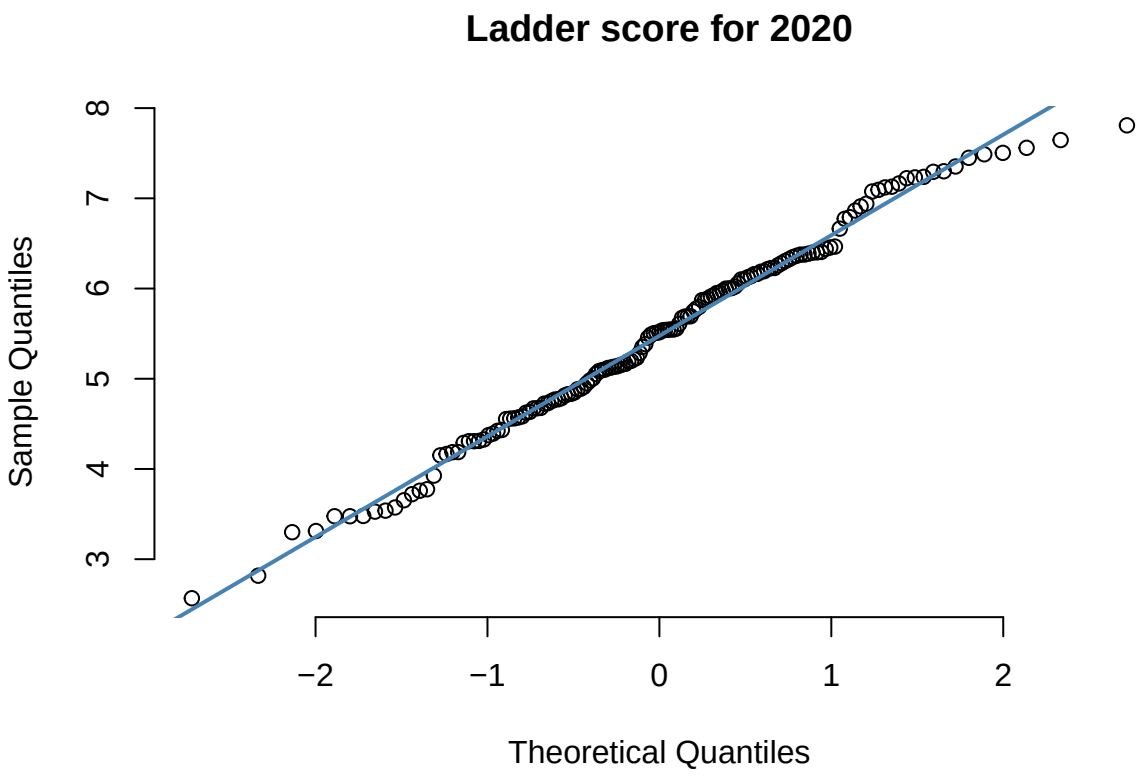
Pravokutni dijagram Ladder score-ova za 2020. i 2021. godinu.



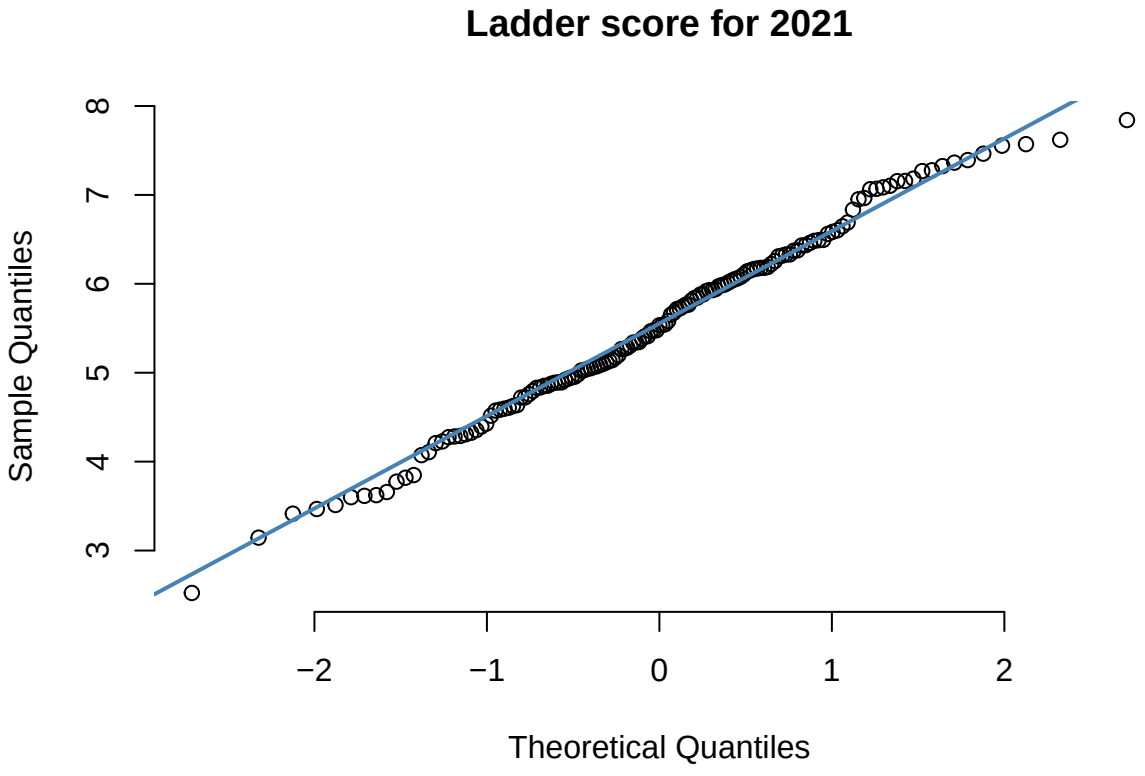
Provest ćemo test o jednakosti aritmetičkih sredina za različite godine. Hipoteze su:
H_0: aritmetičke sredine su jednake
H_1: aritemetičke sredine nisu jednake

Prije provedbe t-testa provjeravamo pretpostavke normalnosti uzorka. S obzirom na to da razmatramo dva uzoraka iz dvije različite regije, možemo pretpostaviti njihovu nezavisnost. Normalnost podataka provjeravamo qq-plotom.

```
qqnorm(whr2020$`Ladder score`, pch = 1, frame = FALSE,main='Ladder score for 2020')
qqline(whr2020$`Ladder score`, col = "steelblue", lwd = 2)
```




```
qqnorm(whr2021$`Ladder score`, pch = 1, frame = FALSE,main='Ladder score for 2021')
qqline(whr2021$`Ladder score`, col = "steelblue", lwd = 2)
```

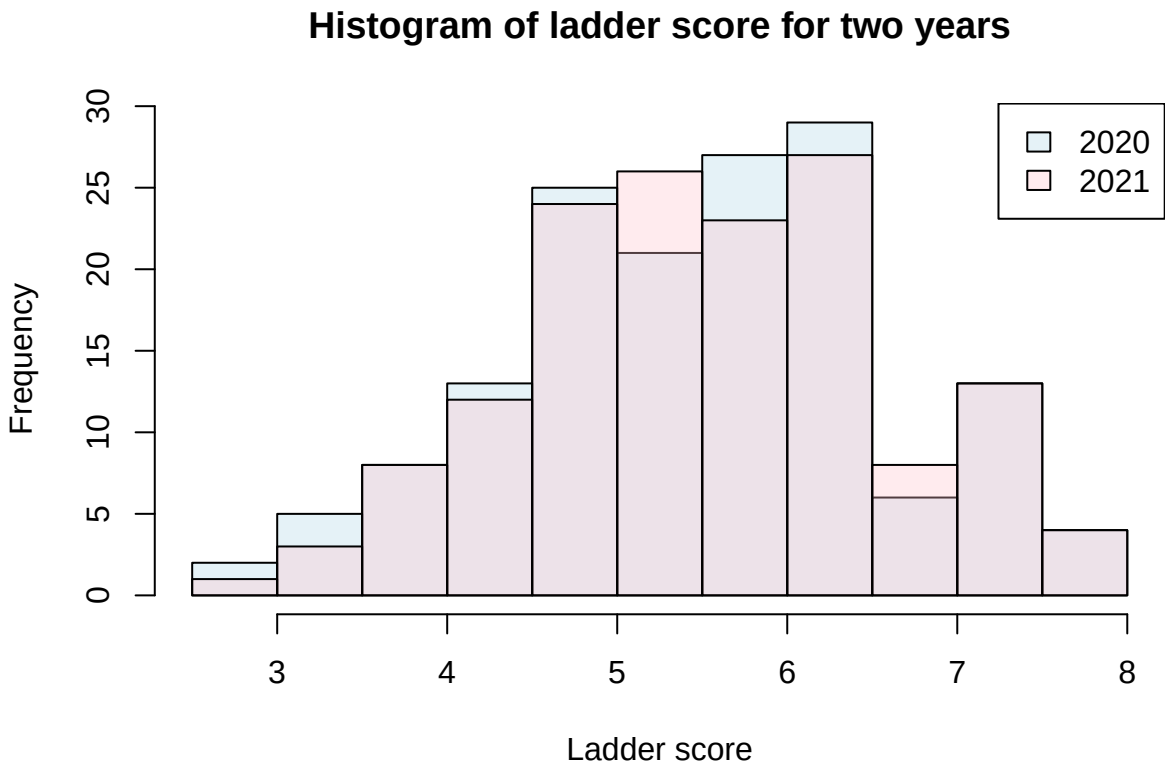


QQ-plot sugerira na normalnost.

```
t.test(whr2020$`Ladder score`, whr2021$`Ladder score`, alternative = "two.sided", var.equal = TRUE)
```

```
##
##  Two Sample t-test
##
## data:  whr2020$`Ladder score` and whr2021$`Ladder score`
## t = -0.47341, df = 300, p-value = 0.6363
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.3072685  0.1881005
## sample estimates:
## mean of x mean of y
##  5.473255  5.532839
```

Na temelju rezultata možemo zaključiti da su aritmetičke sredine razine sreće za dvije godine jednake.

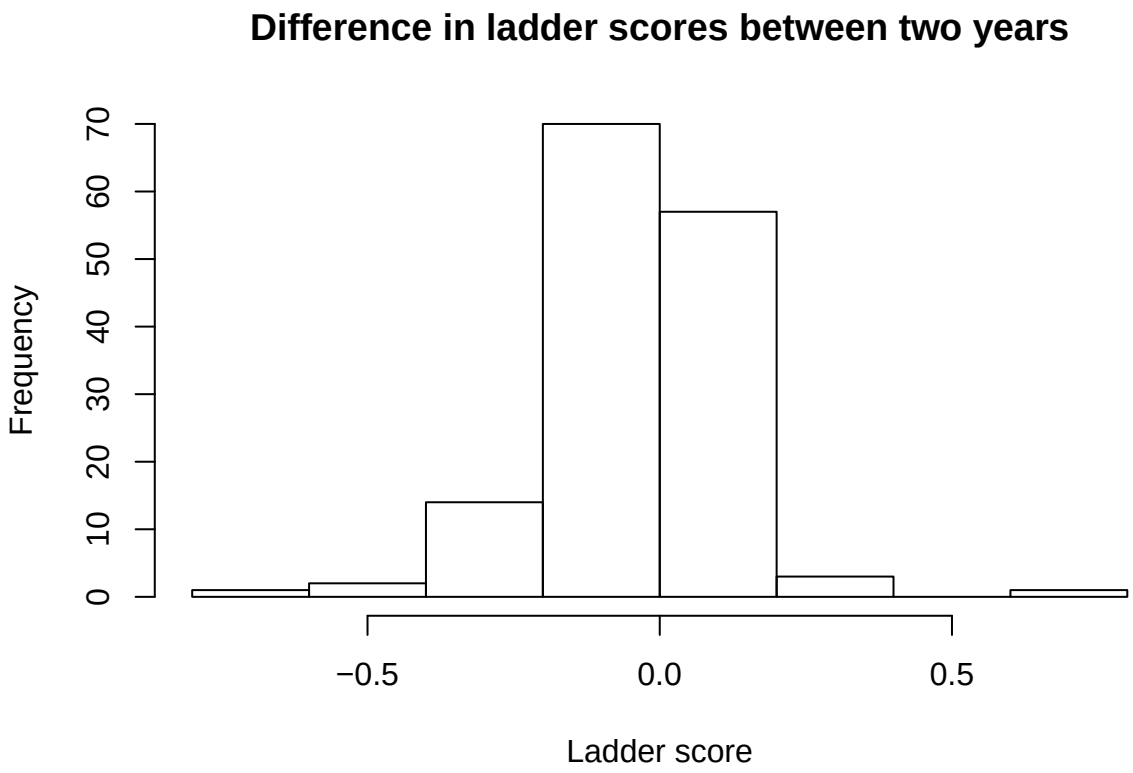


Spojimo podatke iz dvije godine:

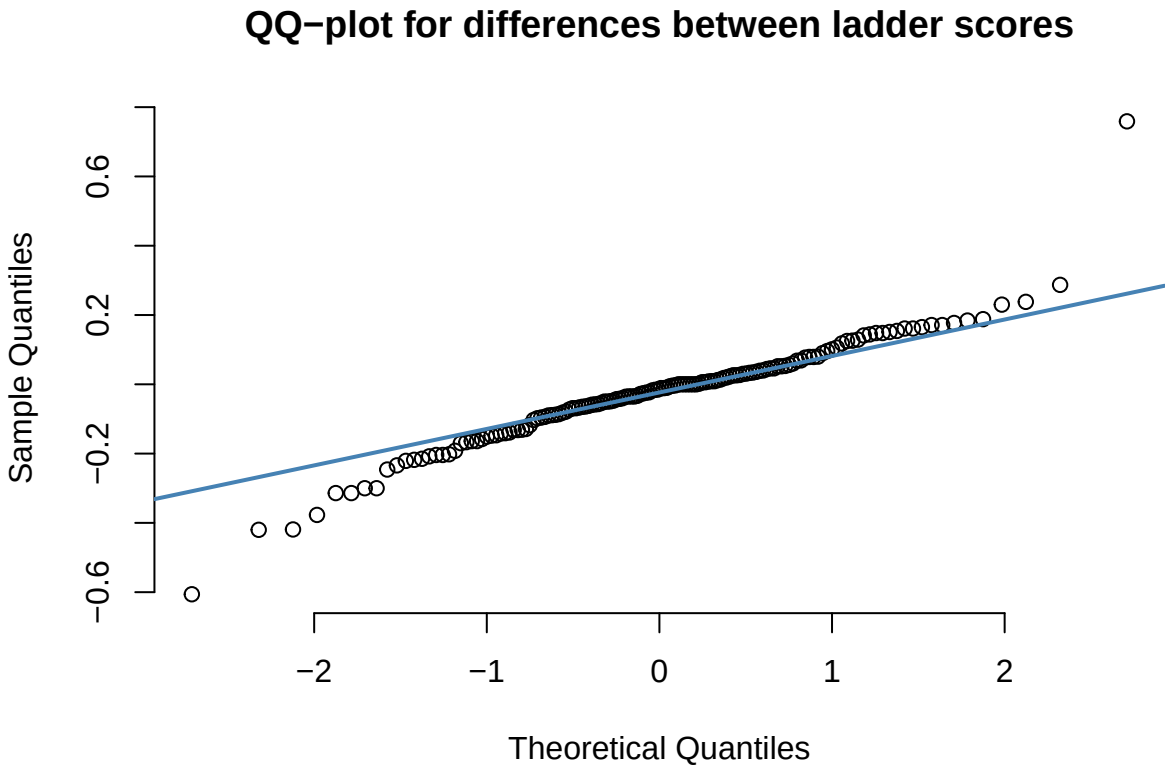
```
mergedData = merge(whr2020, whr2021, by="Country name", suffixes = c(".20",".21"))

hist(mergedData$`Ladder score.20`,
     main=paste('Histogram of ladder score in 2020'),
     xlab='Ladder score')
```


```
hist(mergedData$`Ladder score.21`,
     main=paste('Histogram of ladder score in 2021'),
     xlab='Ladder score')
```

```
hist(mergedData$`Ladder score.20`-mergedData$`Ladder score.21`,
     main=paste('Difference in ladder scores between two years'),
     xlab='Ladder score')
```




```
qqnorm(mergedData$`Ladder score.20`-mergedData$`Ladder score.21`,
       pch = 1,
       frame = FALSE,
       main=paste('QQ-plot for differences between ladder scores'))
qqline(mergedData$`Ladder score.20`-mergedData$`Ladder score.21`,
       col = "steelblue", lwd = 2)
```



Histogram razlika nam sugerira normalnost podataka, dok iz qq-plota vidimo malo odstupanje lijevog repa. Pod pretpostavkom da su podatci normalni, koristimo upareni t-test.

```
t.test(mergedData$`Ladder score.20`,
       mergedData$`Ladder score.21`,
       paired = TRUE,
       alt = "less")
```

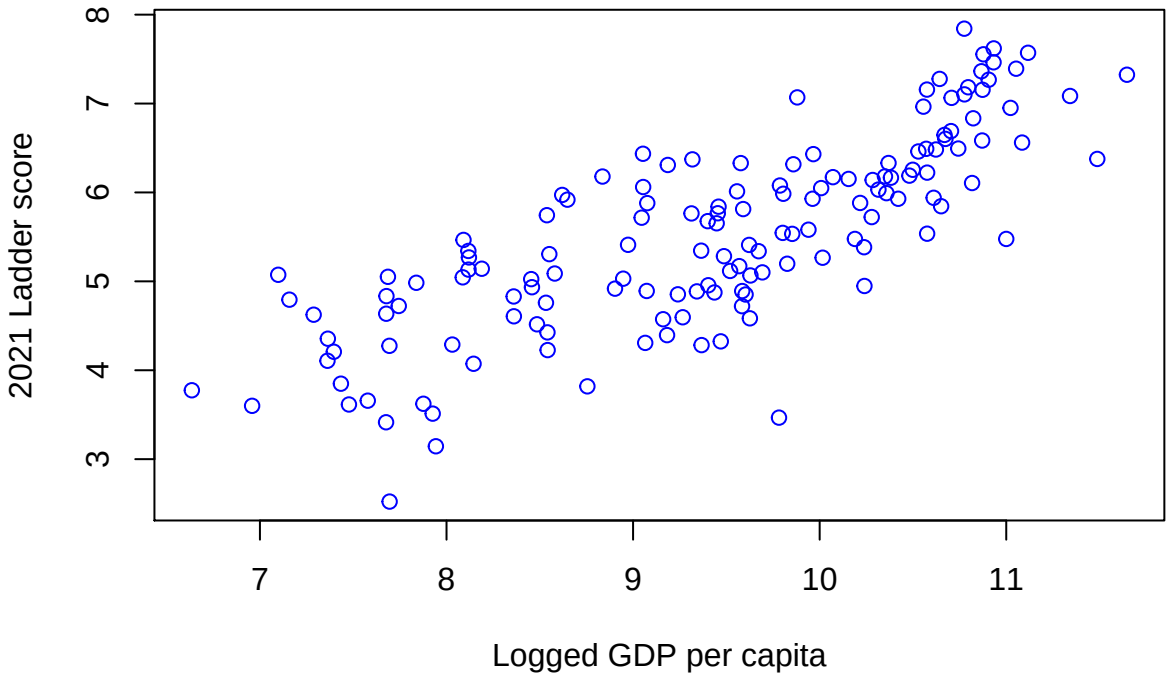
```
##
##  Paired t-test
##
## data:  mergedData$`Ladder score.20` and mergedData$`Ladder score.21`
## t = -2.0749, df = 147, p-value = 0.01987
## alternative hypothesis: true difference in means is less than 0
## 95 percent confidence interval:
##          -Inf -0.005247129
## sample estimates:
## mean of the differences
##             -0.02594595
```

Jako mala p-vrijednost nam ukazuje da postoji statistički značajna razlika u "ladder score-u" u dvije godine. Postoje značajne razlike u sreći pojedinih država.

Ovisnost razine sreće o drugim varijablama u 2021. godini

GDP per capita

Možemo li iz dijagrama raspšrenja naslutiti vezu između GDP per capita i Ladder score-a?

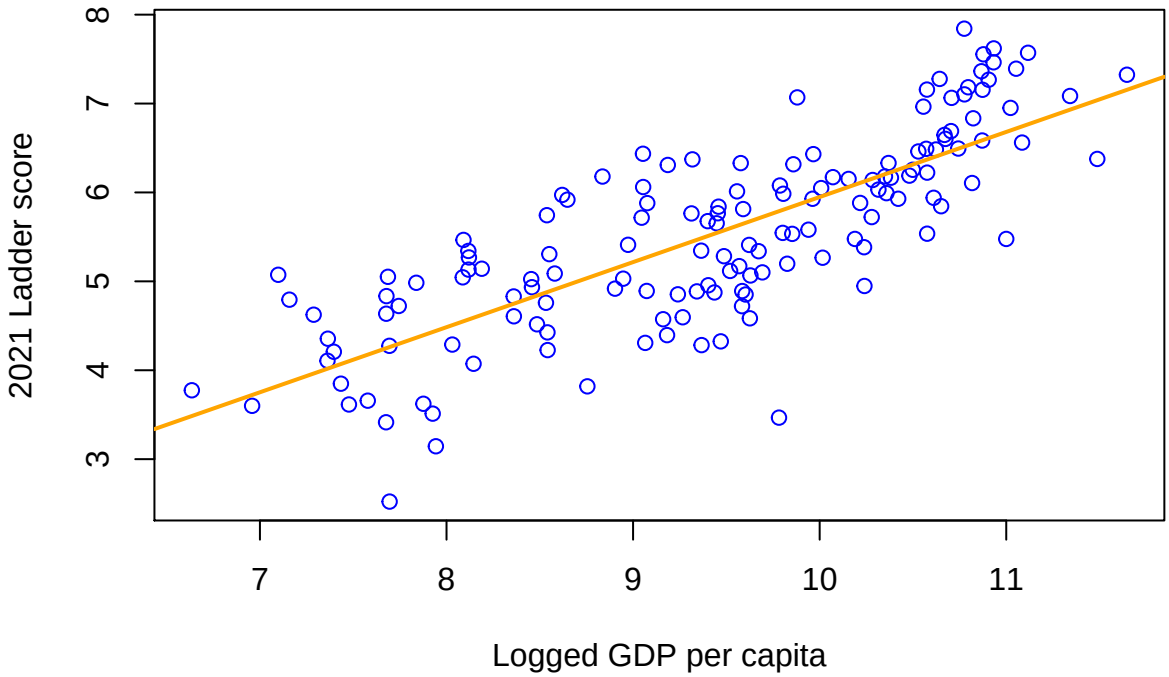


Izračunavamo koeficijente linearne regresije.

```
linreg = lm(formula = whr2021$`Ladder score` ~ whr2021$`Logged GDP per capita`)
summary(linreg)
```

```
##
## Call:
## lm(formula = whr2021$`Ladder score` ~ whr2021$`Logged GDP per capita`)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.32190 -0.46198  0.08206  0.50740  1.32618
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                      -1.3719     0.4456  -3.079  0.00248 **
## whr2021$`Logged GDP per capita`   0.7320     0.0469  15.610  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.661 on 147 degrees of freedom
## Multiple R-squared:  0.6237, Adjusted R-squared:  0.6212
## F-statistic: 243.7 on 1 and 147 DF,  p-value: < 2.2e-16
```

```
plot(whr2021$`Logged GDP per capita`, whr2021$`Ladder score`,
     col="blue",
     xlab='Logged GDP per capita',
     ylab='2021 Ladder score')
abline(linreg$coefficients[1], linreg$coefficients[2], col = "orange", lwd = 2)
```



Testiramo nezavisnost dvije varijable korištenjem t-testa:
H_0: $\beta_1 = 0$
H_1: $\beta_1 \neq 0$