Gini Index and Inequality

ID, Last Name, First Name

2024/01/24

Short Abstract

In this note, we study GINI index using WDI and compare with other index. In an OECD report, ‘OECD Regions and Cities at a Glance 2022’ Link, S80/S20 ratios are used. We consider a question if the ratio is related to GINI index.

Definition S80/S20 ratio: The total income received by the 20% of people with the highest income in a region divided by the total income received by the 20% of people with the lowest income in the same region.

Information of data

Poverty and Inequality

Distribution of income or consumption

Gini Index: SI.POV.GINI [Link]

Income share held by lowest 20%: SI.DST.FRST.20 [Link]

Income share held by second 20%: SI.DST.02ND.20 [Link]

Income share held by third 20%: SI.DST.03RD.20 [Link]

Income share held by fourth 20%: SI.DST.04TH.20 [Link]

Income share held by highest 20%: SI.DST.05TH.20 [Link]

Setup

Install a package `DescTools` first.

```r
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.4.4     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.0
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```r
library(broom)
library(WDI)
library(DescTools)
```

Importing Data

```
df_gini <- WDI(indicator = c(gini = "SI.POV.GINI",
                             `0-20` = "SI.DST.FRST.20",
                             `20-40` = "SI.DST.02ND.20",
                             `40-60` = "SI.DST.03RD.20",
                             `60-80` = "SI.DST.04TH.20",
                             `80-100` = "SI.DST.05TH.20"))
```

```
write_csv(df_gini, "data/gini.csv")
```

```
df_gini <- read_csv("data/gini.csv")
```

```
## Rows: 16758 Columns: 10
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): country, iso2c, iso3c
## dbl (7): year, gini, 0-20, 20-40, 40-60, 60-80, 80-100
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
REGION <- c("1A", "1W", "4E", "6F", "6N", "6X", "7E", "8S", "A4", "A5",
"A9", "B1", "B2", "B3", "B4", "B6", "B7", "B8", "C4", "C5", "C6",
"C7", "C8", "C9", "D2", "D3", "D4", "D5", "D6", "D7", "EU", "F1",
"F6", "M1", "M2", "N6", "OE", "R6", "S1", "S2", "S3", "S4", "T2",
"T3", "T4", "T5", "T6", "T7", "V1", "V2", "V3", "V4", "XC", "XD",
"XE", "XF", "XG", "XH", "XI", "XJ", "XL", "XM", "XN", "XO", "XP",
"XQ", "XT", "XU", "XY", "Z4", "Z7", "ZB", "ZF", "ZG", "ZH", "ZI",
"ZJ", "ZQ", "ZT")
```

Viewing Data

```
df_gini
```

```
## # A tibble: 16,758 x 10
##    country     iso2c iso3c  year  gini `0-20` `20-40` `40-60` `60-80` `80-100`
##    <chr>       <chr> <chr> <dbl> <dbl>  <dbl>   <dbl>   <dbl>   <dbl>    <dbl>
##  1 Afghanistan AF    AFG    1960    NA     NA      NA      NA      NA       NA
##  2 Afghanistan AF    AFG    1961    NA     NA      NA      NA      NA       NA
##  3 Afghanistan AF    AFG    1962    NA     NA      NA      NA      NA       NA
##  4 Afghanistan AF    AFG    1963    NA     NA      NA      NA      NA       NA
##  5 Afghanistan AF    AFG    1964    NA     NA      NA      NA      NA       NA
##  6 Afghanistan AF    AFG    1965    NA     NA      NA      NA      NA       NA
##  7 Afghanistan AF    AFG    1966    NA     NA      NA      NA      NA       NA
##  8 Afghanistan AF    AFG    1967    NA     NA      NA      NA      NA       NA
##  9 Afghanistan AF    AFG    1968    NA     NA      NA      NA      NA       NA
## 10 Afghanistan AF    AFG    1969    NA     NA      NA      NA      NA       NA
## # i 16,748 more rows
```

Transforming Data

We add a new column with the value `s80/s20` = `80-100`/`0-20`.

```
df_gini <- df_gini |> mutate(`s80/s20` = `80-100`/`0-20`)
df_gini
```

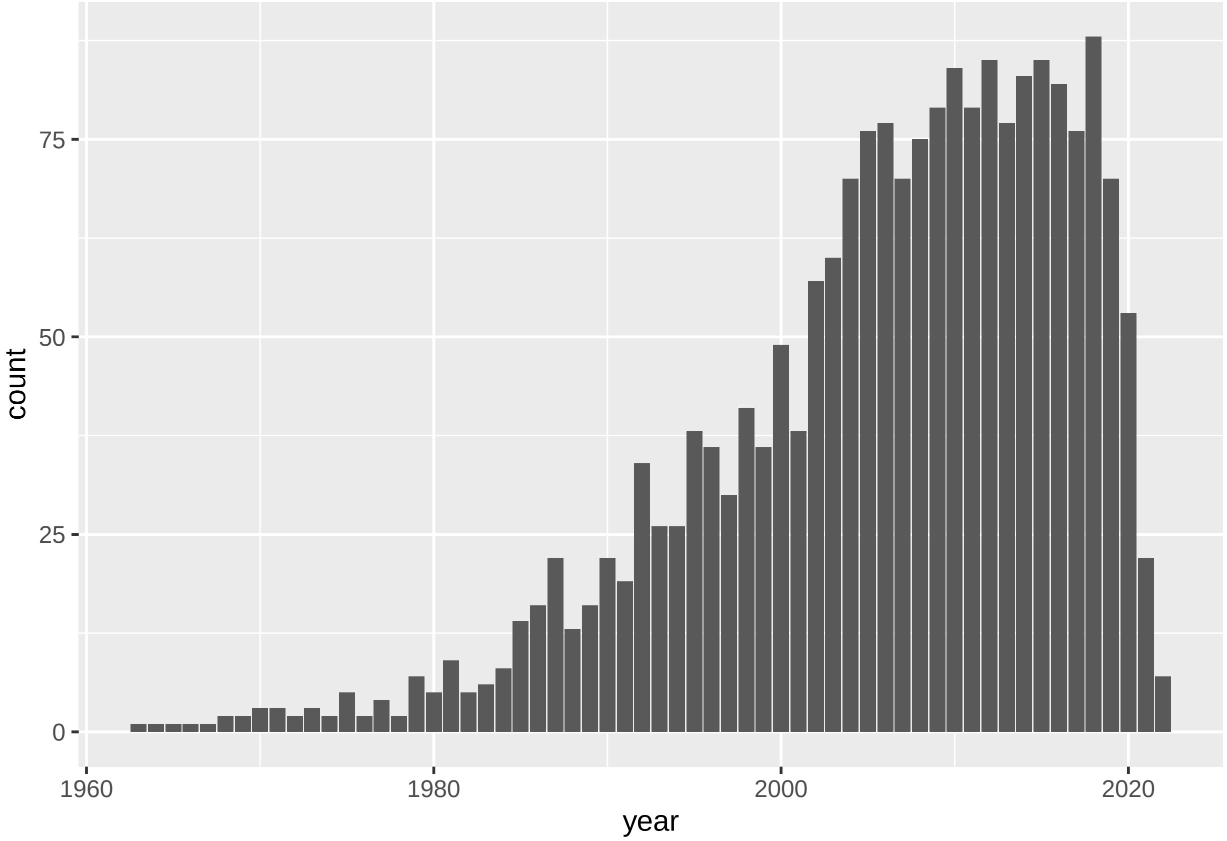
```
## # A tibble: 16,758 x 11
##    country     iso2c iso3c  year  gini `0-20` `20-40` `40-60` `60-80` `80-100`
##    <chr>       <chr> <chr> <dbl> <dbl>  <dbl>   <dbl>   <dbl>   <dbl>    <dbl>
##  1 Afghanistan AF    AFG    1960    NA     NA      NA      NA      NA       NA
##  2 Afghanistan AF    AFG    1961    NA     NA      NA      NA      NA       NA
##  3 Afghanistan AF    AFG    1962    NA     NA      NA      NA      NA       NA
##  4 Afghanistan AF    AFG    1963    NA     NA      NA      NA      NA       NA
##  5 Afghanistan AF    AFG    1964    NA     NA      NA      NA      NA       NA
##  6 Afghanistan AF    AFG    1965    NA     NA      NA      NA      NA       NA
##  7 Afghanistan AF    AFG    1966    NA     NA      NA      NA      NA       NA
##  8 Afghanistan AF    AFG    1967    NA     NA      NA      NA      NA       NA
##  9 Afghanistan AF    AFG    1968    NA     NA      NA      NA      NA       NA
## 10 Afghanistan AF    AFG    1969    NA     NA      NA      NA      NA       NA
## # i 16,748 more rows
## # i 1 more variable: `s80/s20` <dbl>
```

Visualization and Analysis

Number of Data in Each Year

Check the number of data available in year year.

```
df_gini |> drop_na(gini, `0-20`, `80-100`) |>
  ggplot(aes(year)) + geom_bar()
```



Correlation of Three Indicators

We calculate the correlations among three indicators, GINI, top 20% and s80/s20 ratio.

1. Correlation using all available values.
2. Correlation using all available values of countries.
3. Correlation using all available values of countries in 2018.

```
df_gini |> drop_na(gini, `0-20`, `80-100`) |> select(gini, `80-100`, `s80/s20`) |>
  cor() |> as.data.frame()
```

```
##              gini    80-100   s80/s20
## gini    1.0000000 0.9943488 0.8663291
## 80-100  0.9943488 1.0000000 0.8592673
## s80/s20 0.8663291 0.8592673 1.0000000
```

```
df_gini |> drop_na(gini, `0-20`, `80-100`) |>
  filter(!(iso2c %in% REGION)) |> select(gini, `80-100`, `s80/s20`) |>
  cor() |> as.data.frame()
```

```
##              gini    80-100   s80/s20
## gini    1.0000000 0.9943488 0.8663291
## 80-100  0.9943488 1.0000000 0.8592673
## s80/s20 0.8663291 0.8592673 1.0000000
```

```
df_gini |> drop_na(gini, `0-20`, `80-100`) |> filter(year == 2018) |>
  filter(!(iso2c %in% REGION)) |> select(gini, `80-100`, `s80/s20`) |>
  cor() |> as.data.frame()
```

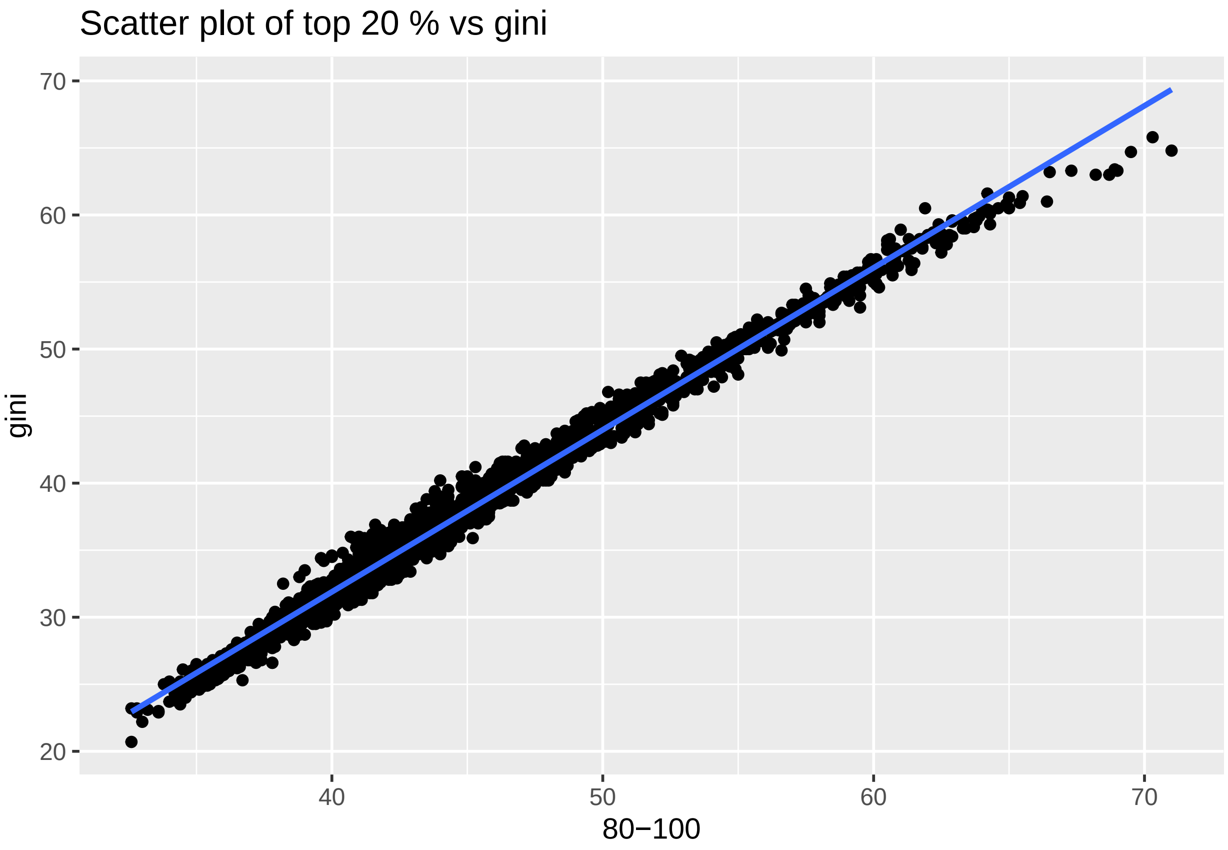
```
##              gini    80-100   s80/s20
## gini    1.0000000 0.9894834 0.9343159
## 80-100  0.9894834 1.0000000 0.9074783
## s80/s20 0.9343159 0.9074783 1.0000000
```

Observations:

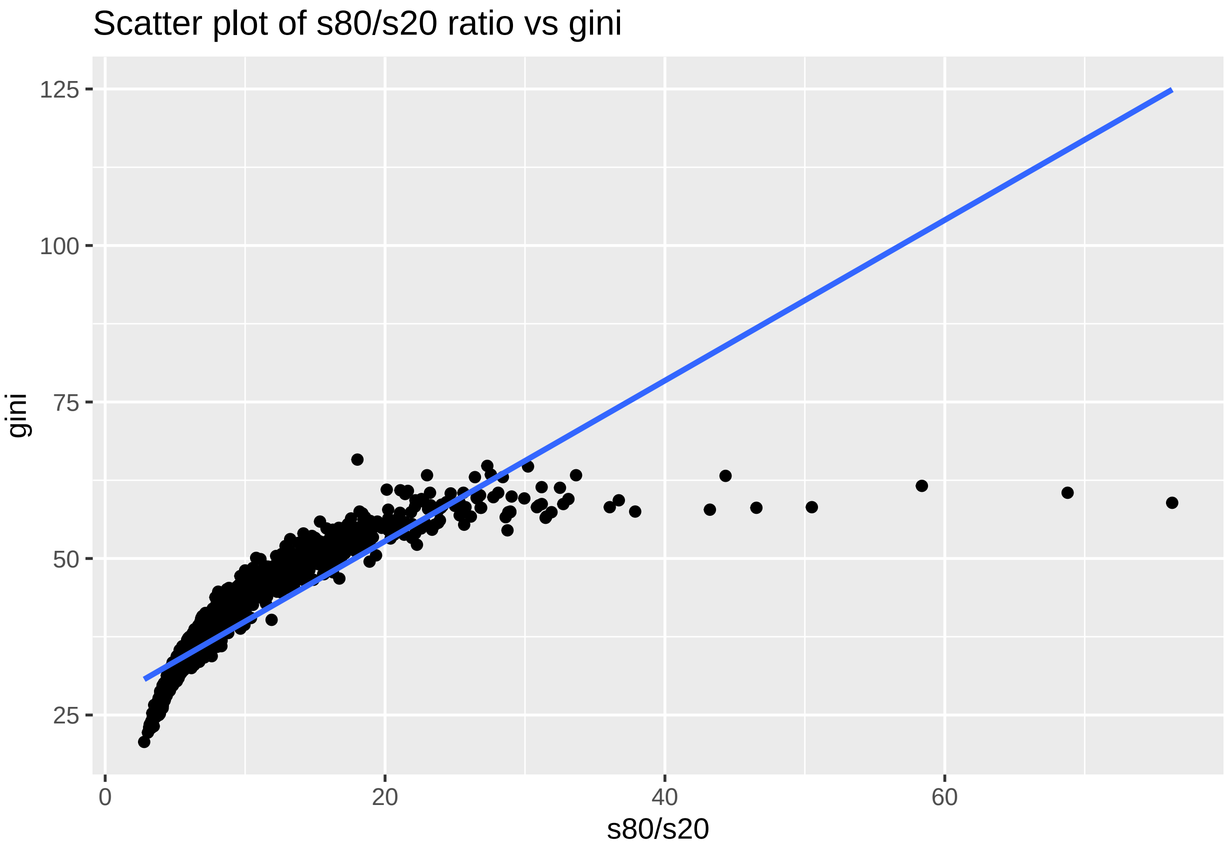
- The correlation between GINI index and the top 20% share of income is very close to 1.
- We chose 2018 as it is the year we have the most available values.
- There are no regional values of these three indices. So the values of the first two coincide.

Scatter Plots

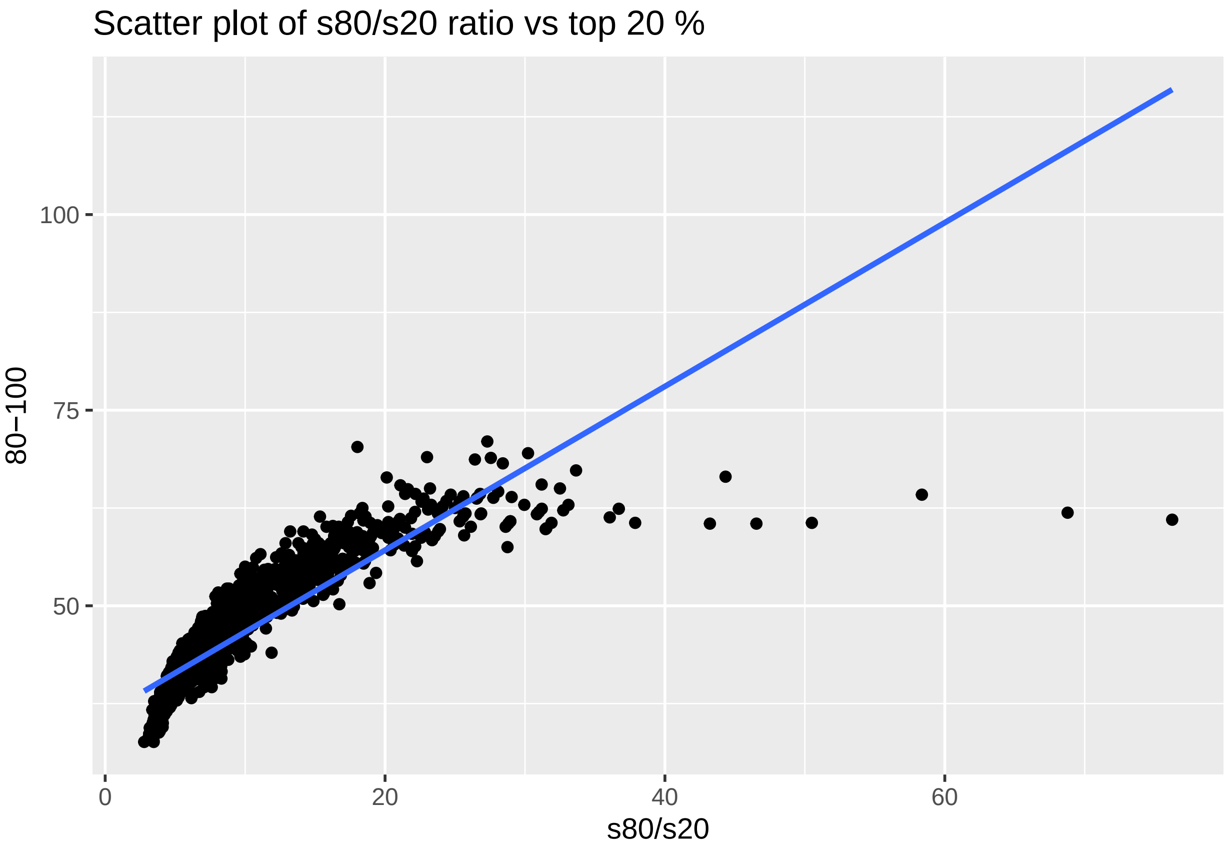
```
df_gini |> drop_na(gini, `0-20`, `80-100`) |>
  ggplot(aes(`80-100`, gini)) + geom_point() +
  geom_smooth(formula = 'y~x', method = "lm", se = FALSE) +
  labs(title = "Scatter plot of top 20 % vs gini")
```



```
df_gini |> drop_na(gini, `0-20`, `80-100`) |>
  ggplot(aes(`s80/s20`, gini)) + geom_point() +
  geom_smooth(formula = 'y~x', method = "lm", se = FALSE) +
  labs(title = "Scatter plot of s80/s20 ratio vs gini")
```


Scatter plot of s80/s20 ratio vs gini

```
df_gini |> drop_na(gini, `0-20`, `80-100`) |>
  ggplot(aes(`s80/s20`, `80-100`)) + geom_point() +
  geom_smooth(formula = 'y~x', method = "lm", se = FALSE) +
  labs(title = "Scatter plot of s80/s20 ratio vs top 20 %")
```



Models

We set three models.

```
model_gini_top20 <- df_gini |> lm(gini ~ `80-100`, data = _)
model_gini_8020 <- df_gini |> lm(gini ~ `s80/s20`, data = _)
model_8020_top20 <- df_gini |> lm(`s80/s20` ~ `80-100`, data = _)
```

Summary of the model gini ~ top 20%

```
model_gini_top20 |> summary()
```

```
##
## Call:
## lm(formula = gini ~ `80-100`, data = df_gini)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.5592 -0.6513 -0.0618  0.5784  3.4748
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -16.456298   0.131171  -125.5   <2e-16 ***
## `80-100`      1.208670   0.002879   419.8   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.9416 on 2005 degrees of freedom
##   (14751 observations deleted due to missingness)
## Multiple R-squared:  0.9887, Adjusted R-squared:  0.9887
## F-statistic: 1.762e+05 on 1 and 2005 DF,  p-value: < 2.2e-16
```

Summary of the model gini ~ s80/s20

```
model_gini_8020 |> summary()
```

```
##
## Call:
## lm(formula = gini ~ `s80/s20`, data = df_gini)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -66.009  -2.487   0.140   2.871  15.560
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 27.12397    0.17022  159.35   <2e-16 ***
## `s80/s20`    1.28242    0.01652   77.65   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.429 on 2004 degrees of freedom
##   (14752 observations deleted due to missingness)
## Multiple R-squared:  0.7505, Adjusted R-squared:  0.7504
## F-statistic:  6029 on 1 and 2004 DF,  p-value: < 2.2e-16
```

Summary of the model s80/s20 ~ top 20%

```
model_8020_top20 |> summary()
```

```
##
## Call:
## lm(formula = `s80/s20` ~ `80-100`, data = df_gini)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -8.242 -1.450 -0.068  0.975 56.544
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -23.327946   0.427285   -54.6   <2e-16 ***
## `80-100`      0.705481   0.009382    75.2   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.064 on 2004 degrees of freedom
##   (14752 observations deleted due to missingness)
## Multiple R-squared:  0.7383, Adjusted R-squared:  0.7382
## F-statistic:  5655 on 1 and 2004 DF,  p-value: < 2.2e-16
```

broom::tidy and broom::glance

```
tidy(model_gini_top20) |> rbind(tidy(model_gini_8020)) |> rbind(tidy(model_8020_top20))
```

```
## # A tibble: 6 x 5
##   term        estimate std.error statistic p.value
##   <chr>          <dbl>     <dbl>     <dbl>   <dbl>
## 1 (Intercept)  -16.5     0.131      -125.        0
## 2 `80-100`       1.21    0.00288     420.        0
## 3 (Intercept)   27.1     0.170       159.        0
## 4 `s80/s20`      1.28    0.0165       77.6       0
## 5 (Intercept)  -23.3     0.427       -54.6       0
## 6 `80-100`       0.705   0.00938      75.2       0
```

```
glance(model_gini_top20) |> rbind(glance(model_gini_8020)) |> rbind(glance(model_8020_top20))
```

```
## # A tibble: 3 x 12
##   r.squared adj.r.squared sigma statistic p.value    df logLik    AIC    BIC
##       <dbl>         <dbl> <dbl>     <dbl>   <dbl> <dbl>  <dbl>  <dbl>  <dbl>
## 1     0.989         0.989 0.942   176193.       0     1 -2726.  5458.  5475.
## 2     0.751         0.750 4.43      6029.       0     1 -5831. 11667. 11684.
## 3     0.738         0.738 3.06      5655.       0     1 -5092. 10189. 10206.
## # i 3 more variables: deviance <dbl>, df.residual <int>, nobs <int>
```

Conclusion

The GINI index and the income share held by highest 20% is strongly correlated. The relation is even stronger than the correlation between the GINI index and the `s80/s20` ratio.

Calculation Model of Gini Index

```
df_gini_calc <- df_gini |>
  mutate(`0` = 0, `20` = `0-20`,
         `40` = `0-20` + `20-40`,
         `60` = `0-20` + `20-40` + `40-60`,
         `80` = `0-20` + `20-40` + `40-60` + `60-80`,
         `100` = 100) |>
  select(-c(`0-20`:`60-80`))
df_gini_calc %>% drop_na()
```

```
## # A tibble: 2,003 x 13
##    country iso2c iso3c  year  gini `80-100` `s80/s20`   `0`  `20`  `40`  `60`
##    <chr>   <chr> <chr> <dbl> <dbl>    <dbl>     <dbl> <dbl> <dbl> <dbl> <dbl>
##  1 Albania AL    ALB    1996  27       36.1      3.92     0   9.2  22.9  40.6
##  2 Albania AL    ALB    2002  31.7     40.4      4.81     0   8.4  21    37.5
##  3 Albania AL    ALB    2005  30.6     39.2      4.67     0   8.4  21.3  38.3
##  4 Albania AL    ALB    2008  30       39        4.38     0   8.9  22    38.8
##  5 Albania AL    ALB    2012  29       37.8      4.25     0   8.9  22.1  39.4
##  6 Albania AL    ALB    2014  34.6     41.7      5.96     0   7    18.5  34.9
##  7 Albania AL    ALB    2015  32.8     40.6      5.27     0   7.7  19.8  36.3
##  8 Albania AL    ALB    2016  33.7     41.2      5.64     0   7.3  19.1  35.5
##  9 Albania AL    ALB    2017  33.1     40.7      5.36     0   7.6  19.6  36.1
## 10 Albania AL    ALB    2018  30.1     38.2      4.84     0   7.9  20.9  38.4
## # i 1,993 more rows
## # i 2 more variables: `80` <dbl>, `100` <dbl>
```

```
df_gini_calc_long <- df_gini_calc |>  pivot_longer(`0`:`100`, names_to = "classes", values_to = "cumula
df_gini_calc_long %>% drop_na()
```

```
## # A tibble: 12,018 x 9
##    country iso2c iso3c  year  gini `80-100` `s80/s20` classes cumulative_share
##    <chr>   <chr> <chr> <dbl> <dbl>    <dbl>     <dbl>   <dbl>            <dbl>
##  1 Albania AL    ALB    1996  27       36.1      3.92       0              0
##  2 Albania AL    ALB    1996  27       36.1      3.92      20              9.2
##  3 Albania AL    ALB    1996  27       36.1      3.92      40             22.9
##  4 Albania AL    ALB    1996  27       36.1      3.92      60             40.6
##  5 Albania AL    ALB    1996  27       36.1      3.92      80             63.9
##  6 Albania AL    ALB    1996  27       36.1      3.92     100            100
##  7 Albania AL    ALB    2002  31.7     40.4      4.81       0              0
##  8 Albania AL    ALB    2002  31.7     40.4      4.81      20              8.4
##  9 Albania AL    ALB    2002  31.7     40.4      4.81      40             21
## 10 Albania AL    ALB    2002  31.7     40.4      4.81      60             37.5
## # i 12,008 more rows
```

```
df_gini_f <- df_gini_calc_long |> group_by(country, year) |>
  drop_na(gini) |>
  reframe(gini, gini_spline = round(100-AUC(classes, cumulative_share, method = "spline")/50, digits = 
  distinct(country, year, gini, gini_spline, gini_trapezoid, `80-100`, `s80/s20`)
df_gini_f
```

```
## # A tibble: 2,009 x 7
##    country  year  gini gini_spline gini_trapezoid `80-100` `s80/s20`
##    <chr>   <dbl> <dbl>       <dbl>          <dbl>    <dbl>     <dbl>
##  1 Albania  1996  27          26.4           25.4     36.1      3.92
##  2 Albania  2002  31.7        30.6           29.4     40.4      4.81
##  3 Albania  2005  30.6        29.7           28.5     39.2      4.67
##  4 Albania  2008  30          28.9           27.7     39        4.38
##  5 Albania  2012  29          28.1           27       37.8      4.25
##  6 Albania  2014  34.6        33.9           32.6     41.7      5.96
##  7 Albania  2015  32.8        32             30.8     40.6      5.27
##  8 Albania  2016  33.7        33.1           31.8     41.2      5.64
##  9 Albania  2017  33.1        32.2           30.9     40.7      5.36
## 10 Albania  2018  30.1        29.6           28.4     38.2      4.84
## # i 1,999 more rows
```

```
df_gini_f |> drop_na(gini, gini_spline, gini_trapezoid, `80-100`, `s80/s20`) |> select(gini, gini_splin
```

```
##                     gini gini_spline gini_trapezoid    80-100   s80/s20
## gini           1.0000000   0.9993752      0.9992505 0.9943488 0.8663291
## gini_spline    0.9993752   1.0000000      0.9999799 0.9913027 0.8666667
## gini_trapezoid 0.9992505   0.9999799      1.0000000 0.9908249 0.8665828
## 80-100         0.9943488   0.9913027      0.9908249 1.0000000 0.8592673
## s80/s20        0.8663291   0.8666667      0.8665828 0.8592673 1.0000000
```

Observation:

- Since gini_spline and gini_trapezoid are calculated using the definition of the gini index, they are strongly correlated, though they are not exactly equal.