HW5_jaeyounglee

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November 2, 2020

Problem 1

Mission Complete

Problem 2

Mission Complete

Problem 3

Using tidy concepts, get and clean the following data on education from the World Bank.

http://databank.worldbank.org/data/download/Edstats_csv.zip

How many data points were there in the complete dataset? In your cleaned dataset?

Choosing 2 countries, create a summary table of indicators for comparison.

```
### Choose two countries by random sampling ###
set.seed(1000292)
country <-
  fread(input = "./Edstats/EdStatsCountry.csv", header = TRUE) %>%
  select('Country Code')
sample_country <- sample(country$`Country Code`, size = 2)
sample_country # South Korea and Greece
```

```
## [1] "KOR" "GRC"
```

```
### Load data ###
edstats <- fread(input = "./Edstats/EdStatsData.csv", header = TRUE)
dim(edstats) # Dimension of raw data
```

```
## [1] 886930     70
```

```
names(edstats) = c('country', 'code_country',
                   'indicator', 'code_indicator',
                   1970:2017, seq(2020, 2100, by = 5), 'V70') # Rename the columns
edstats <- edstats %>% select(-4, -(53:70)) # Remove future and indicator code

### Choose two countries ###
```

```r
edstats_kor <- edstats %>% filter(code_country == sample_country[1]) # South Korea
edstats_grc <- edstats %>% filter(code_country == sample_country[2]) # Greece

### Gather the data and remove missing values ###
gather_kor <- edstats_kor %>%
  gather(key = "year", value = "n", 4:51) %>%
  filter(!is.na(n))

gather_grc <- edstats_grc %>%
  gather(key = "year", value = "n", 4:51) %>%
  filter(!is.na(n))

#### Spread data and remove redundant variables ###
spread_kor <- gather_kor %>% spread(key = indicator, value = n)

spread_grc <- gather_grc %>% spread(key = indicator, value = n)

# Find columns that have more than 10 missing values
# Use South Korea data to make equivalent columns for both countries
nuisance_col <- NULL
for(i in 1:ncol(spread_kor)){
  column <- spread_kor %>% select(i)
  count_missing <- sum(is.na(column))
  if(count_missing > 10){
    nuisance_col <- c(nuisance_col, i)
  }
}

# Find columns which name contain gender
name_kor <- spread_kor %>% select(-nuisance_col) %>% names
index_kor <- which(str_detect(name_kor, 'ale'))

name_grc <- spread_grc %>% select(-nuisance_col) %>% names
index_grc <- which(str_detect(name_grc, 'ale'))

# Remove redundant variables
tidy_kor <- spread_kor %>% select(-nuisance_col) %>% select(-index_kor)
tidy_grc <- spread_grc %>% select(-nuisance_col) %>% select(-index_grc)


# Dimension of tidy datasets
dim(tidy_kor) # Dimension of data for Korea
```

```
## [1] 47 98
```

```r
dim(tidy_grc) # Dimension of data for Greece
```

```
## [1] 47 94
```

```r
# Select indicators that we are interested in for each dataset
interest_kor <- tidy_kor %>% select(3, 27, 29)
interest_grc <- tidy_grc %>% select(3, 30, 31)
```

```r
# Make year as numeric
interest_kor$year <-  as.numeric(interest_kor$year)
interest_grc$year <-  as.numeric(interest_grc$year)

# Summary table
knitr::kable(summary(interest_kor), caption = 'Summary of indicators, Korea')
```

Table 1: Summary of indicators, Korea

year	GDP per capita (constant 2005 US)|$GNI(currentUS)$	
Min. :1970	Min. : 1815	Min. :9.153e+09
1st Qu.:1982	1st Qu.: 4033	1st Qu.:7.418e+10
Median :1993	Median :10280	Median :3.691e+11
Mean :1993	Mean :11580	Mean :4.878e+11
3rd Qu.:2004	3rd Qu.:18237	3rd Qu.:8.272e+11
Max. :2016	Max. :25459	Max. :1.416e+12

```r
knitr::kable(summary(interest_grc), caption = 'Summary of indicators, Greece')
```

Table 2: Summary of indicators, Greece

year	GDP per capita (current US$)	GNI, PPP (current international $)
Min. :1970	Min. : 1494	Min. :1.385e+11
1st Qu.:1982	1st Qu.: 5200	1st Qu.:1.791e+11
Median :1993	Median :11091	Median :2.601e+11
Mean :1993	Mean :12371	Mean :2.400e+11
3rd Qu.:2004	3rd Qu.:18274	3rd Qu.:2.874e+11
Max. :2016	Max. :31997	Max. :3.316e+11
NA	NA	NA's :20

Two countries are sampled from the raw data. The tables are summary of tidy data sets with some interesting indicators. The dimension of data for Korea is $(47, 98)$ and that for Greece is $(47, 94)$.

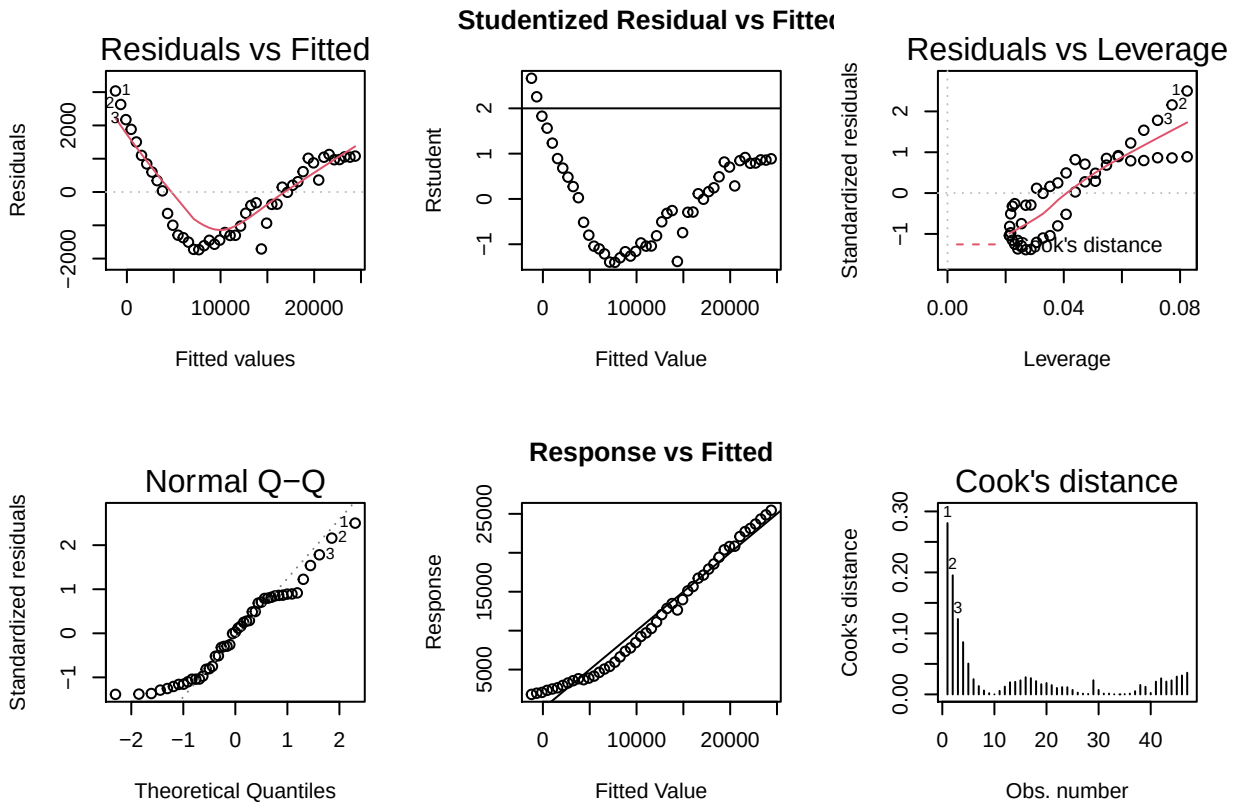
Problem 4

Using *base* plotting functions, create a single figure that is composed of the first two rows of plots from SAS's simple linear regression diagnostics as shown here: https://support.sas.com/rnd/app/ODSGraphics/examples/reg.html. Demonstrate the plot using suitable data from problem 3.

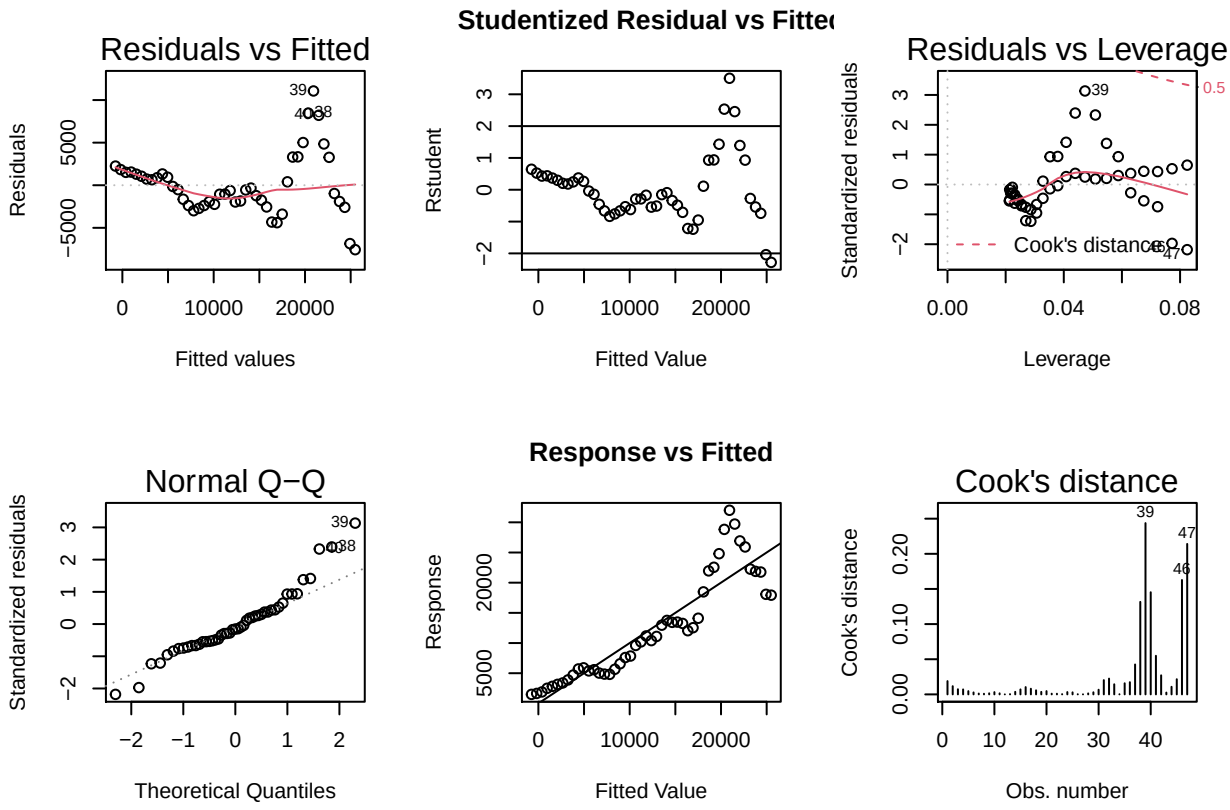
```
# Simple linear regression diagnostics using base R function
# Make names simpler
names(interest_kor) <- c('year', 'gdp', 'gni')
names(interest_grc) <- c('year', 'gdp', 'gni')

# Fit simple linear model
# Want to know the linear relationship between GDP and Year for each country
lm_kor <- lm(gdp ~ year, data = interest_kor)
lm_grc <- lm(gdp ~ year, data = interest_grc)

# Model diagnostic plots
# Korea
# Residaul plot and Q-Q plot
par(mfcol = c(2,3))
plot(lm_kor, 1:2)
# Studentized residual vs fitted, Response vs fitted
plot(lm_kor$fitted.values, MASS::studres(lm_kor),
     main = 'Studentized Residual vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Rstudent'); abline(h = 2); abline(h = -2)
plot(lm_kor$fitted.values, lm_kor$model$gdp,
     main = 'Response vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Response'); abline(a = 1, b = 1)
# Cook's distance, Residual vs Leverage
plot(lm_kor, 5)
plot(lm_kor, 4)
```



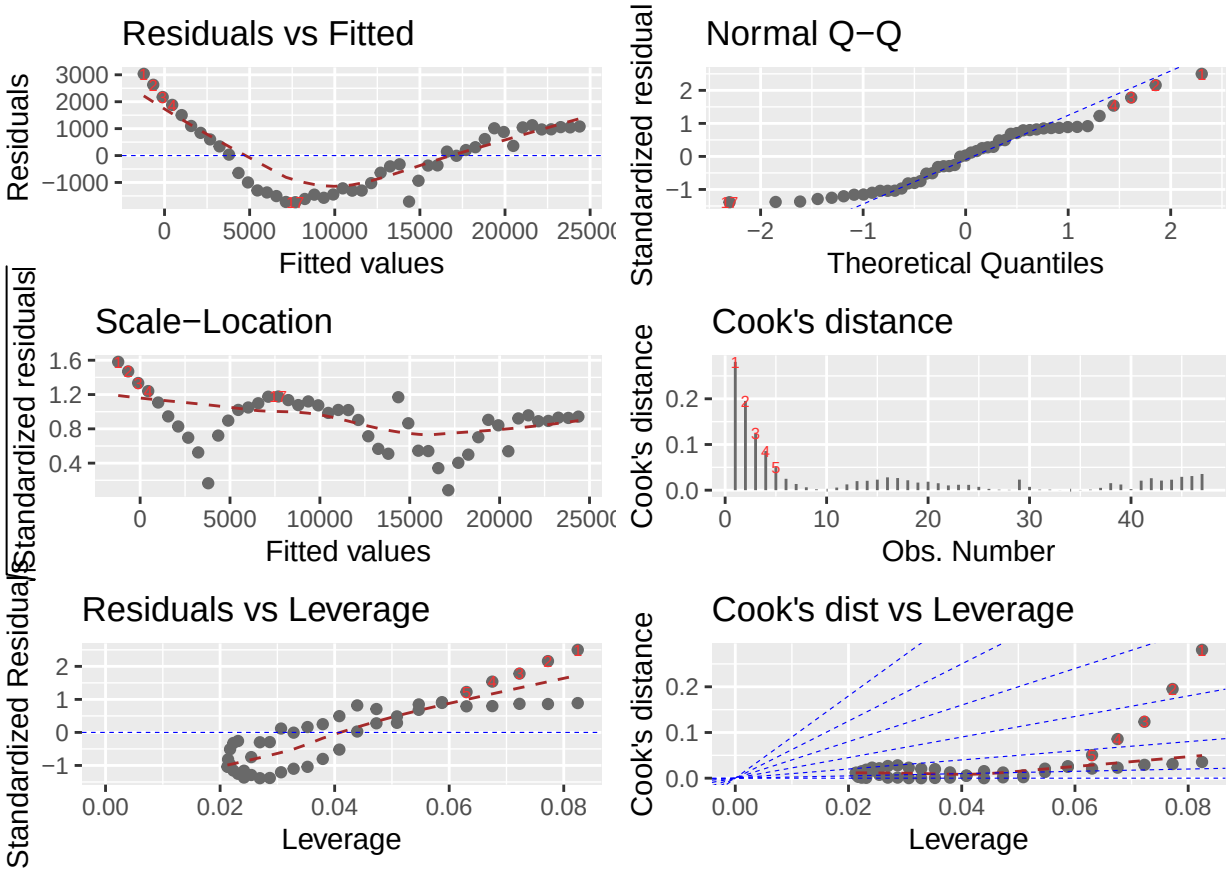

```
# Greece
# Residaul plot and Q-Q plot
par(mfcol = c(2,3))
plot(lm_grc, 1:2)
# Studentized residual vs fitted, Response vs fitted
plot(lm_grc$fitted.values, MASS::studres(lm_grc),
     main = 'Studentized Residual vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Rstudent'); abline(h = 2); abline(h = -2)
plot(lm_grc$fitted.values, lm_grc$model$gdp,
     main = 'Response vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Response'); abline(a = 1, b = 1)
# Cook's distance, Residual vs Leverage
plot(lm_grc, 5)
plot(lm_grc, 4)
```


Residuals vs Fitted
Residuals
Fitted values
Studentized Residual vs Fitte
Rstudent
Fitted Value
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Response vs Fitted
Response
Fitted Value
Cook's distance
Cook's distance
Obs. number

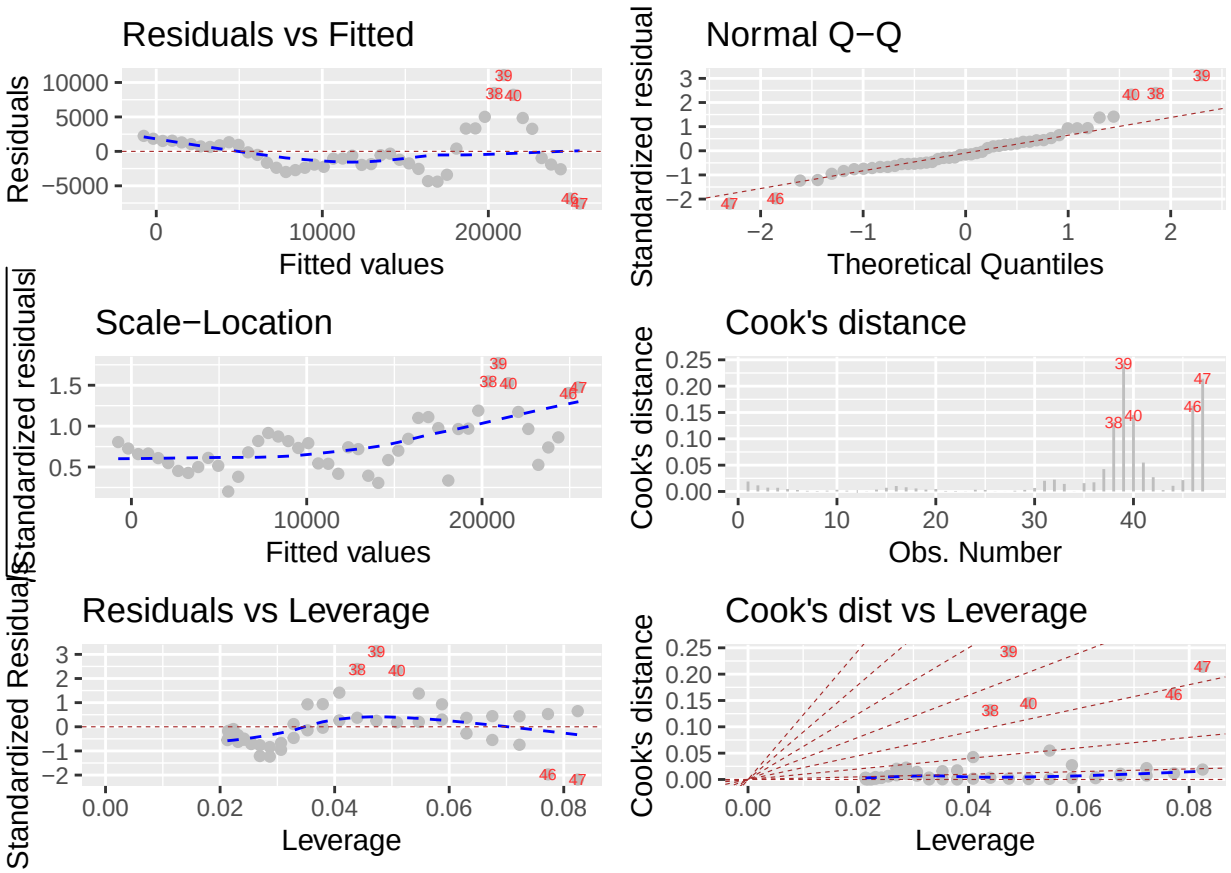
Problem 5

Recreate the plot in problem 3 using ggplot2 functions. Note: there are many extension libraries for ggplot, you will probably find an extension to the ggplot2 functionality will do exactly what you want.

```
# Simple linear regression diagnostics using ggplot2
# Using autoplot
# Reference : https://cran.r-project.org/web/packages/ggfortify/vignettes/plot_lm.html
autoplot(lm_kor, 1:6, colour = 'dimgrey',
         smooth.colour = 'brown', smooth.linetype = 'dashed',
         ad.colour = 'blue',
         label.size = 2, label.n = 5, label.colour = 'firebrick1',
         ncol = 2)
```




```
autoplot(lm_grc, 1:6, colour = 'grey',
         smooth.colour = 'blue', smooth.linetype = 'dashed',
         ad.colour = 'brown',
         label.size = 2, label.n = 5, label.colour = 'firebrick1',
         ncol = 2)
```




```
# Using ggplot
# Reference : https://rpubs.com/therimalaya/43190
# Korea

# Residual plot
plot_resid_kor <- ggplot(lm_kor, aes(.fitted, .resid)) +
  geom_point() +
  stat_smooth(method="loess") +
  geom_hline(yintercept=0, col="red", linetype="dashed") +
  xlab("Fitted values")+ylab("Residuals") +
  ggtitle("Residual vs Fitted Plot") +
  theme_bw()

# Normal Q-Q plot
qq_kor <- ggplot(lm_kor, aes(sample = lm_kor$residuals)) +
  stat_qq(size = 2) +
  stat_qq_line(color = 'red')+
  xlab("Theoretical Quantiles")+ylab("Standardized Residuals") +
  ggtitle("Normal Q-Q") +
  theme_bw()

# Standardized residual plot
plot_standard_resid_kor <- ggplot(lm_kor, aes(.fitted, sqrt(abs(.stdresid)))) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm = TRUE) +
  xlab("Fitted Value") +
```

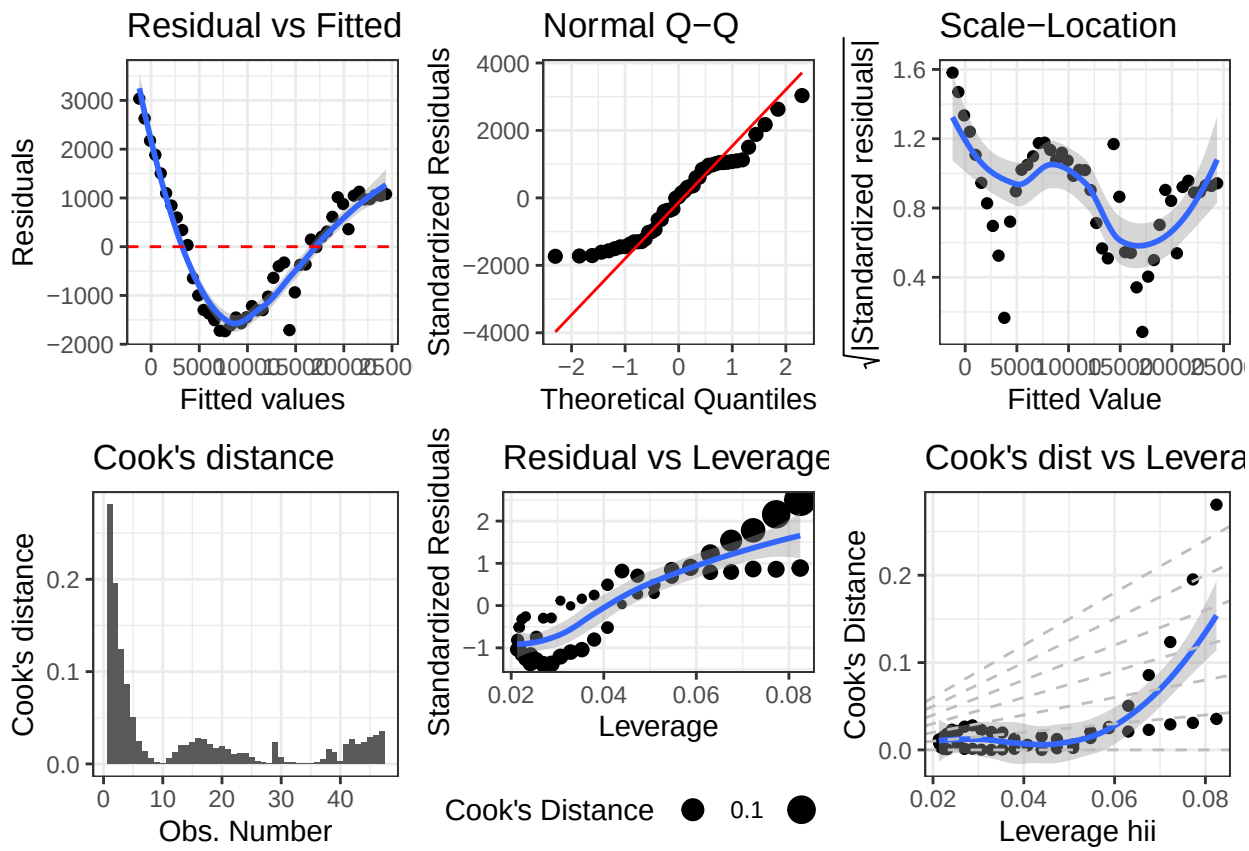
```
  ylab(expression(sqrt("|Standardized residuals|"))) +
  ggtitle("Scale-Location") +
  theme_bw()

# Cook's distance
cook_kor <- ggplot(lm_kor, aes(seq_along(.cooksd), .cooksd)) +
  geom_bar(stat="identity", position="identity") +
  xlab("Obs. Number") +
  ylab("Cook's distance") +
  ggtitle("Cook's distance")+theme_bw()

# Residual vs Leverage
leverage_kor <- ggplot(lm_kor, aes(.hat, .stdresid)) +
  geom_point(aes(size=.cooksd), na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage") +
  ylab("Standardized Residuals") +
  ggtitle("Residual vs Leverage Plot") +
  scale_size_continuous("Cook's Distance", range=c(1,5)) +
  theme_bw() +
  theme(legend.position="bottom")

# Cook's distance vs Leverage
lev_cook_kor <- ggplot(lm_kor, aes(.hat, .cooksd)) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage hii")+ylab("Cook's Distance") +
  ggtitle("Cook's dist vs Leverage hii/(1-hii)") +
  geom_abline(slope=seq(0,3,0.5), color="gray", linetype="dashed") +
  theme_bw()

# Diagnostic plot
ggarrange(plot_resid_kor, qq_kor,
          plot_standard_resid_kor, cook_kor,
          leverage_kor, lev_cook_kor, nrow = 2, ncol = 3)
```




```r
# Using ggplot
# Greece

# Residual plot
plot_resid_grc <- ggplot(lm_grc, aes(.fitted, .resid)) +
  geom_point() +
  stat_smooth(method="loess") +
  geom_hline(yintercept=0, col="red", linetype="dashed") +
  xlab("Fitted values")+ylab("Residuals") +
  ggtitle("Residual vs Fitted Plot") +
  theme_bw()

# Normal Q-Q plot
qq_grc <- ggplot(lm_grc, aes(sample = lm_grc$residuals)) +
  stat_qq(size = 2) +
  stat_qq_line(color = 'red')+
  xlab("Theoretical Quantiles")+ylab("Standardized Residuals") +
  ggtitle("Normal Q-Q") +
  theme_bw()

# Standardized residual plot
plot_standard_resid_grc <- ggplot(lm_grc, aes(.fitted, sqrt(abs(.stdresid)))) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm = TRUE) +
  xlab("Fitted Value") +
  ylab(expression(sqrt("|Standardized residuals|"))) +
```

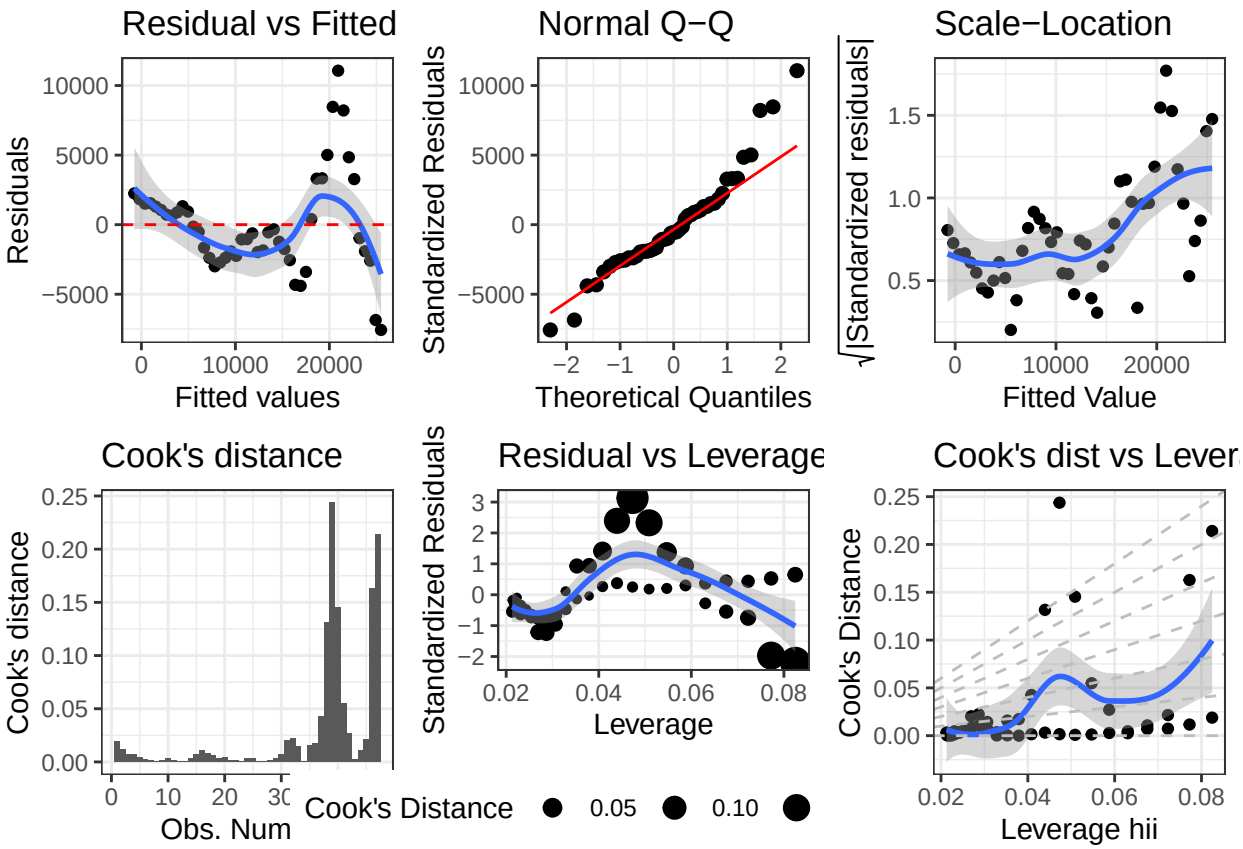
```
  ggtitle("Scale-Location") +
  theme_bw()

# Cook's distance
cook_grc <- ggplot(lm_grc, aes(seq_along(.cooksd), .cooksd)) +
  geom_bar(stat="identity", position="identity") +
  xlab("Obs. Number") +
  ylab("Cook's distance") +
  ggtitle("Cook's distance")+theme_bw()

# Residual vs Leverage plot
leverage_grc <- ggplot(lm_grc, aes(.hat, .stdresid)) +
  geom_point(aes(size=.cooksd), na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage") +
  ylab("Standardized Residuals") +
  ggtitle("Residual vs Leverage Plot") +
  scale_size_continuous("Cook's Distance", range=c(1,5)) +
  theme_bw() +
  theme(legend.position="bottom")

# Cook's distance vs Leverage plot
lev_cook_grc <- ggplot(lm_grc, aes(.hat, .cooksd)) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage hii")+ylab("Cook's Distance") +
  ggtitle("Cook's dist vs Leverage hii/(1-hii)") +
  geom_abline(slope=seq(0,3,0.5), color="gray", linetype="dashed") +
  theme_bw()

# Diagnostic plot
ggarrange(plot_resid_grc, qq_grc,
          plot_standard_resid_grc, cook_grc,
          leverage_grc, lev_cook_grc, nrow = 2, ncol = 3)
```



Problem 6

Mission Complete

Appendix

```r
knitr::opts_chunk$set(echo = TRUE, message = FALSE, warning = FALSE)
library(data.table)
library(tidyverse)
library(ggplot2)
library(ggfortify)
library(ggpubr)
### Choose two countries by random sampling ###
set.seed(1000292)
country <-
  fread(input = "./Edstats/EdStatsCountry.csv", header = TRUE) %>%
  select('Country Code')
sample_country <- sample(country$`Country Code`, size = 2)
sample_country # South Korea and Greece

### Load data ###
edstats <- fread(input = "./Edstats/EdStatsData.csv", header = TRUE)
dim(edstats) # Dimension of raw data
names(edstats) = c('country', 'code_country',
                   'indicator', 'code_indicator',
                   1970:2017, seq(2020, 2100, by = 5), 'V70') # Rename the columns
edstats <- edstats %>% select(-4, -(53:70)) # Remove future and indicator code

### Choose two countries ###
edstats_kor <- edstats %>% filter(code_country == sample_country[1]) # South Korea
edstats_grc <- edstats %>% filter(code_country == sample_country[2]) # Greece

### Gather the data and remove missing values ###
gather_kor <- edstats_kor %>%
  gather(key = "year", value = "n", 4:51) %>%
  filter(!is.na(n))

gather_grc <- edstats_grc %>%
  gather(key = "year", value = "n", 4:51) %>%
  filter(!is.na(n))

#### Spread data and remove redundant variables ###
spread_kor <- gather_kor %>% spread(key = indicator, value = n)

spread_grc <- gather_grc %>% spread(key = indicator, value = n)

# Find columns that have more than 10 missing values
# Use South Korea data to make equivalent columns for both countries
nuisance_col <- NULL
for(i in 1:ncol(spread_kor)){
  column <- spread_kor %>% select(i)
  count_missing <- sum(is.na(column))
  if(count_missing > 10){
    nuisance_col <- c(nuisance_col, i)
  }
}
```

```r
# Find columns which name contain gender
name_kor <- spread_kor %>% select(-nuisance_col) %>% names
index_kor <- which(str_detect(name_kor, 'ale'))

name_grc <- spread_grc %>% select(-nuisance_col) %>% names
index_grc <- which(str_detect(name_grc, 'ale'))

# Remove redundant variables
tidy_kor <- spread_kor %>% select(-nuisance_col) %>% select(-index_kor)
tidy_grc <- spread_grc %>% select(-nuisance_col) %>% select(-index_grc)


# Dimension of tidy datasets
dim(tidy_kor) # Dimension of data for Korea
dim(tidy_grc) # Dimension of data for Greece

# Select indicators that we are interested in for each dataset
interest_kor <- tidy_kor %>% select(3, 27, 29)
interest_grc <- tidy_grc %>% select(3, 30, 31)

# Make year as numeric
interest_kor$year <-  as.numeric(interest_kor$year)
interest_grc$year <-  as.numeric(interest_grc$year)

# Summary table
knitr::kable(summary(interest_kor), caption = 'Summary of indicators, Korea')
knitr::kable(summary(interest_grc), caption = 'Summary of indicators, Greece')

# Simple linear regression diagnostics using base R function
# Make names simpler
names(interest_kor) <- c('year', 'gdp', 'gni')
names(interest_grc) <- c('year', 'gdp', 'gni')

# Fit simple linear model
# Want to know the linear relationship between GDP and Year for each country
lm_kor <- lm(gdp ~ year, data = interest_kor)
lm_grc <- lm(gdp ~ year, data = interest_grc)

# Model diagnostic plots
# Korea
# Residaul plot and Q-Q plot
par(mfcol = c(2,3))
plot(lm_kor, 1:2)
# Studentized residual vs fitted, Response vs fitted
plot(lm_kor$fitted.values, MASS::studres(lm_kor),
     main = 'Studentized Residual vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Rstudent'); abline(h = 2); abline(h = -2)
plot(lm_kor$fitted.values, lm_kor$model$gdp,
     main = 'Response vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Response'); abline(a = 1, b = 1)
# Cook's distance, Residual vs Leverage
```

```r
plot(lm_kor, 5)
plot(lm_kor, 4)

# Greece
# Residaul plot and Q-Q plot
par(mfcol = c(2,3))
plot(lm_grc, 1:2)
# Studentized residual vs fitted, Response vs fitted
plot(lm_grc$fitted.values, MASS::studres(lm_grc),
     main = 'Studentized Residual vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Rstudent'); abline(h = 2); abline(h = -2)
plot(lm_grc$fitted.values, lm_grc$model$gdp,
     main = 'Response vs Fitted',
     xlab = 'Fitted Value',
     ylab = 'Response'); abline(a = 1, b = 1)
# Cook's distance, Residual vs Leverage
plot(lm_grc, 5)
plot(lm_grc, 4)

# Simple linear regression diagnostics using ggplot2
# Using autoplot
# Reference : https://cran.r-project.org/web/packages/ggfortify/vignettes/plot_lm.html
autoplot(lm_kor, 1:6, colour = 'dimgrey',
         smooth.colour = 'brown', smooth.linetype = 'dashed',
         ad.colour = 'blue',
         label.size = 2, label.n = 5, label.colour = 'firebrick1',
         ncol = 2)
autoplot(lm_grc, 1:6, colour = 'grey',
         smooth.colour = 'blue', smooth.linetype = 'dashed',
         ad.colour = 'brown',
         label.size = 2, label.n = 5, label.colour = 'firebrick1',
         ncol = 2)


# Using ggplot
# Reference : https://rpubs.com/therimalaya/43190
# Korea

# Residual plot
plot_resid_kor <- ggplot(lm_kor, aes(.fitted, .resid)) +
  geom_point() +
  stat_smooth(method="loess") +
  geom_hline(yintercept=0, col="red", linetype="dashed") +
  xlab("Fitted values")+ylab("Residuals") +
  ggtitle("Residual vs Fitted Plot") +
  theme_bw()

# Normal Q-Q plot
qq_kor <- ggplot(lm_kor, aes(sample = lm_kor$residuals)) +
  stat_qq(size = 2) +
  stat_qq_line(color = 'red')+
  xlab("Theoretical Quantiles")+ylab("Standardized Residuals") +
```

```
  ggtitle("Normal Q-Q") +
  theme_bw()

# Standardized residual plot
plot_standard_resid_kor <- ggplot(lm_kor, aes(.fitted, sqrt(abs(.stdresid)))) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm = TRUE) +
  xlab("Fitted Value") +
  ylab(expression(sqrt("|Standardized residuals|"))) +
  ggtitle("Scale-Location") +
  theme_bw()

# Cook's distance
cook_kor <- ggplot(lm_kor, aes(seq_along(.cooksd), .cooksd)) +
  geom_bar(stat="identity", position="identity") +
  xlab("Obs. Number") +
  ylab("Cook's distance") +
  ggtitle("Cook's distance")+theme_bw()

# Residual vs Leverage
leverage_kor <- ggplot(lm_kor, aes(.hat, .stdresid)) +
  geom_point(aes(size=.cooksd), na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage") +
  ylab("Standardized Residuals") +
  ggtitle("Residual vs Leverage Plot") +
  scale_size_continuous("Cook's Distance", range=c(1,5)) +
  theme_bw() +
  theme(legend.position="bottom")

# Cook's distance vs Leverage
lev_cook_kor <- ggplot(lm_kor, aes(.hat, .cooksd)) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage hii")+ylab("Cook's Distance") +
  ggtitle("Cook's dist vs Leverage hii/(1-hii)") +
  geom_abline(slope=seq(0,3,0.5), color="gray", linetype="dashed") +
  theme_bw()

# Diagnostic plot
ggarrange(plot_resid_kor, qq_kor,
          plot_standard_resid_kor, cook_kor,
          leverage_kor, lev_cook_kor, nrow = 2, ncol = 3)

# Using ggplot
# Greece

# Residual plot
plot_resid_grc <- ggplot(lm_grc, aes(.fitted, .resid)) +
  geom_point() +
  stat_smooth(method="loess") +
  geom_hline(yintercept=0, col="red", linetype="dashed") +
  xlab("Fitted values")+ylab("Residuals") +
```

```
  ggtitle("Residual vs Fitted Plot") +
  theme_bw()

# Normal Q-Q plot
qq_grc <- ggplot(lm_grc, aes(sample = lm_grc$residuals)) +
  stat_qq(size = 2) +
  stat_qq_line(color = 'red')+
  xlab("Theoretical Quantiles")+ylab("Standardized Residuals") +
  ggtitle("Normal Q-Q") +
  theme_bw()

# Standardized residual plot
plot_standard_resid_grc <- ggplot(lm_grc, aes(.fitted, sqrt(abs(.stdresid)))) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm = TRUE) +
  xlab("Fitted Value") +
  ylab(expression(sqrt("|Standardized residuals|"))) +
  ggtitle("Scale-Location") +
  theme_bw()

# Cook's distance
cook_grc <- ggplot(lm_grc, aes(seq_along(.cooksd), .cooksd)) +
  geom_bar(stat="identity", position="identity") +
  xlab("Obs. Number") +
  ylab("Cook's distance") +
  ggtitle("Cook's distance")+theme_bw()

# Residual vs Leverage plot
leverage_grc <- ggplot(lm_grc, aes(.hat, .stdresid)) +
  geom_point(aes(size=.cooksd), na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage") +
  ylab("Standardized Residuals") +
  ggtitle("Residual vs Leverage Plot") +
  scale_size_continuous("Cook's Distance", range=c(1,5)) +
  theme_bw() +
  theme(legend.position="bottom")

# Cook's distance vs Leverage plot
lev_cook_grc <- ggplot(lm_grc, aes(.hat, .cooksd)) +
  geom_point(na.rm=TRUE) +
  stat_smooth(method="loess", na.rm=TRUE) +
  xlab("Leverage hii")+ylab("Cook's Distance") +
  ggtitle("Cook's dist vs Leverage hii/(1-hii)") +
  geom_abline(slope=seq(0,3,0.5), color="gray", linetype="dashed") +
  theme_bw()

# Diagnostic plot
ggarrange(plot_resid_grc, qq_grc,
          plot_standard_resid_grc, cook_grc,
          leverage_grc, lev_cook_grc, nrow = 2, ncol = 3)
```