STAT 346 Final Project

Can Money Buy Happiness?: Understanding the Differential Between a Country's GDP Rank and Happiness Rank

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Adding and Cleaning Data

```
# Explanatory Variables
census_data <- read_csv("~/Desktop/export.csv", show_col_types = FALSE)
who_data <- read_csv("~/Desktop/Annex 2-4-Table 1.csv", show_col_types = FALSE)
gdp_data <- read_csv("~/Desktop/GDP_data.csv", show_col_types = FALSE)
wh_data <- read_csv("~/Desktop/WHD.csv", show_col_types = FALSE)
who_data <- who_data[-(1:4),]
colnames(census_data)[4] ="country"
colnames(who_data)[1] ="country"
colnames(who_data)[2] ="Clean_energy_access_prop"
colnames(who_data)[3] ="Harmful_air_mean_conc"
colnames(who_data)[4] ="Mortality_homicide_rate"
colnames(who_data)[5] ="Adult_obesity_rate"
colnames(who_data)[6] ="Tobacco_use_rate"
colnames(who_data)[7] ="Expenditure_health_perc"
colnames(who_data)[8] ="Mortality_suicide_rate"
colnames(who_data)[9] ="Alcohol_consuption_liters"
df_merge <- merge(census_data,who_data, by = "country")
df_merge <- df_merge[-c(2:5) ]

# Categorical Variable
hc_data <- read_csv("~/Desktop/UNHC.csv", show_col_types = FALSE)
univ <- hc_data$country
univ_var <- c()
for (i in 1:nrow(df_merge)) {
  ifelse(df_merge[i,1] %in% univ, univ_var[i] <- 1, univ_var[i] <- 0)
}
df_merge["Univ_hc"] <- univ_var
df_merge$Univ_hc <- as.factor(df_merge$Univ_hc)

# Covid Deaths
covid_deaths <- read_csv("~/Desktop/covidData.csv", show_col_types = FALSE)
# -- Cumulative Deaths from 01/03/2020-12/31/2022
newest_covid <- covid_deaths[covid_deaths$Date_reported == "2022-12-31", ]
cv_dummy_df <- data.frame(newest_covid$Country, newest_covid$Cumulative_deaths)
colnames(cv_dummy_df)[1] <- "country"
colnames(cv_dummy_df)[2] <- "tot_deaths"
df_merge <- merge(df_merge, cv_dummy_df, by = "country")

# Corruption
```

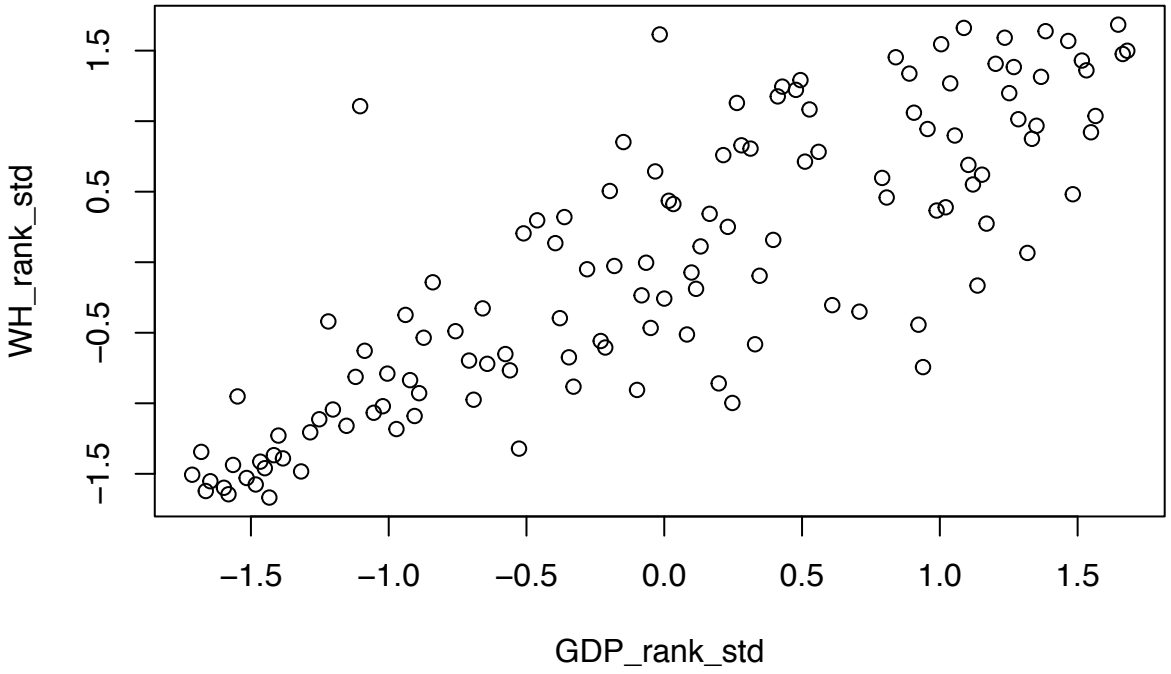
```r
cpi_data <- read_csv("~/Desktop/CPI.csv", show_col_types = FALSE)
# -- Lower Scores == More Corruption
cpi_data <- cpi_data[-(1:2),]
cpi_dummy_df <- data.frame(cpi_data$`Corruption Perceptions Index 2022: Global scores`, cpi_data$...4)
colnames(cpi_dummy_df)[1] <- "country"
colnames(cpi_dummy_df)[2] <- "cpi_score"
df_merge <- merge(df_merge, cpi_dummy_df, by = "country")
df_merge$cpi_score <- as.numeric(df_merge$cpi_score)

# Response Variable
gdp_dummy_df <- data.frame(gdp_data$country, gdp_data$rank)
colnames(gdp_dummy_df)[1] <- "country"
colnames(gdp_dummy_df)[2] <- "GDP_rank"

df_merge <- merge(df_merge, gdp_dummy_df, by = "country")

wh_dummy_df <- data.frame(wh_data$country, wh_data$rank)
colnames(wh_dummy_df)[1] <- "country"
colnames(wh_dummy_df)[2] <- "WH_rank"

df_merge <- merge(df_merge, wh_dummy_df, by = "country")

df_merge$GDP_rank_std <- ((df_merge$GDP_rank) - mean(df_merge$GDP_rank))/sd(df_merge$GDP_rank)
df_merge$WH_rank_std <- ((df_merge$WH_rank) - mean(df_merge$WH_rank))/sd(df_merge$WH_rank)

df_merge["DIF_rank"] <- (df_merge$GDP_rank_std - df_merge$WH_rank_std)

# Cleaning Data
# Make missing data NA
for (i in 1:length(df_merge)) { # columns
  for (j in 1:nrow(df_merge)) { # rows
    ifelse(df_merge[j,i] == "-", df_merge[j,i] <- NA, NA)
  }
}

# Round <1 to 0
for (i in 1:length(df_merge)) { # columns
  for (j in 1:nrow(df_merge)) { # rows
    ifelse(df_merge[j,i] == "<1" || df_merge[j,i] == "<0.1", df_merge[j,i] <- 0, NA)
  }
}

# Convert Characters to Numeric
for (i in (8:15)) {
  df_merge[,i] <- as.numeric(df_merge[,i])
}

# Rename columns with spaces
colnames(df_merge)[2:7] <- c("Population", "rate_nat_increase", "tot_fert_rate", "life_exp_males", "lif
attach(df_merge)
```

```
#write.csv(df_merge, "/Users/Greta/Desktop/master_df.csv", row.names=TRUE)
```

Goal: Understanding the Phenomenon in General

Exploratory Data Analysis

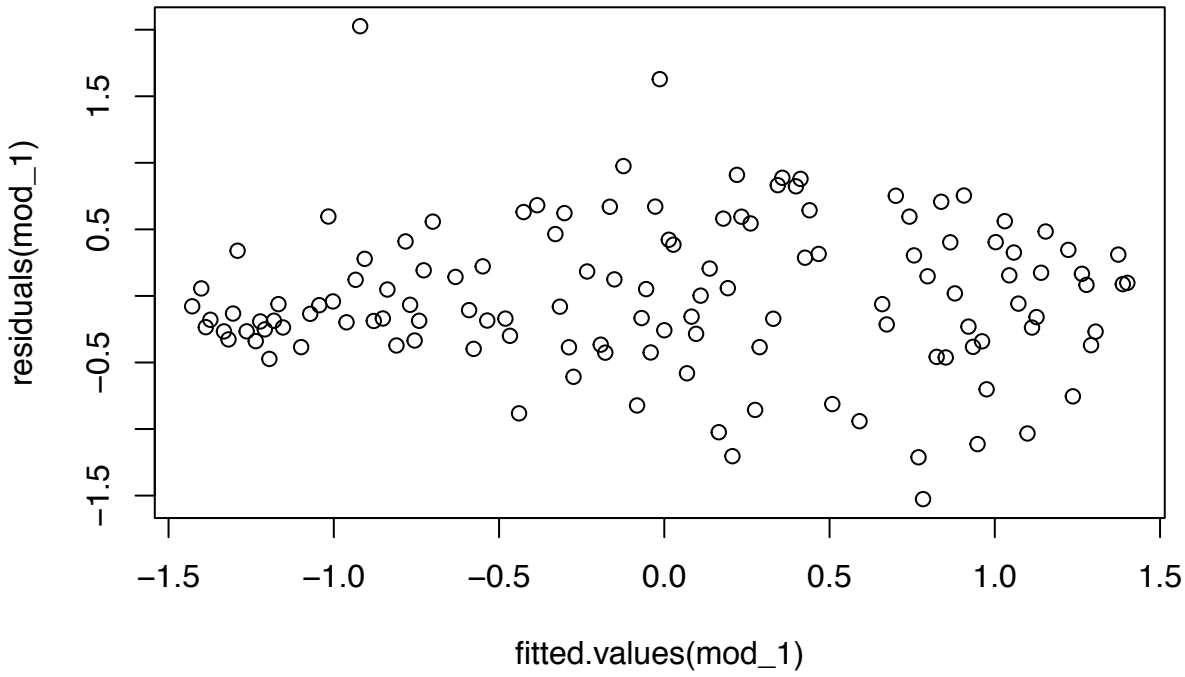
```
# Response Variables
plot(WH_rank_std ~ GDP_rank_std)
```




```
mod_1 <- lm(WH_rank_std~GDP_rank_std)
summary(mod_1)
```

```
##
## Call:
## lm(formula = WH_rank_std ~ GDP_rank_std)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.52639 -0.31305 -0.06676  0.34281  2.02637
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -1.576e-16  4.918e-02    0.00        1
## GDP_rank_std  8.338e-01  4.938e-02   16.89   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5543 on 125 degrees of freedom
## Multiple R-squared:  0.6952, Adjusted R-squared:  0.6928
## F-statistic: 285.2 on 1 and 125 DF,  p-value: < 2.2e-16
```

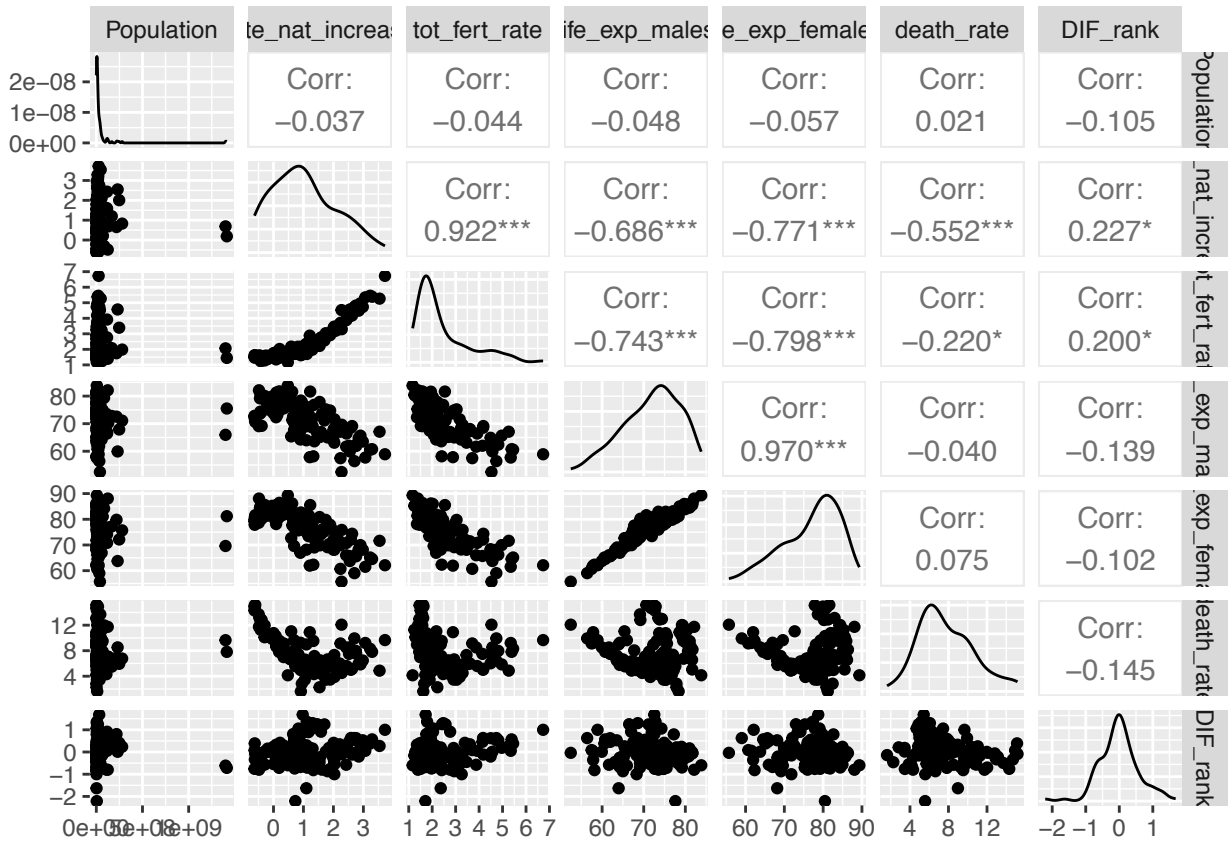
```
res1 <- plot(residuals(mod_1) ~ fitted.values(mod_1))
```



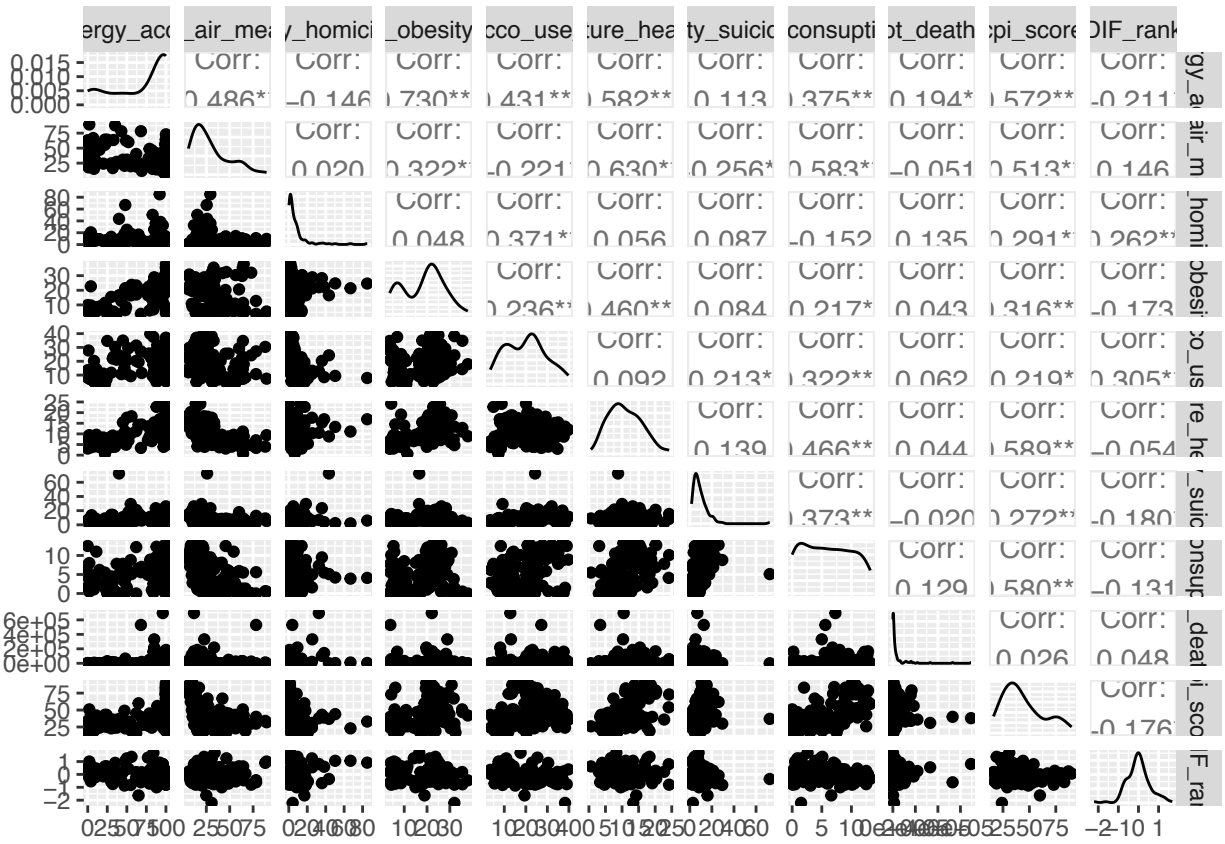

```
res1
```

```
## NULL
```

```
# Explanation: We can see that GDP explains some, but not all of variation in the happiness rating
# of a country, so what else is there to explain why some countries are happier than others,
# compared to

# Census Data Pairs
ggpairs(df_merge[,c(2,3,4,5,6,7,23)])
```

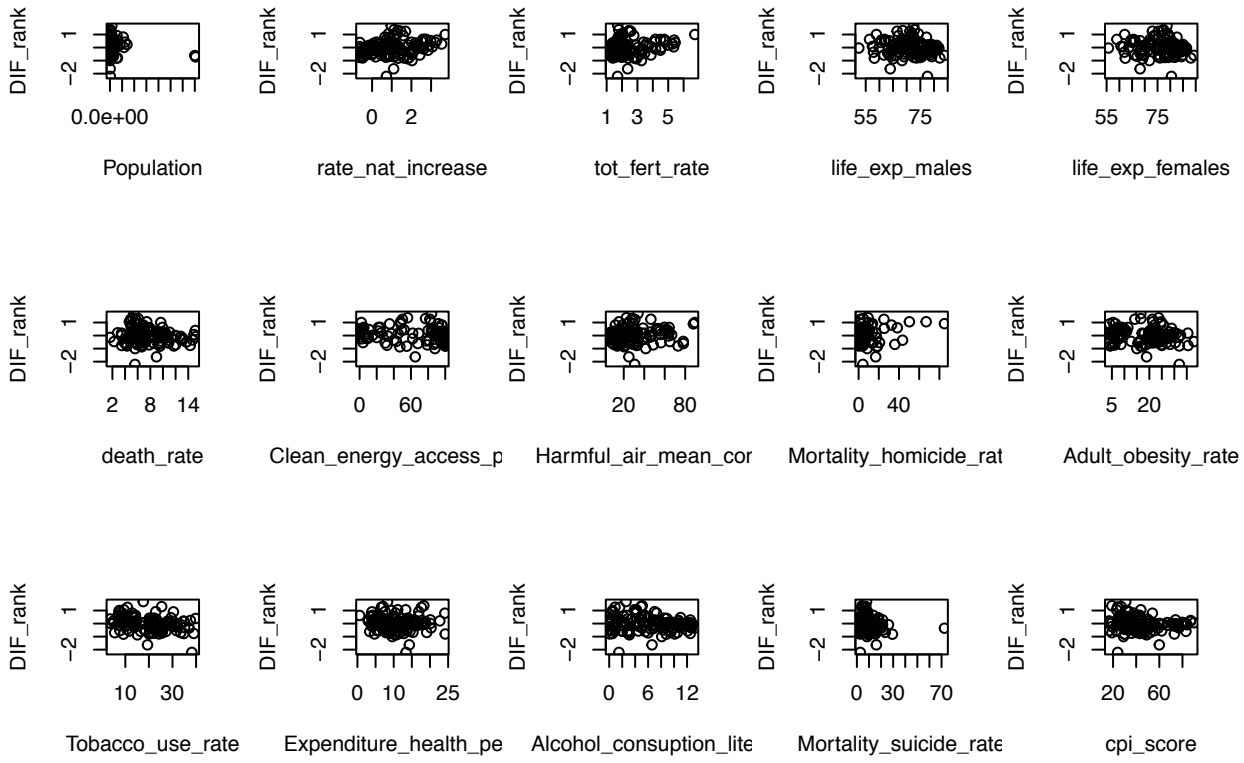



```
# WHO Data Pairs
ggpairs(df_merge[,c(8,9,10,11,12,13,14,15,17,18,23)])
```



Transformations

```
par(mfrow=c(3,5))
plot(DIF_rank~Population)
plot(DIF_rank~rate_nat_increase)
plot(DIF_rank~tot_fert_rate)
plot(DIF_rank~life_exp_males)
plot(DIF_rank~life_exp_females)
plot(DIF_rank~death_rate)
plot(DIF_rank~Clean_energy_access_prop)
plot(DIF_rank~Harmful_air_mean_conc)
plot(DIF_rank~Mortality_homicide_rate)
plot(DIF_rank~Adult_obesity_rate)
plot(DIF_rank~Tobacco_use_rate)
plot(DIF_rank~Expenditure_health_perc)
plot(DIF_rank~Alcohol_consuption_liters)
plot(DIF_rank~Mortality_suicide_rate)
plot(DIF_rank~cpi_score)
```




```
# Transform Non-Linear Relationships as Necessary
df_merge$PopulationT <- log(df_merge$Population)
df_merge$tot_fert_rateT <- log(df_merge$tot_fert_rate)
df_merge$Harmful_air_mean_concT <- log(df_merge$Harmful_air_mean_conc)
df_merge$Mortality_homicide_rateT <- log(df_merge$Mortality_homicide_rate)
df_merge$Mortality_suicide_rateT <- log(df_merge$Mortality_suicide_rate)
df_merge$cpi_scoreT <- log(df_merge$cpi_score)
```

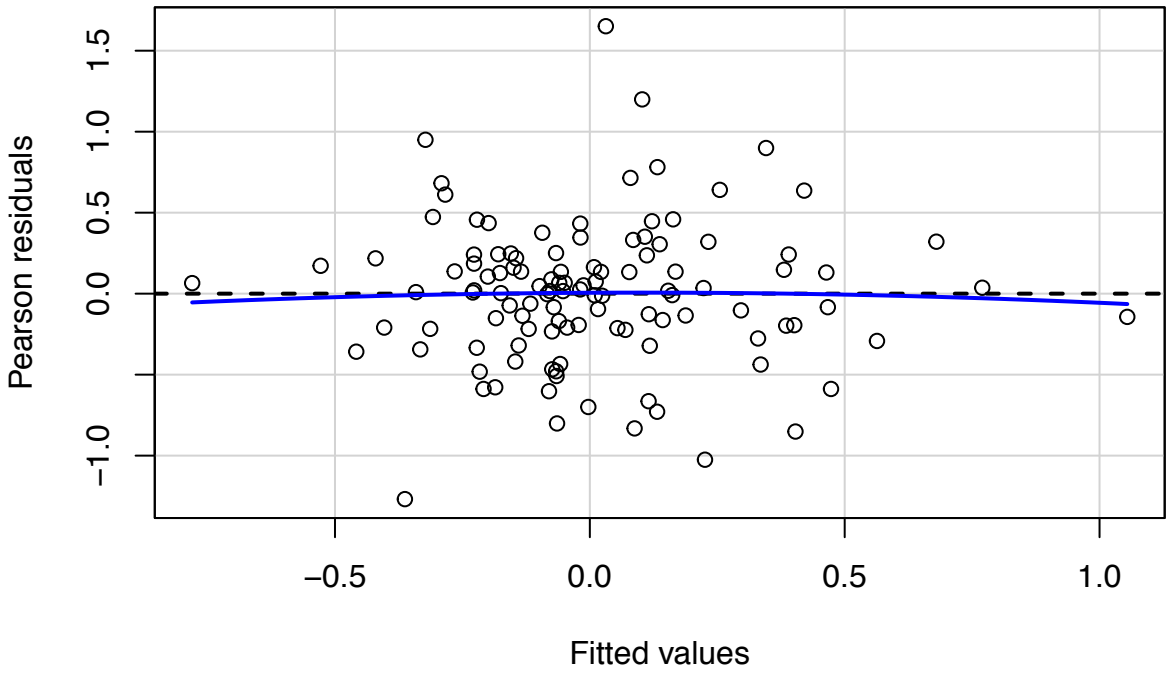
Preliminary Data Analysis: Model Selection Using Automatic Selection Procedure

```
df_merge_noNA <- na.omit(df_merge)
# Original Model Before Transformations
myformula <- formula(paste(colnames(df_merge)[23], paste(colnames(df_merge_noNA)[2:18], collapse = "+")
mod_noT <- lm(myformula, data = df_merge)
summary(mod_noT)
```

```
##
## Call:
## lm(formula = myformula, data = df_merge)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.26838 -0.21745  0.01623  0.22782  1.65104
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)               -2.910e+00  2.412e+00  -1.206   0.2306
## Population                -6.908e-10  3.147e-10  -2.195   0.0306 *
## rate_nat_increase          3.397e-02  6.412e-01   0.053   0.9579
## tot_fert_rate              7.263e-02  3.962e-01   0.183   0.8549
```

```
## life_exp_males            -2.915e-02  3.716e-02  -0.784   0.4347
## life_exp_females           6.340e-02  3.835e-02   1.653   0.1015
## death_rate                 1.136e-02  9.748e-02   0.117   0.9075
## Clean_energy_access_prop  -1.476e-03  3.270e-03  -0.452   0.6526
## Harmful_air_mean_conc      6.946e-03  3.506e-03   1.981   0.0504 .
## Mortality_homicide_rate    1.105e-02  5.160e-03   2.142   0.0347 *
## Adult_obesity_rate        -1.230e-02  8.978e-03  -1.370   0.1740
## Tobacco_use_rate          -3.274e-03  7.482e-03  -0.438   0.6626
## Expenditure_health_perc    1.106e-02  1.509e-02   0.733   0.4654
## Mortality_suicide_rate    -8.532e-03  7.287e-03  -1.171   0.2446
## Alcohol_consuption_liters  7.190e-04  1.883e-02   0.038   0.9696
## Univ_hc1                  -1.609e-01  1.250e-01  -1.287   0.2011
## tot_deaths                 1.160e-06  6.207e-07   1.869   0.0647 .
## cpi_score                 -9.258e-04  4.724e-03  -0.196   0.8450
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4749 on 97 degrees of freedom
##   (12 observations deleted due to missingness)
## Multiple R-squared:  0.276,  Adjusted R-squared:  0.1491
## F-statistic: 2.175 on 17 and 97 DF,  p-value: 0.009317
```

```
residualPlot(mod_noT)
```

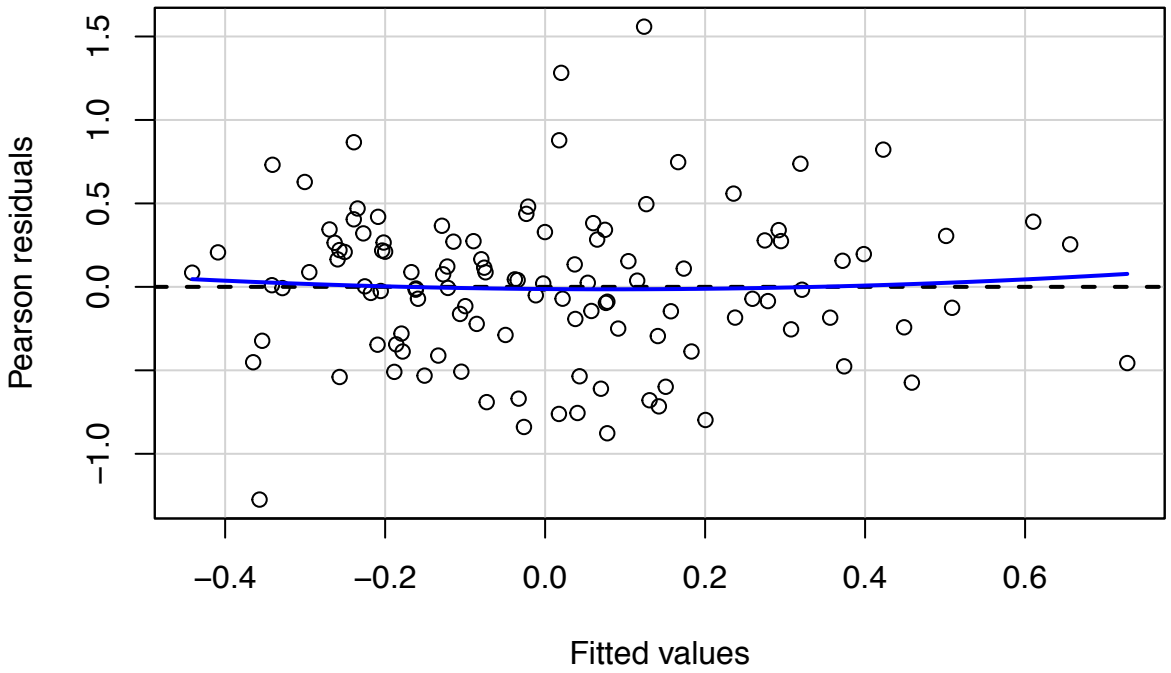



```
# Model with Transformed Non-Linear Variables
mod_T <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_males + life_exp_femal
summary(mod_T)
```

```
##
## Call:
## lm(formula = DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
```

```
##     Alcohol_consuption_liters + Univ_hc + tot_deaths + cpi_score,
##     data = df_merge)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.27421 -0.28397  0.00993  0.27232  1.55870
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -5.262e+00  2.010e+00  -2.618   0.0103 *
## PopulationT                 3.006e-02  4.184e-02   0.718   0.4742
## rate_nat_increase           6.349e-01  3.747e-01   1.695   0.0934 .
## tot_fert_rateT             -9.557e-01  7.416e-01  -1.289   0.2006
## life_exp_males             -2.156e-02  4.191e-02  -0.514   0.6081
## life_exp_females            7.412e-02  3.664e-02   2.023   0.0458 *
## death_rate                  8.809e-02  5.113e-02   1.723   0.0881 .
## Clean_energy_access_prop   -2.275e-03  3.447e-03  -0.660   0.5108
## Harmful_air_mean_concT      9.643e-02  1.147e-01   0.841   0.4024
## Mortality_homicide_rateT    1.155e-01  7.218e-02   1.600   0.1128
## Adult_obesity_rate         -3.156e-03  9.702e-03  -0.325   0.7457
## Tobacco_use_rate           -4.480e-03  7.696e-03  -0.582   0.5619
## Expenditure_health_perc     8.109e-03  1.603e-02   0.506   0.6140
## Mortality_suicide_rateT    -5.618e-02  1.005e-01  -0.559   0.5775
## Alcohol_consuption_liters -5.261e-03  1.935e-02  -0.272   0.7862
## Univ_hc1                   -1.736e-01  1.341e-01  -1.295   0.1983
## tot_deaths                  3.856e-07  6.802e-07   0.567   0.5721
## cpi_score                   5.148e-04  5.218e-03   0.099   0.9216
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.491 on 97 degrees of freedom
##   (12 observations deleted due to missingness)
## Multiple R-squared:  0.2259, Adjusted R-squared:  0.0902
## F-statistic: 1.665 on 17 and 97 DF,  p-value: 0.06288
```

```
residualPlot(mod_T)
```




```
# Model Selection
mod_noNA <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_males + life_exp_fe
# Summary matches model with missing data
bw_aic2 = step(mod_noNA, direction = "backward")
```

```
## Start:  AIC=-147.18
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Alcohol_consuption_liters + Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - cpi_scoreT                  1   0.00469 23.389 -149.16
## - Alcohol_consuption_liters   1   0.01852 23.403 -149.09
## - Adult_obesity_rate          1   0.02523 23.410 -149.06
## - Expenditure_health_perc     1   0.05960 23.444 -148.89
## - life_exp_males              1   0.06658 23.451 -148.85
## - tot_deaths                  1   0.07602 23.460 -148.81
## - Mortality_suicide_rateT     1   0.08018 23.465 -148.79
## - Tobacco_use_rate            1   0.08366 23.468 -148.77
## - Clean_energy_access_prop    1   0.10752 23.492 -148.65
## - PopulationT                 1   0.12706 23.511 -148.56
## - Harmful_air_mean_concT      1   0.16777 23.552 -148.36
## - tot_fert_rateT              1   0.40275 23.787 -147.22
## - Univ_hc                     1   0.40953 23.794 -147.18
## <none>                                    23.384 -147.18
## - Mortality_homicide_rateT    1   0.63071 24.015 -146.12
## - rate_nat_increase           1   0.69035 24.075 -145.83
## - death_rate                  1   0.71009 24.095 -145.74
## - life_exp_females            1   0.99496 24.379 -144.39
##
## Step:  AIC=-149.16
```

```
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Alcohol_consuption_liters + Univ_hc + tot_deaths
##
##                             Df Sum of Sq    RSS     AIC
## - Alcohol_consuption_liters  1   0.01663 23.406 -151.07
## - Adult_obesity_rate         1   0.02717 23.416 -151.02
## - life_exp_males             1   0.06193 23.451 -150.85
## - Expenditure_health_perc    1   0.06740 23.456 -150.82
## - Mortality_suicide_rateT    1   0.07605 23.465 -150.78
## - tot_deaths                 1   0.07809 23.467 -150.77
## - Tobacco_use_rate           1   0.08421 23.473 -150.74
## - Clean_energy_access_prop   1   0.10288 23.492 -150.65
## - PopulationT                1   0.12239 23.512 -150.56
## - Harmful_air_mean_concT     1   0.16822 23.557 -150.33
## - tot_fert_rateT             1   0.39849 23.788 -149.21
## <none>                                   23.389 -149.16
## - Univ_hc                    1   0.42095 23.810 -149.10
## - Mortality_homicide_rateT   1   0.62748 24.017 -148.11
## - rate_nat_increase          1   0.69429 24.083 -147.79
## - death_rate                 1   0.73347 24.122 -147.60
## - life_exp_females           1   0.99154 24.381 -146.38
##
## Step:  AIC=-151.07
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Univ_hc + tot_deaths
##
##                            Df Sum of Sq    RSS     AIC
## - Adult_obesity_rate        1   0.03293 23.439 -152.91
## - life_exp_males            1   0.05668 23.462 -152.80
## - Expenditure_health_perc   1   0.05919 23.465 -152.78
## - tot_deaths                1   0.07020 23.476 -152.73
## - Tobacco_use_rate          1   0.08617 23.492 -152.65
## - Clean_energy_access_prop  1   0.09034 23.496 -152.63
## - Mortality_suicide_rateT   1   0.09421 23.500 -152.61
## - PopulationT               1   0.13040 23.536 -152.44
## - Harmful_air_mean_concT    1   0.19365 23.599 -152.13
## - tot_fert_rateT            1   0.40286 23.809 -151.11
## <none>                                  23.406 -151.07
## - Univ_hc                   1   0.44108 23.847 -150.93
## - Mortality_homicide_rateT  1   0.64134 24.047 -149.97
## - rate_nat_increase         1   0.68914 24.095 -149.74
## - death_rate                1   0.72763 24.133 -149.55
## - life_exp_females          1   0.98582 24.392 -148.33
##
## Step:  AIC=-152.91
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
```

```
##     Expenditure_health_perc + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths
##
##                             Df Sum of Sq    RSS     AIC
## - Expenditure_health_perc    1   0.06344 23.502 -154.60
## - tot_deaths                 1   0.06862 23.507 -154.58
## - Tobacco_use_rate           1   0.07925 23.518 -154.53
## - life_exp_males             1   0.08701 23.526 -154.49
## - Mortality_suicide_rateT    1   0.10968 23.548 -154.38
## - PopulationT                1   0.17077 23.609 -154.08
## - Harmful_air_mean_concT     1   0.17664 23.615 -154.05
## - Clean_energy_access_prop   1   0.26990 23.709 -153.60
## <none>                                   23.439 -152.91
## - Univ_hc                    1   0.41298 23.852 -152.90
## - tot_fert_rateT             1   0.51665 23.955 -152.41
## - Mortality_homicide_rateT   1   0.61300 24.052 -151.94
## - death_rate                 1   0.77897 24.218 -151.15
## - rate_nat_increase          1   0.79606 24.235 -151.07
## - life_exp_females           1   1.10320 24.542 -149.62
##
## Step:  AIC=-154.6
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Mortality_suicide_rateT + Univ_hc + tot_deaths
##
##                             Df Sum of Sq    RSS     AIC
## - tot_deaths                 1   0.05047 23.552 -156.35
## - life_exp_males             1   0.05627 23.558 -156.33
## - Mortality_suicide_rateT    1   0.09559 23.598 -156.13
## - Tobacco_use_rate           1   0.11542 23.617 -156.04
## - Harmful_air_mean_concT     1   0.13296 23.635 -155.95
## - PopulationT                1   0.16562 23.668 -155.79
## - Clean_energy_access_prop   1   0.23243 23.735 -155.47
## - Univ_hc                    1   0.36543 23.867 -154.83
## <none>                                   23.502 -154.60
## - tot_fert_rateT             1   0.56364 24.066 -153.88
## - rate_nat_increase          1   0.85506 24.357 -152.49
## - Mortality_homicide_rateT   1   0.89266 24.395 -152.31
## - death_rate                 1   0.91665 24.419 -152.20
## - life_exp_females           1   1.06634 24.568 -151.50
##
## Step:  AIC=-156.36
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Mortality_suicide_rateT + Univ_hc
##
##                             Df Sum of Sq    RSS     AIC
## - life_exp_males             1   0.06535 23.618 -158.04
## - Mortality_suicide_rateT    1   0.10036 23.653 -157.87
## - Tobacco_use_rate           1   0.11740 23.670 -157.78
## - Harmful_air_mean_concT     1   0.12177 23.674 -157.76
## - Clean_energy_access_prop   1   0.21723 23.770 -157.30
```

```
## - Univ_hc                   1   0.32863 23.881 -156.76
## - PopulationT               1   0.36906 23.922 -156.57
## <none>                                  23.552 -156.35
## - tot_fert_rateT            1   0.62552 24.178 -155.34
## - rate_nat_increase         1   0.88726 24.440 -154.10
## - death_rate                1   0.96002 24.513 -153.76
## - Mortality_homicide_rateT  1   1.06320 24.616 -153.28
## - life_exp_females          1   1.09900 24.651 -153.11
##
## Step:  AIC=-158.04
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Mortality_suicide_rateT + Univ_hc
##
##                            Df Sum of Sq    RSS     AIC
## - Mortality_suicide_rateT   1   0.08963 23.707 -159.60
## - Tobacco_use_rate          1   0.11271 23.731 -159.49
## - Harmful_air_mean_concT    1   0.15192 23.770 -159.30
## - Clean_energy_access_prop  1   0.24578 23.864 -158.85
## - PopulationT               1   0.37924 23.997 -158.21
## <none>                                  23.618 -158.04
## - Univ_hc                   1   0.45166 24.070 -157.86
## - tot_fert_rateT            1   0.63552 24.253 -156.98
## - rate_nat_increase         1   0.88242 24.500 -155.82
## - death_rate                1   1.15054 24.768 -154.57
## - Mortality_homicide_rateT  1   1.55533 25.173 -152.70
## - life_exp_females          1   2.72589 26.344 -147.47
##
## Step:  AIC=-159.6
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Univ_hc
##
##                            Df Sum of Sq    RSS     AIC
## - Tobacco_use_rate          1   0.09059 23.798 -161.16
## - Harmful_air_mean_concT    1   0.19643 23.904 -160.65
## - Clean_energy_access_prop  1   0.20466 23.912 -160.61
## <none>                                  23.707 -159.60
## - PopulationT               1   0.42381 24.131 -159.56
## - Univ_hc                   1   0.43364 24.141 -159.52
## - tot_fert_rateT            1   0.65127 24.359 -158.49
## - rate_nat_increase         1   0.96322 24.671 -157.02
## - death_rate                1   1.09977 24.807 -156.39
## - Mortality_homicide_rateT  1   1.66720 25.375 -153.79
## - life_exp_females          1   2.90017 26.608 -148.33
##
## Step:  AIC=-161.16
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Univ_hc
##
##                            Df Sum of Sq    RSS     AIC
```

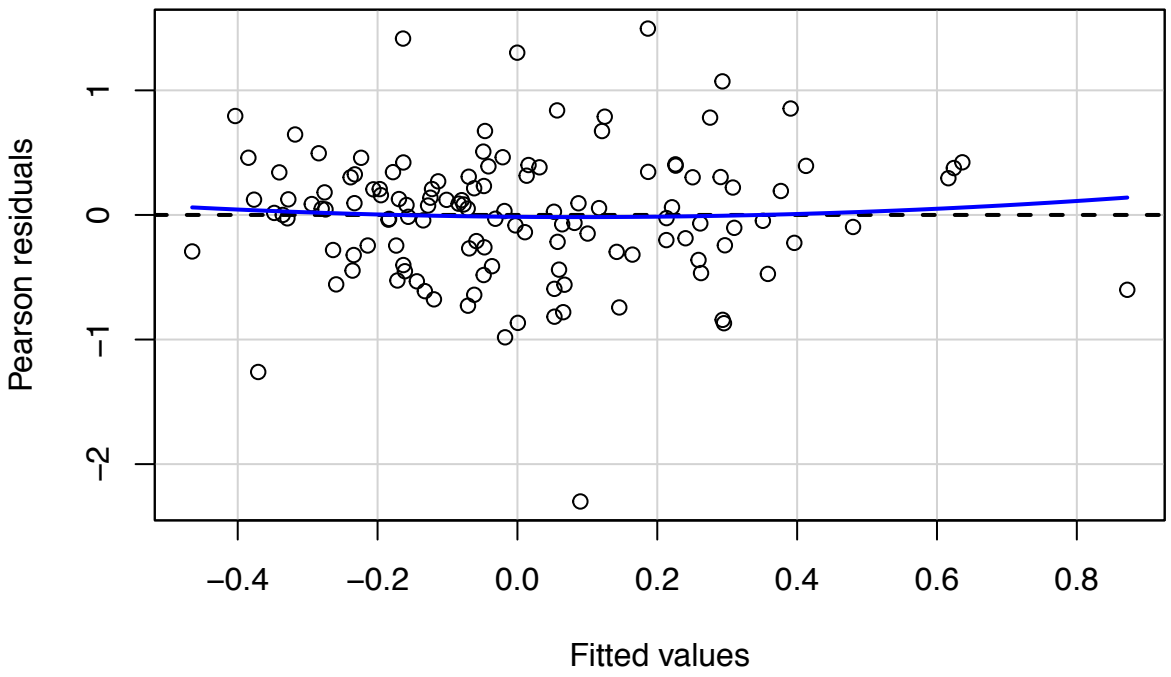
```
## - Harmful_air_mean_concT    1   0.14871 23.947 -162.45
## - Clean_energy_access_prop  1   0.18448 23.983 -162.27
## - Univ_hc                   1   0.41310 24.211 -161.18
## <none>                                  23.798 -161.16
## - PopulationT               1   0.43331 24.231 -161.09
## - tot_fert_rateT            1   0.76181 24.560 -159.54
## - death_rate                1   1.19890 24.997 -157.51
## - rate_nat_increase         1   1.27895 25.077 -157.14
## - Mortality_homicide_rateT  1   2.04968 25.848 -153.66
## - life_exp_females          1   3.12127 26.919 -148.99
##
## Step:  AIC=-162.45
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Mortality_homicide_rateT + Univ_hc
##
##                             Df Sum of Sq    RSS     AIC
## - Clean_energy_access_prop  1   0.16184 24.109 -163.67
## <none>                                  23.947 -162.45
## - Univ_hc                   1   0.59035 24.537 -161.65
## - PopulationT               1   0.72955 24.676 -161.00
## - tot_fert_rateT            1   0.75942 24.706 -160.86
## - death_rate                1   1.08901 25.036 -159.33
## - rate_nat_increase         1   1.26635 25.213 -158.52
## - Mortality_homicide_rateT  1   1.91092 25.858 -155.62
## - life_exp_females          1   3.08982 27.037 -150.49
##
## Step:  AIC=-163.67
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Mortality_homicide_rateT +
##     Univ_hc
##
##                             Df Sum of Sq    RSS     AIC
## <none>                                  24.109 -163.67
## - Univ_hc                   1   0.72546 24.834 -162.26
## - PopulationT               1   0.78115 24.890 -162.00
## - tot_fert_rateT            1   0.82082 24.930 -161.82
## - death_rate                1   1.33312 25.442 -159.48
## - rate_nat_increase         1   1.60621 25.715 -158.25
## - Mortality_homicide_rateT  1   1.78209 25.891 -157.47
## - life_exp_females          1   2.92880 27.038 -152.49
```

```
# AIC-Determined Model
# ----- So different depending on using transformed or not
mod_bwAIC <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_females + death_ra
summary(mod_bwAIC)
```

```
##
## Call:
## lm(formula = DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Mortality_homicide_rateT +
##     Univ_hc, data = df_merge)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
```

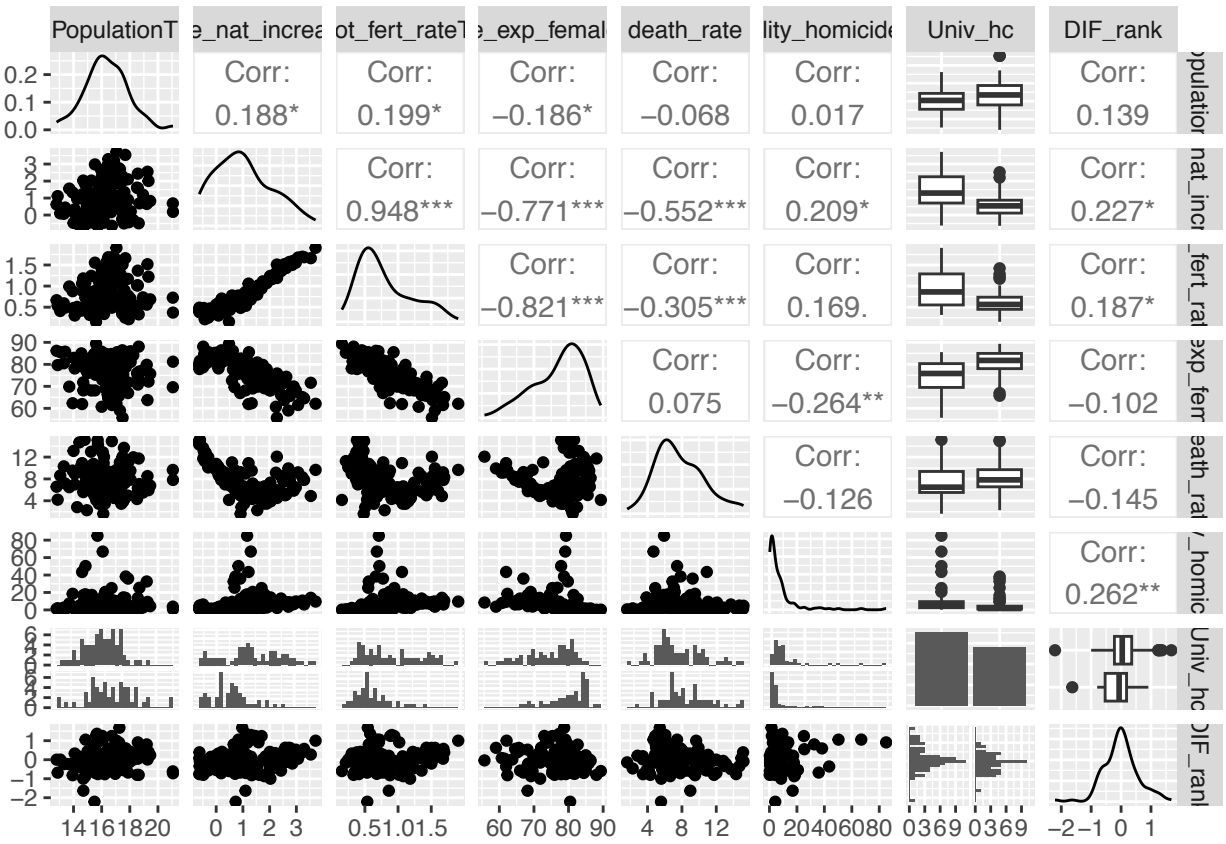
```
## -2.29981 -0.28724  0.04438  0.30543  1.49585
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -5.76174    1.62846  -3.538 0.000576 ***
## PopulationT               0.06939    0.03410   2.035 0.044056 *
## rate_nat_increase         0.89137    0.33432   2.666 0.008738 **
## tot_fert_rateT           -1.34188    0.68193  -1.968 0.051422 .
## life_exp_females          0.05077    0.01579   3.215 0.001677 **
## death_rate                0.10354    0.04371   2.369 0.019463 *
## Mortality_homicide_rateT  0.12909    0.05106   2.528 0.012775 *
## Univ_hc1                 -0.20644    0.11550  -1.787 0.076442 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5367 on 119 degrees of freedom
## Multiple R-squared:  0.1814, Adjusted R-squared:  0.1333
## F-statistic: 3.768 on 7 and 119 DF,  p-value: 0.001003
```

```
residualPlot(mod_bwAIC)
```



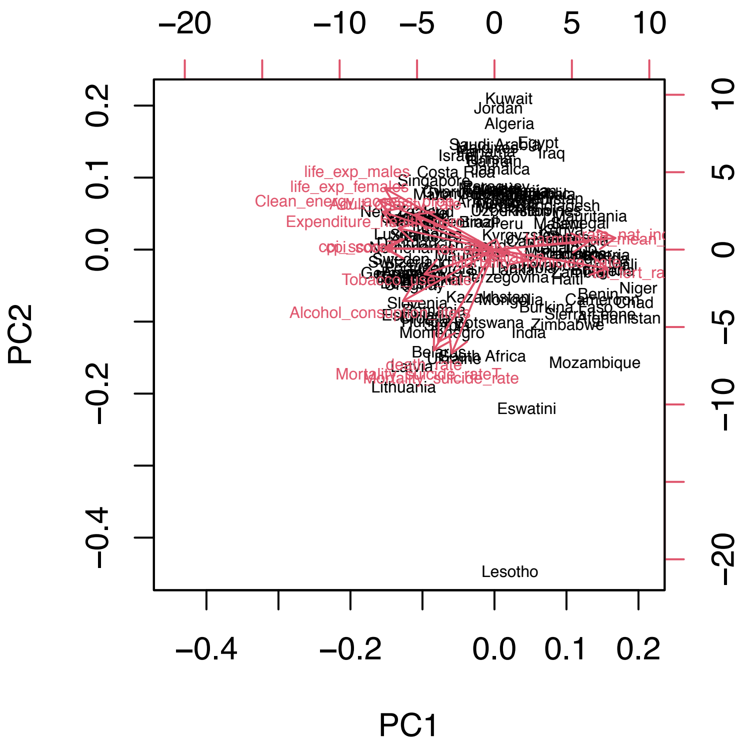

```
# Final Model
ggpairs(df_merge[,c(24,3,25,6,7,10,16, 23)])
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



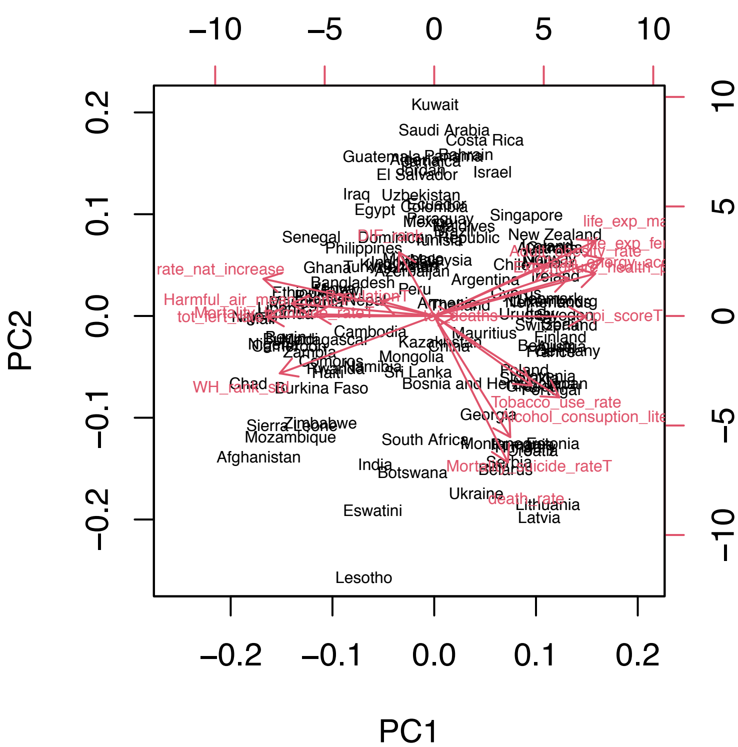
Investigate Groupings by Principal Component Analysis

```
# Non-Transformed Data
pcp = prcomp(df_merge_noNA[, -c(1,16,19,20,21,22,23,24,25,26,27)], center = TRUE, scale = TRUE)
biplot(pcp, cex = 0.5, xlabs = df_merge_noNA$country)
```



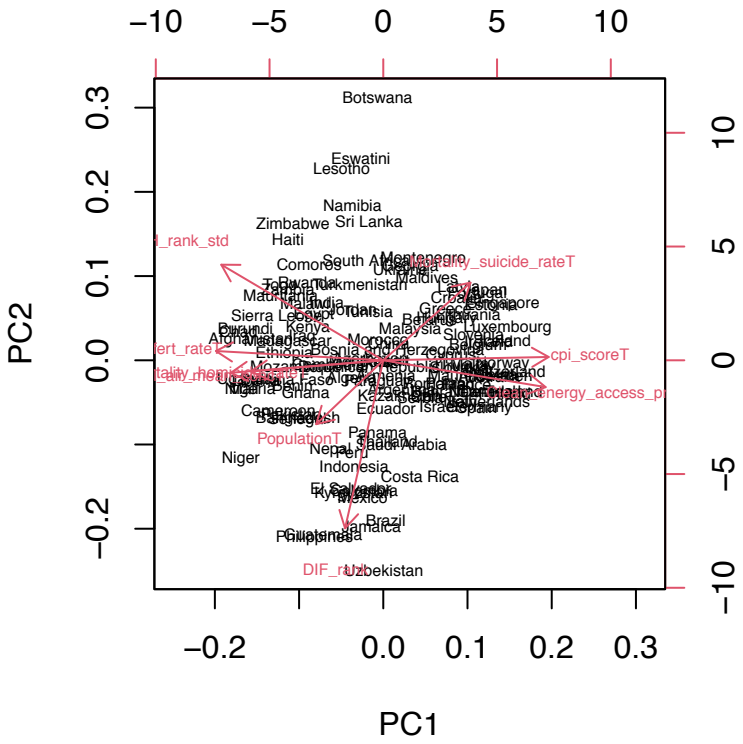
Transformed Data

```
pcpT = prcomp(df_merge_noNA[, -c(1,2,4,9,10,14,18,16,19,20,21)], center = TRUE, scale = TRUE)
biplot(pcpT, cex = 0.5, xlabs = df_merge_noNA$country)
```



Final Model (Excluding categorical variable)

```
pcpT = prcomp(df_merge_noNA[, -c(1:7,9:20,21)], center = TRUE, scale = TRUE)
biplot(pcpT, cex = 0.5, xlabs = df_merge_noNA$country)
```



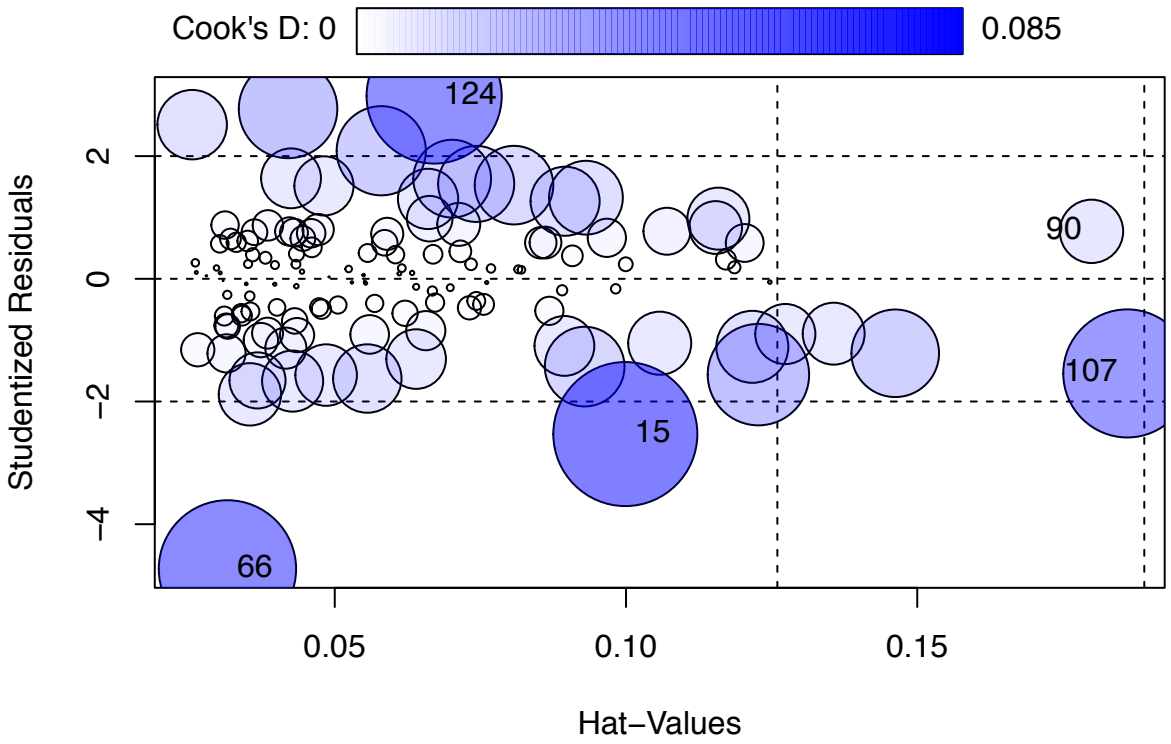
Check Multicollinearity

```
vif(mod_bwAIC)
```

```
##              PopulationT       rate_nat_increase           tot_fert_rateT
##                 1.194667               54.416278                32.549900
##         life_exp_females             death_rate Mortality_homicide_rateT
##                 5.689041                6.848762                 1.742542
##                 Univ_hc
##                 1.449913
```

Investigate the Countries that are High Leverage Points

```
influencePlot(mod_bwAIC, col=c(1,1))
```




```
##         StudRes        Hat      CookD
## 15  -2.5309970 0.09988576 0.08499729
## 66  -4.7289219 0.03157620 0.07727232
## 90   0.7734527 0.17991352 0.01646078
## 107 -1.5423757 0.18605820 0.06719584
## 124  2.9794075 0.06705869 0.07480577
```

```
"Low Leverage/High Residuals:"
```

```
## [1] "Low Leverage/High Residuals:"
```

```
df_merge[66,1]
```

```
## [1] "Lebanon"
```

```
"High Leverage/Low Residuals:"
```

```
## [1] "High Leverage/Low Residuals:"
```

```
df_merge[90,1]
```

```
## [1] "Niger"
```

```
"High Residual/Low Leverage/High Cooks Distance"
```

```
## [1] "High Residual/Low Leverage/High Cooks Distance"
```

```
df_merge[124,1]
```

```
## [1] "Uzbekistan"
```

```
"High Residual/High Cooks Distance:"
```

```
## [1] "High Residual/High Cooks Distance:"
```

```
df_merge[15,1]
```

```
## [1] "Botswana"
```

```
"High Leverage/High Cooks Distance/Low Residual:"
```

```
## [1] "High Leverage/High Cooks Distance/Low Residual:"
```

```
df_merge[107,1]
```

```
## [1] "Singapore"
```

```
# We see know reason to remove these countries, however we will examine them and also view them in ligh
```

Investigate Subsets of Countries

As the biplot showed, there was clustering of countries based on their economic development status, therefore we are interested in investigating how subsets of countries divided by their economic development status influences the model. We subsetted countries into thirds by their GDP rank, then fitted the final model on each subset.

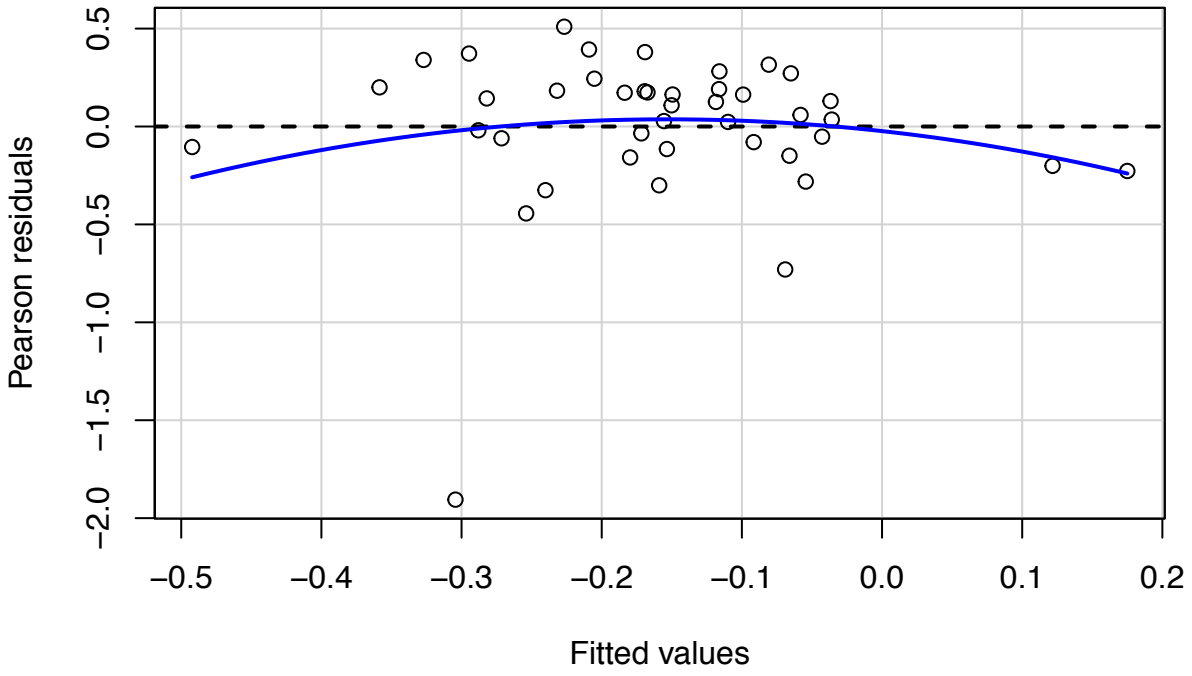
```
df_merge_first <- subset(df_merge, GDP_rank < 74)
df_merge_second <- subset(df_merge, GDP_rank < 138 & GDP_rank > 74)
df_merge_third <- subset(df_merge, GDP_rank > 138)

"First Subset Model"
```

```
## [1] "First Subset Model"
```

```
mod_first <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_females + death_ra
summary(mod_first)
```

```
##
## Call:
## lm(formula = DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Mortality_homicide_rateT +
##     Univ_hc, data = df_merge_first)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.90546 -0.11252  0.08376  0.18875  0.50954
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -2.184875   4.095338  -0.534    0.597
## PopulationT               0.005154   0.054996   0.094    0.926
## rate_nat_increase        -0.104562   1.185146  -0.088    0.930
## tot_fert_rateT            1.153312   1.299834   0.887    0.381
## life_exp_females          0.016144   0.042048   0.384    0.703
## death_rate                0.012270   0.165180   0.074    0.941
## Mortality_homicide_rateT -0.075999   0.140899  -0.539    0.593
## Univ_hc1                 -0.099455   0.214106  -0.465    0.645
##
## Residual standard error: 0.4293 on 34 degrees of freedom
## Multiple R-squared:  0.08705,    Adjusted R-squared:  -0.1009
## F-statistic: 0.4631 on 7 and 34 DF,  p-value: 0.8541
```

```
residualPlot(mod_first)
```




```
"Second Subset Model"
```

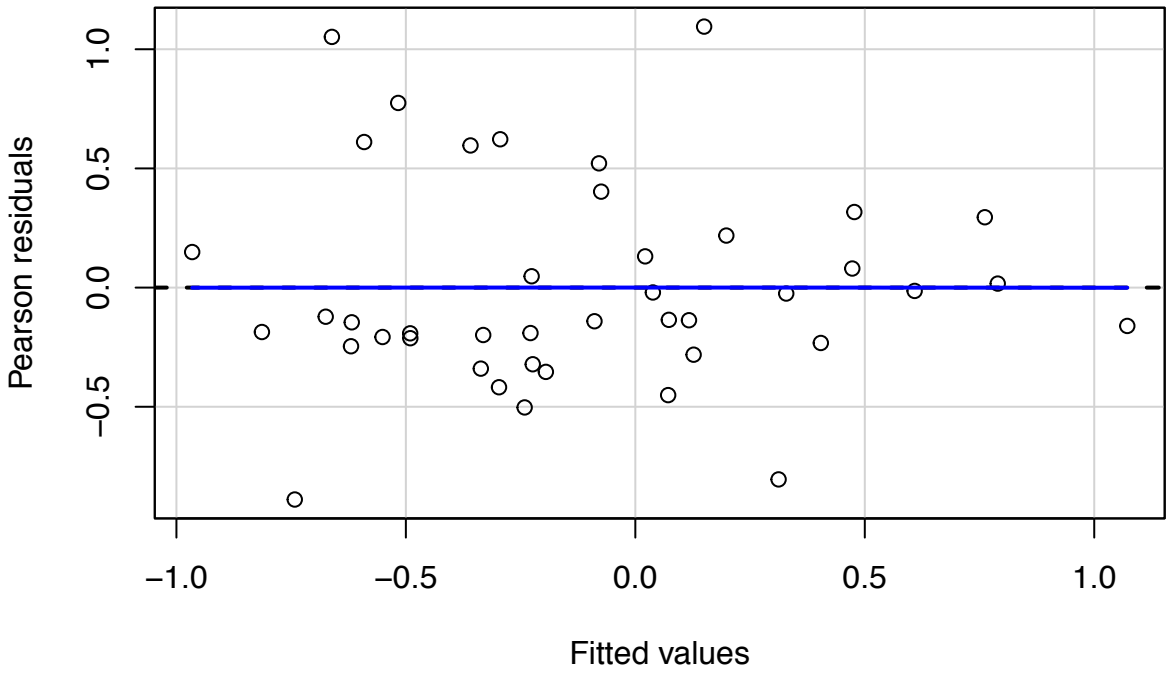
```
## [1] "Second Subset Model"
```

```
mod_second <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_females + death_ra
summary(mod_second)
```

```
##
## Call:
## lm(formula = DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Mortality_homicide_rateT +
##     Univ_hc, data = df_merge_second)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.8891 -0.2273 -0.1361  0.2011  1.0950
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -5.18533    4.35620  -1.190    0.242
## PopulationT               0.03170    0.05279   0.601    0.552
## rate_nat_increase        -0.26308    1.01664  -0.259    0.797
## tot_fert_rateT           -0.59164    1.41480  -0.418    0.678
## life_exp_females          0.06379    0.03882   1.643    0.110
## death_rate               -0.04726    0.15383  -0.307    0.761
## Mortality_homicide_rateT  0.38440    0.08052   4.774 3.36e-05 ***
## Univ_hc1                 -0.23491    0.17179  -1.367    0.180
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4759 on 34 degrees of freedom
## Multiple R-squared:  0.5423, Adjusted R-squared:  0.4481
```

```
## F-statistic: 5.755 on 7 and 34 DF,  p-value: 0.0001893
```

```
residualPlot(mod_second)
```




```
"Third Subset Model"
```

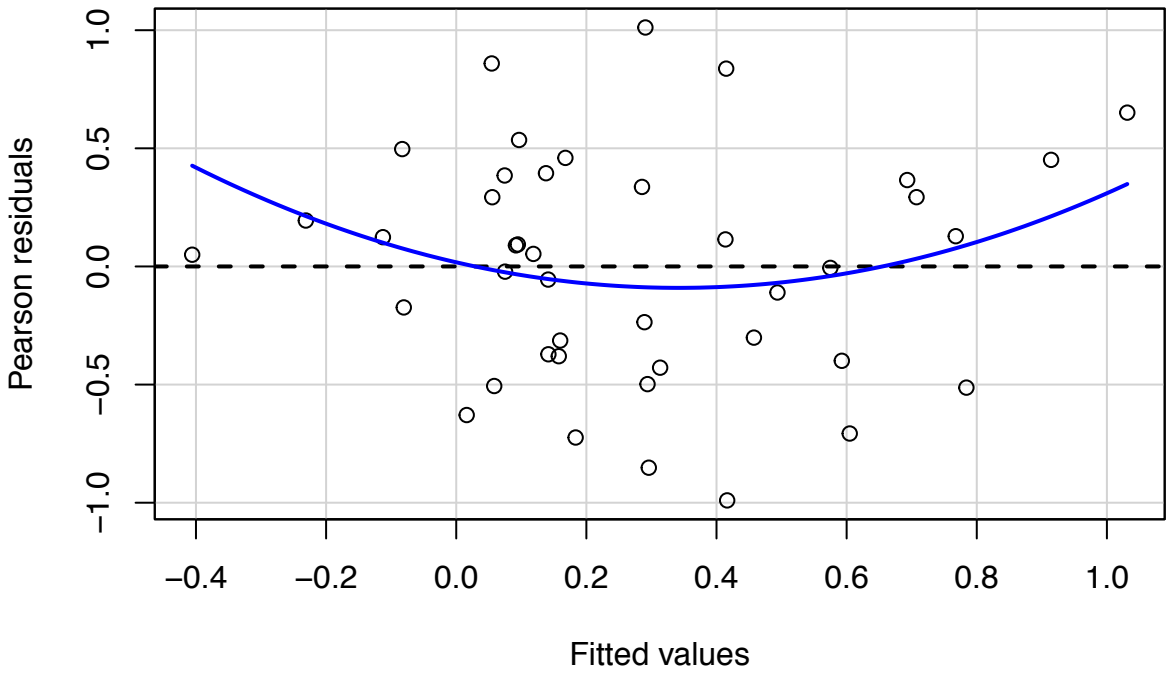
```
## [1] "Third Subset Model"
```

```
mod_third <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_females + death_ra
summary(mod_third)
```

```
##
## Call:
## lm(formula = DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_females + death_rate + Mortality_homicide_rateT +
##     Univ_hc, data = df_merge_third)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.99014 -0.37787  0.05141  0.35844  1.01142
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)               -3.56093    4.08458  -0.872  0.38943
## PopulationT               -0.02418    0.07172  -0.337  0.73811
## rate_nat_increase          1.71256    0.61180   2.799  0.00838 **
## tot_fert_rateT            -3.54761    1.40059  -2.533  0.01609 *
## life_exp_females           0.05365    0.04362   1.230  0.22716
## death_rate                 0.19883    0.11848   1.678  0.10247
## Mortality_homicide_rateT -0.07927    0.11770  -0.673  0.50520
## Univ_hc1                  -0.06718    0.26168  -0.257  0.79894
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5278 on 34 degrees of freedom
```

```
## Multiple R-squared:  0.2931, Adjusted R-squared:  0.1475
## F-statistic: 2.014 on 7 and 34 DF,  p-value: 0.08202
```

```
residualPlot(mod_third)
```




```
# The model only fulfills assumptions about residuals for the middle subset of our data.
```

Remodeling By Subset

```
# Subset 1: Model Selection
df_merge_firstnoNA <- na.omit(df_merge_first)
mod_S1 <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_males + life_exp_fema

bw_aicS1 = step(mod_S1, direction = "backward")
```

```
## Start:  AIC=-120.71
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Alcohol_consuption_liters + Univ_hc + tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - Mortality_homicide_rateT   1   0.00000 0.79541 -122.71
## - Harmful_air_mean_concT     1   0.00000 0.79541 -122.71
## - death_rate                 1   0.00005 0.79546 -122.71
## - tot_fert_rateT             1   0.00014 0.79555 -122.70
## - Alcohol_consuption_liters  1   0.00019 0.79560 -122.70
## - rate_nat_increase          1   0.00119 0.79659 -122.65
## - Expenditure_health_perc    1   0.00498 0.80038 -122.46
## - Tobacco_use_rate           1   0.00769 0.80309 -122.33
## - PopulationT                1   0.02366 0.81907 -121.54
## <none>                                   0.79541 -120.71
```

```
## - Adult_obesity_rate         1   0.09800 0.89341 -118.06
## - life_exp_females           1   0.10956 0.90496 -117.55
## - life_exp_males             1   0.14384 0.93924 -116.06
## - Mortality_suicide_rateT    1   0.15883 0.95424 -115.43
## - cpi_scoreT                 1   0.18992 0.98533 -114.15
## - tot_deaths                 1   0.21389 1.00929 -113.19
## - Univ_hc                    1   0.32561 1.12102 -108.99
## - Clean_energy_access_prop   1   0.33517 1.13057 -108.65
##
## Step:  AIC=-122.71
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Adult_obesity_rate + Tobacco_use_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Alcohol_consuption_liters +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - Harmful_air_mean_concT     1   0.00000 0.79541 -124.71
## - death_rate                 1   0.00007 0.79547 -124.71
## - tot_fert_rateT             1   0.00018 0.79558 -124.70
## - Alcohol_consuption_liters  1   0.00020 0.79560 -124.70
## - rate_nat_increase          1   0.00166 0.79707 -124.63
## - Expenditure_health_perc    1   0.00619 0.80160 -124.40
## - Tobacco_use_rate           1   0.00794 0.80334 -124.31
## - PopulationT                1   0.02368 0.81909 -123.54
## <none>                                   0.79541 -122.71
## - life_exp_females           1   0.11452 0.90992 -119.33
## - Adult_obesity_rate         1   0.11573 0.91114 -119.28
## - life_exp_males             1   0.16369 0.95910 -117.23
## - Mortality_suicide_rateT    1   0.16499 0.96039 -117.17
## - cpi_scoreT                 1   0.19128 0.98669 -116.09
## - tot_deaths                 1   0.21389 1.00929 -115.19
## - Clean_energy_access_prop   1   0.33821 1.13362 -110.54
## - Univ_hc                    1   0.36610 1.16150 -109.57
##
## Step:  AIC=-124.71
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Adult_obesity_rate + Tobacco_use_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Alcohol_consuption_liters + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - death_rate                 1   0.00007 0.79547 -126.71
## - tot_fert_rateT             1   0.00019 0.79560 -126.70
## - Alcohol_consuption_liters  1   0.00024 0.79564 -126.70
## - rate_nat_increase          1   0.00172 0.79713 -126.62
## - Expenditure_health_perc    1   0.00660 0.80200 -126.38
## - Tobacco_use_rate           1   0.00808 0.80348 -126.31
## - PopulationT                1   0.02540 0.82081 -125.45
## <none>                                   0.79541 -124.71
## - life_exp_females           1   0.12714 0.92255 -120.78
## - Adult_obesity_rate         1   0.13724 0.93265 -120.34
## - life_exp_males             1   0.16394 0.95934 -119.22
```

```
## - Mortality_suicide_rateT    1   0.17190 0.96731 -118.89
## - tot_deaths                 1   0.22120 1.01660 -116.90
## - cpi_scoreT                 1   0.26676 1.06217 -115.14
## - Clean_energy_access_prop   1   0.35549 1.15090 -111.93
## - Univ_hc                    1   0.36847 1.16388 -111.48
##
## Step:  AIC=-126.71
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + Clean_energy_access_prop +
##     Adult_obesity_rate + Tobacco_use_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Alcohol_consuption_liters + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - Alcohol_consuption_liters  1   0.00029 0.79576 -128.69
## - tot_fert_rateT             1   0.00145 0.79692 -128.63
## - Expenditure_health_perc    1   0.00752 0.80299 -128.33
## - Tobacco_use_rate           1   0.00801 0.80348 -128.31
## - PopulationT                1   0.02572 0.82119 -127.44
## - rate_nat_increase          1   0.03219 0.82766 -127.12
## <none>                                   0.79547 -126.71
## - life_exp_females           1   0.12977 0.92525 -122.66
## - Adult_obesity_rate         1   0.13816 0.93363 -122.30
## - Mortality_suicide_rateT    1   0.17524 0.97071 -120.74
## - life_exp_males             1   0.19245 0.98793 -120.04
## - tot_deaths                 1   0.22122 1.01669 -118.89
## - cpi_scoreT                 1   0.26684 1.06231 -117.14
## - Clean_energy_access_prop   1   0.36301 1.15849 -113.67
## - Univ_hc                    1   0.40113 1.19661 -112.38
##
## Step:  AIC=-128.69
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + Clean_energy_access_prop +
##     Adult_obesity_rate + Tobacco_use_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Univ_hc + tot_deaths + cpi_scoreT
##
##                            Df Sum of Sq     RSS     AIC
## - tot_fert_rateT            1   0.00120 0.79697 -130.63
## - Expenditure_health_perc   1   0.00723 0.80300 -130.33
## - Tobacco_use_rate          1   0.00992 0.80568 -130.20
## - PopulationT               1   0.02745 0.82321 -129.34
## - rate_nat_increase         1   0.03940 0.83516 -128.76
## <none>                                  0.79576 -128.69
## - life_exp_females          1   0.13565 0.93141 -124.40
## - Adult_obesity_rate        1   0.15788 0.95364 -123.45
## - Mortality_suicide_rateT   1   0.17501 0.97077 -122.74
## - life_exp_males            1   0.19217 0.98794 -122.04
## - tot_deaths                1   0.22626 1.02203 -120.68
## - cpi_scoreT                1   0.29211 1.08788 -118.19
## - Clean_energy_access_prop  1   0.40457 1.20034 -114.25
## - Univ_hc                   1   0.40884 1.20460 -114.11
##
## Step:  AIC=-130.63
## DIF_rank ~ PopulationT + rate_nat_increase + life_exp_males +
```

```
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - Tobacco_use_rate           1   0.00886 0.80582 -132.19
## - Expenditure_health_perc    1   0.00933 0.80630 -132.17
## - PopulationT                1   0.02669 0.82366 -131.31
## <none>                                   0.79697 -130.63
## - rate_nat_increase          1   0.05298 0.84995 -130.06
## - life_exp_females           1   0.13614 0.93311 -126.33
## - Adult_obesity_rate         1   0.16459 0.96156 -125.12
## - Mortality_suicide_rateT    1   0.17567 0.97263 -124.67
## - life_exp_males             1   0.19723 0.99419 -123.79
## - tot_deaths                 1   0.22526 1.02223 -122.68
## - cpi_scoreT                 1   0.29388 1.09085 -120.08
## - Univ_hc                    1   0.41672 1.21369 -115.81
## - Clean_energy_access_prop   1   0.43890 1.23587 -115.08
##
## Step:  AIC=-132.19
## DIF_rank ~ PopulationT + rate_nat_increase + life_exp_males +
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - Expenditure_health_perc    1   0.01442 0.82025 -133.48
## - PopulationT                1   0.03211 0.83793 -132.63
## <none>                                   0.80582 -132.19
## - rate_nat_increase          1   0.04415 0.84997 -132.06
## - life_exp_females           1   0.13111 0.93694 -128.16
## - Adult_obesity_rate         1   0.15609 0.96192 -127.11
## - Mortality_suicide_rateT    1   0.16688 0.97270 -126.66
## - life_exp_males             1   0.19715 1.00298 -125.44
## - tot_deaths                 1   0.23674 1.04256 -123.89
## - cpi_scoreT                 1   0.28829 1.09412 -121.96
## - Univ_hc                    1   0.43181 1.23764 -117.03
## - Clean_energy_access_prop   1   0.49152 1.29734 -115.14
##
## Step:  AIC=-133.48
## DIF_rank ~ PopulationT + rate_nat_increase + life_exp_males +
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     Mortality_suicide_rateT + Univ_hc + tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq     RSS     AIC
## - rate_nat_increase          1   0.03850 0.85875 -133.65
## <none>                                   0.82025 -133.48
## - PopulationT                1   0.04709 0.86734 -133.25
## - life_exp_females           1   0.13125 0.95150 -129.54
## - Mortality_suicide_rateT    1   0.15682 0.97707 -128.48
## - Adult_obesity_rate         1   0.15798 0.97823 -128.44
## - life_exp_males             1   0.18707 1.00732 -127.26
## - tot_deaths                 1   0.23523 1.05548 -125.39
## - cpi_scoreT                 1   0.28583 1.10608 -123.52
```

```
## - Univ_hc                   1   0.42023 1.24048 -118.94
## - Clean_energy_access_prop  1   0.55276 1.37301 -114.88
##
## Step:  AIC=-133.65
## DIF_rank ~ PopulationT + life_exp_males + life_exp_females +
##     Clean_energy_access_prop + Adult_obesity_rate + Mortality_suicide_rateT +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                            Df Sum of Sq     RSS     AIC
## - PopulationT               1   0.04014 0.89889 -133.82
## <none>                                  0.85875 -133.65
## - Mortality_suicide_rateT   1   0.12076 0.97951 -130.38
## - life_exp_females          1   0.16844 1.02719 -128.48
## - tot_deaths                1   0.19802 1.05677 -127.35
## - Adult_obesity_rate        1   0.24351 1.10226 -125.66
## - life_exp_males            1   0.30380 1.16256 -123.53
## - cpi_scoreT                1   0.34852 1.20727 -122.02
## - Univ_hc                   1   0.50333 1.36209 -117.19
## - Clean_energy_access_prop  1   0.62314 1.48189 -113.82
##
## Step:  AIC=-133.82
## DIF_rank ~ life_exp_males + life_exp_females + Clean_energy_access_prop +
##     Adult_obesity_rate + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                            Df Sum of Sq     RSS     AIC
## <none>                                  0.89889 -133.82
## - Mortality_suicide_rateT   1   0.10858 1.00747 -131.26
## - life_exp_females          1   0.13578 1.03466 -130.19
## - tot_deaths                1   0.18911 1.08800 -128.18
## - life_exp_males            1   0.26973 1.16862 -125.32
## - Adult_obesity_rate        1   0.29320 1.19209 -124.53
## - cpi_scoreT                1   0.33666 1.23555 -123.09
## - Univ_hc                   1   0.58109 1.47998 -115.87
## - Clean_energy_access_prop  1   0.61469 1.51358 -114.98
```

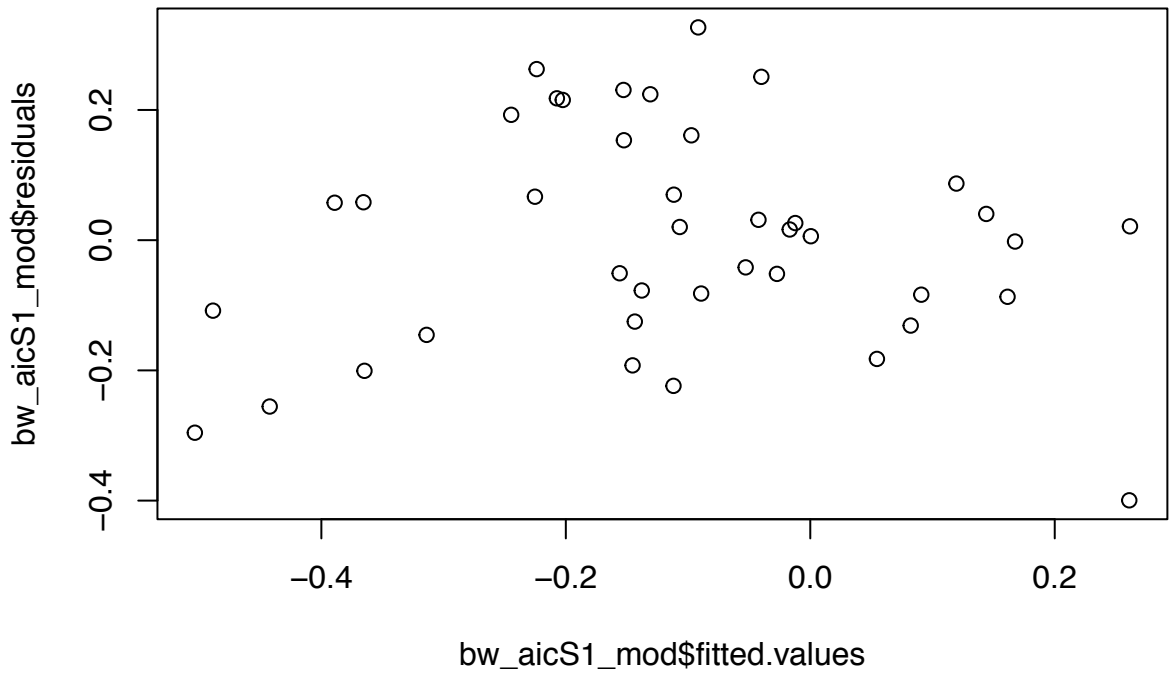
```
# ---- Final Model: Mortality_suicide_rateT, life_exp_females, life_exp_males,
# Clean_energy_access_prop, cpi_scoreT, Adult_obesity_rate, Univ_hc
```

```
bw_aicS1_mod <- lm(DIF_rank~life_exp_males + life_exp_females + Clean_energy_access_prop + Adult_obesity
summary(bw_aicS1_mod)
```

```
##
## Call:
## lm(formula = DIF_rank ~ life_exp_males + life_exp_females + Clean_energy_access_prop +
##     Adult_obesity_rate + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths + cpi_scoreT, data = df_merge_first)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.39955 -0.10827  0.01639  0.08696  0.32678
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)               2.167e+00  1.924e+00   1.127 0.268309
```

```
## life_exp_males            5.844e-02  2.745e-02   2.129 0.041025 *
## life_exp_females         -4.761e-02  3.910e-02  -1.218 0.232272
## Clean_energy_access_prop -5.979e-02  1.450e-02  -4.125 0.000246 ***
## Adult_obesity_rate        2.318e-02  7.617e-03   3.043 0.004649 **
## Mortality_suicide_rateT   1.865e-01  9.376e-02   1.989 0.055357 .
## Univ_hc1                 -3.052e-01  8.980e-02  -3.399 0.001828 **
## tot_deaths                1.388e-06  6.719e-07   2.067 0.046952 *
## cpi_scoreT                5.408e-01  2.178e-01   2.484 0.018435 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1874 on 32 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.5598, Adjusted R-squared:  0.4497
## F-statistic: 5.086 on 8 and 32 DF,  p-value: 0.0003893
```

```
plot(bw_aicS1_mod$residuals ~ bw_aicS1_mod$fitted.values)
```




```
vif(bw_aicS1_mod)
```

```
##           life_exp_males         life_exp_females Clean_energy_access_prop
##                 8.372807                 8.828509                 1.639454
##       Adult_obesity_rate  Mortality_suicide_rateT                  Univ_hc
##                 2.421033                 2.626652                 2.117361
##                tot_deaths               cpi_scoreT
##                 1.185672                 2.975962
```

```
# Subset 2: Model Selection
df_merge_secondnoNA <- na.omit(df_merge_second)
mod_S2 <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_males + life_exp_fema

bw_aicS2 = step(mod_S2, direction = "backward")
```

```
## Start:  AIC=-39.13
```

```
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Alcohol_consuption_liters + Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Adult_obesity_rate          1   0.00009 4.8571 -41.128
## - rate_nat_increase           1   0.00140 4.8584 -41.118
## - life_exp_males              1   0.00726 4.8642 -41.073
## - death_rate                  1   0.00858 4.8656 -41.063
## - PopulationT                 1   0.03061 4.8876 -40.896
## - Mortality_suicide_rateT     1   0.05042 4.9074 -40.746
## - Clean_energy_access_prop    1   0.05271 4.9097 -40.729
## - Univ_hc                     1   0.06358 4.9206 -40.647
## - tot_fert_rateT              1   0.08196 4.9389 -40.509
## - Tobacco_use_rate            1   0.08350 4.9405 -40.498
## - tot_deaths                  1   0.10664 4.9636 -40.325
## - Harmful_air_mean_concT      1   0.11009 4.9671 -40.299
## - Alcohol_consuption_liters   1   0.25872 5.1157 -39.208
## <none>                                    4.8570 -39.129
## - life_exp_females            1   0.27798 5.1350 -39.069
## - Expenditure_health_perc     1   0.44102 5.2980 -37.913
## - cpi_scoreT                  1   0.47936 5.3363 -37.646
## - Mortality_homicide_rateT    1   1.81129 6.6683 -29.402
##
## Step:  AIC=-41.13
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Alcohol_consuption_liters +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - rate_nat_increase           1   0.00137 4.8584 -43.117
## - death_rate                  1   0.00851 4.8656 -43.063
## - life_exp_males              1   0.00934 4.8664 -43.057
## - PopulationT                 1   0.03240 4.8895 -42.882
## - Mortality_suicide_rateT     1   0.05591 4.9130 -42.704
## - Univ_hc                     1   0.06778 4.9248 -42.615
## - Tobacco_use_rate            1   0.08686 4.9439 -42.472
## - tot_fert_rateT              1   0.09110 4.9482 -42.440
## - Clean_energy_access_prop    1   0.10082 4.9579 -42.368
## - tot_deaths                  1   0.11760 4.9747 -42.243
## - Harmful_air_mean_concT      1   0.13150 4.9886 -42.140
## - Alcohol_consuption_liters   1   0.26255 5.1196 -41.180
## <none>                                    4.8571 -41.128
## - life_exp_females            1   0.28618 5.1432 -41.010
## - Expenditure_health_perc     1   0.44999 5.3071 -39.850
## - cpi_scoreT                  1   0.48914 5.3462 -39.578
## - Mortality_homicide_rateT    1   2.10173 6.9588 -29.824
##
## Step:  AIC=-43.12
## DIF_rank ~ PopulationT + tot_fert_rateT + life_exp_males + life_exp_females +
```

```
##     death_rate + Clean_energy_access_prop + Harmful_air_mean_concT +
##     Mortality_homicide_rateT + Tobacco_use_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Alcohol_consuption_liters + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - life_exp_males              1   0.00906 4.8675 -45.049
## - PopulationT                 1   0.03105 4.8895 -44.882
## - Mortality_suicide_rateT     1   0.05521 4.9136 -44.699
## - Univ_hc                     1   0.06641 4.9248 -44.615
## - Tobacco_use_rate            1   0.09534 4.9538 -44.398
## - Clean_energy_access_prop    1   0.09946 4.9579 -44.368
## - tot_deaths                  1   0.11624 4.9747 -44.243
## - Harmful_air_mean_concT      1   0.13338 4.9918 -44.115
## - death_rate                  1   0.15952 5.0180 -43.922
## - Alcohol_consuption_liters   1   0.26137 5.1198 -43.179
## <none>                                    4.8584 -43.117
## - life_exp_females            1   0.47468 5.3331 -41.668
## - cpi_scoreT                  1   0.48779 5.3462 -41.578
## - Expenditure_health_perc     1   0.50268 5.3611 -41.475
## - tot_fert_rateT              1   0.88583 5.7443 -38.920
## - Mortality_homicide_rateT    1   2.13572 6.9942 -31.636
##
## Step:  AIC=-45.05
## DIF_rank ~ PopulationT + tot_fert_rateT + life_exp_females +
##     death_rate + Clean_energy_access_prop + Harmful_air_mean_concT +
##     Mortality_homicide_rateT + Tobacco_use_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Alcohol_consuption_liters + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - PopulationT                 1   0.03630 4.9038 -46.774
## - Mortality_suicide_rateT     1   0.04616 4.9137 -46.699
## - Univ_hc                     1   0.07594 4.9434 -46.476
## - Tobacco_use_rate            1   0.08730 4.9548 -46.391
## - Clean_energy_access_prop    1   0.09176 4.9593 -46.358
## - tot_deaths                  1   0.14891 5.0164 -45.934
## - Harmful_air_mean_concT      1   0.14942 5.0169 -45.930
## - death_rate                  1   0.23558 5.1031 -45.300
## <none>                                    4.8675 -45.049
## - Alcohol_consuption_liters   1   0.29622 5.1637 -44.863
## - Expenditure_health_perc     1   0.49637 5.3639 -43.456
## - cpi_scoreT                  1   0.50165 5.3691 -43.419
## - tot_fert_rateT              1   0.88299 5.7505 -40.880
## - life_exp_females            1   1.34889 6.2164 -37.998
## - Mortality_homicide_rateT    1   2.13796 7.0054 -33.576
##
## Step:  AIC=-46.77
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Alcohol_consuption_liters +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
```

```
## - Mortality_suicide_rateT    1   0.06483 4.9686 -48.288
## - Tobacco_use_rate           1   0.08277 4.9866 -48.154
## - Clean_energy_access_prop   1   0.11187 5.0157 -47.939
## - tot_deaths                 1   0.11368 5.0175 -47.926
## - Harmful_air_mean_concT     1   0.11535 5.0192 -47.913
## - Univ_hc                    1   0.15184 5.0556 -47.645
## - death_rate                 1   0.22424 5.1280 -47.119
## - Alcohol_consuption_liters  1   0.27137 5.1752 -46.781
## <none>                                   4.9038 -46.774
## - cpi_scoreT                 1   0.46535 5.3692 -45.419
## - Expenditure_health_perc    1   0.52071 5.4245 -45.040
## - tot_fert_rateT             1   0.93958 5.8434 -42.288
## - life_exp_females           1   1.33404 6.2378 -39.870
## - Mortality_homicide_rateT   1   2.10417 7.0080 -35.563
##
## Step:  AIC=-48.29
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Tobacco_use_rate +
##     Expenditure_health_perc + Alcohol_consuption_liters + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Clean_energy_access_prop    1   0.06440 5.0330 -49.811
## - Tobacco_use_rate            1   0.08410 5.0527 -49.667
## - Harmful_air_mean_concT      1   0.14603 5.1147 -49.216
## - Univ_hc                     1   0.16319 5.1318 -49.092
## - tot_deaths                  1   0.17455 5.1432 -49.010
## - death_rate                  1   0.25280 5.2214 -48.451
## <none>                                    4.9686 -48.288
## - cpi_scoreT                  1   0.46673 5.4354 -46.966
## - Alcohol_consuption_liters   1   0.67026 5.6389 -45.606
## - Expenditure_health_perc     1   0.72828 5.6969 -45.227
## - tot_fert_rateT              1   0.88543 5.8541 -44.220
## - life_exp_females            1   1.52456 6.4932 -40.386
## - Mortality_homicide_rateT    1   2.05676 7.0254 -37.471
##
## Step:  AIC=-49.81
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Harmful_air_mean_concT +
##     Mortality_homicide_rateT + Tobacco_use_rate + Expenditure_health_perc +
##     Alcohol_consuption_liters + Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Tobacco_use_rate            1   0.10064 5.1337 -51.079
## - Harmful_air_mean_concT      1   0.15398 5.1870 -50.696
## - tot_deaths                  1   0.16108 5.1941 -50.646
## - Univ_hc                     1   0.18929 5.2223 -50.445
## - death_rate                  1   0.23086 5.2639 -50.152
## <none>                                    5.0330 -49.811
## - cpi_scoreT                  1   0.47177 5.5048 -48.496
## - Alcohol_consuption_liters   1   0.62621 5.6592 -47.472
## - Expenditure_health_perc     1   0.77726 5.8103 -46.498
## - tot_fert_rateT              1   0.91819 5.9512 -45.611
## - life_exp_females            1   1.46370 6.4967 -42.366
## - Mortality_homicide_rateT    1   2.04271 7.0757 -39.207
```

```
##
## Step:  AIC=-51.08
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Harmful_air_mean_concT +
##     Mortality_homicide_rateT + Expenditure_health_perc + Alcohol_consuption_liters +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - tot_deaths                  1   0.19401 5.3277 -51.706
## - Harmful_air_mean_concT      1   0.20254 5.3362 -51.647
## - Univ_hc                     1   0.20776 5.3414 -51.611
## <none>                                    5.1337 -51.079
## - death_rate                  1   0.33883 5.4725 -50.714
## - cpi_scoreT                  1   0.38310 5.5168 -50.416
## - Alcohol_consuption_liters   1   0.63797 5.7716 -48.745
## - Expenditure_health_perc     1   0.72715 5.8608 -48.177
## - tot_fert_rateT              1   0.83402 5.9677 -47.509
## - life_exp_females            1   1.60672 6.7404 -43.004
## - Mortality_homicide_rateT    1   2.28507 7.4187 -39.456
##
## Step:  AIC=-51.71
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Harmful_air_mean_concT +
##     Mortality_homicide_rateT + Expenditure_health_perc + Alcohol_consuption_liters +
##     Univ_hc + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Univ_hc                     1    0.0647 5.3924 -53.259
## - Harmful_air_mean_concT      1    0.1306 5.4583 -52.810
## <none>                                    5.3277 -51.706
## - death_rate                  1    0.3213 5.6490 -51.539
## - Alcohol_consuption_liters   1    0.5366 5.8642 -50.156
## - Expenditure_health_perc     1    0.5424 5.8701 -50.119
## - cpi_scoreT                  1    0.5675 5.8951 -49.961
## - tot_fert_rateT              1    0.8672 6.1949 -48.126
## - life_exp_females            1    1.9736 7.3013 -42.046
## - Mortality_homicide_rateT    1    4.3595 9.6872 -31.584
##
## Step:  AIC=-53.26
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Harmful_air_mean_concT +
##     Mortality_homicide_rateT + Expenditure_health_perc + Alcohol_consuption_liters +
##     cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Harmful_air_mean_concT      1    0.1259 5.5183 -54.405
## <none>                                    5.3924 -53.259
## - death_rate                  1    0.3389 5.7313 -53.004
## - Alcohol_consuption_liters   1    0.5000 5.8924 -51.978
## - Expenditure_health_perc     1    0.5006 5.8930 -51.974
## - tot_fert_rateT              1    0.8039 6.1963 -50.118
## - cpi_scoreT                  1    0.8233 6.2157 -50.002
## - life_exp_females            1    2.1254 7.5178 -42.965
## - Mortality_homicide_rateT    1    4.4601 9.8525 -32.958
##
## Step:  AIC=-54.41
## DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate + Mortality_homicide_rateT +
```

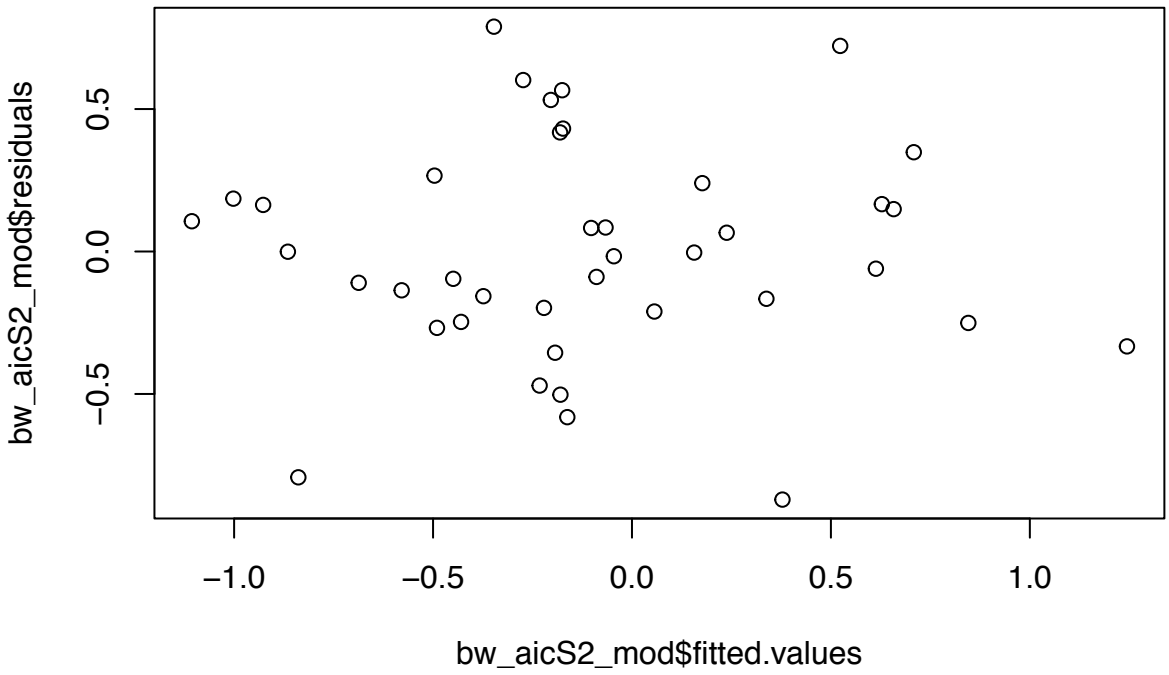
```
##     Expenditure_health_perc + Alcohol_consuption_liters + cpi_scoreT
##
##                             Df Sum of Sq    RSS     AIC
## <none>                                    5.5183 -54.405
## - death_rate                 1    0.3718 5.8901 -53.993
## - Expenditure_health_perc    1    0.4148 5.9331 -53.724
## - Alcohol_consuption_liters  1    0.5218 6.0401 -53.062
## - tot_fert_rateT             1    0.6917 6.2100 -52.036
## - cpi_scoreT                 1    0.9142 6.4325 -50.733
## - life_exp_females           1    2.1359 7.6542 -44.300
## - Mortality_homicide_rateT   1    4.3359 9.8542 -34.952
```

```
# ---- Final Model: Mortality_suicide_rateT, life_exp_females, death_rate,
# tot_fert_rateT, Clean_energy_access_prop, cpi_scoreT, Mortality_homicide_rateT
```

```
bw_aicS2_mod <- lm(DIF_rank~tot_fert_rateT + life_exp_females + death_rate + Mortality_homicide_rateT +
summary(bw_aicS2_mod)
```

```
##
## Call:
## lm(formula = DIF_rank ~ tot_fert_rateT + life_exp_females + death_rate +
##     Mortality_homicide_rateT + Expenditure_health_perc + Alcohol_consuption_liters +
##     cpi_scoreT, data = df_merge_second)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.87074 -0.21981 -0.01026  0.19907  0.78905
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -3.97294    2.26708  -1.752  0.08928 .
## tot_fert_rateT             -1.04946    0.50692  -2.070  0.04658 *
## life_exp_females            0.07486    0.02150   3.482  0.00146 **
## death_rate                  0.05868    0.04552   1.289  0.20657
## Mortality_homicide_rateT    0.40644    0.07555   5.380 6.58e-06 ***
## Expenditure_health_perc     0.02730    0.01952   1.398  0.17160
## Alcohol_consuption_liters -0.05757    0.03202  -1.798  0.08156 .
## cpi_scoreT                 -0.67177    0.29525  -2.275  0.02973 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4212 on 32 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.6607, Adjusted R-squared:  0.5865
## F-statistic: 8.902 on 7 and 32 DF,  p-value: 4.705e-06
```

```
plot(bw_aicS2_mod$residuals ~ bw_aicS2_mod$fitted.values)
```




```
vif(bw_aicS2_mod)
```

```
##            tot_fert_rateT          life_exp_females                 death_rate
##                  2.897843                 2.038561                   3.730778
##  Mortality_homicide_rateT   Expenditure_health_perc Alcohol_consuption_liters
##                  1.710491                 1.492865                   2.521421
##                cpi_scoreT
##                  1.212466
```

```
# Subset 3: Model Selection
df_merge_thirdnoNA <- na.omit(df_merge_third)
mod_S3 <- lm(DIF_rank~PopulationT + rate_nat_increase + tot_fert_rateT + life_exp_males + life_exp_femal

bw_aicS3 = step(mod_S3, direction = "backward")
```

```
## Start:  AIC=-46.08
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Harmful_air_mean_concT + Mortality_homicide_rateT + Adult_obesity_rate +
##     Tobacco_use_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Alcohol_consuption_liters + Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Harmful_air_mean_concT      1   0.00007 4.0247 -48.083
## - Alcohol_consuption_liters   1   0.00514 4.0298 -48.036
## - PopulationT                 1   0.01227 4.0369 -47.971
## - Tobacco_use_rate            1   0.03326 4.0579 -47.779
## - cpi_scoreT                  1   0.09595 4.1206 -47.212
## - death_rate                  1   0.11101 4.1357 -47.077
## - Univ_hc                     1   0.13267 4.1573 -46.884
## - Mortality_homicide_rateT    1   0.18971 4.2144 -46.379
## <none>                                    4.0247 -46.084
## - Mortality_suicide_rateT     1   0.29213 4.3168 -45.491
```

```
## - Expenditure_health_perc    1   0.29438 4.3190 -45.472
## - Adult_obesity_rate         1   0.37006 4.3947 -44.829
## - Clean_energy_access_prop   1   0.55398 4.5786 -43.312
## - life_exp_males             1   0.63791 4.6626 -42.640
## - tot_fert_rateT             1   0.68973 4.7144 -42.231
## - life_exp_females           1   1.02324 5.0479 -39.702
## - rate_nat_increase          1   1.07298 5.0976 -39.339
## - tot_deaths                 1   1.13834 5.1630 -38.868
##
## Step:  AIC=-48.08
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Mortality_homicide_rateT + Adult_obesity_rate + Tobacco_use_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Alcohol_consuption_liters +
##     Univ_hc + tot_deaths + cpi_scoreT
##
##                              Df Sum of Sq    RSS     AIC
## - Alcohol_consuption_liters  1   0.00537 4.0301 -50.034
## - PopulationT                1   0.01232 4.0370 -49.970
## - Tobacco_use_rate           1   0.03475 4.0595 -49.765
## - cpi_scoreT                 1   0.09939 4.1241 -49.180
## - death_rate                 1   0.12934 4.1541 -48.913
## - Univ_hc                    1   0.14133 4.1661 -48.806
## - Mortality_homicide_rateT   1   0.19400 4.2187 -48.341
## <none>                                   4.0247 -48.083
## - Mortality_suicide_rateT    1   0.29933 4.3241 -47.429
## - Expenditure_health_perc    1   0.35917 4.3839 -46.920
## - Adult_obesity_rate         1   0.43791 4.4626 -46.262
## - Clean_energy_access_prop   1   0.61488 4.6396 -44.823
## - tot_fert_rateT             1   0.72187 4.7466 -43.979
## - life_exp_males             1   0.72282 4.7476 -43.972
## - life_exp_females           1   1.04844 5.0732 -41.517
## - tot_deaths                 1   1.14984 5.1746 -40.785
## - rate_nat_increase          1   1.16767 5.1924 -40.658
##
## Step:  AIC=-50.03
## DIF_rank ~ PopulationT + rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + death_rate + Clean_energy_access_prop +
##     Mortality_homicide_rateT + Adult_obesity_rate + Tobacco_use_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                             Df Sum of Sq    RSS     AIC
## - PopulationT                1   0.01238 4.0425 -51.920
## - Tobacco_use_rate           1   0.03378 4.0639 -51.725
## - cpi_scoreT                 1   0.10636 4.1365 -51.070
## - Univ_hc                    1   0.13717 4.1673 -50.795
## - death_rate                 1   0.16086 4.1910 -50.586
## - Mortality_homicide_rateT   1   0.21262 4.2427 -50.131
## <none>                                   4.0301 -50.034
## - Mortality_suicide_rateT    1   0.29479 4.3249 -49.422
## - Expenditure_health_perc    1   0.39801 4.4281 -48.549
## - Adult_obesity_rate         1   0.43279 4.4629 -48.260
## - Clean_energy_access_prop   1   0.61045 4.6405 -46.815
```

```
## - tot_fert_rateT            1   0.75487 4.7850 -45.681
## - life_exp_males            1   0.77609 4.8062 -45.518
## - life_exp_females          1   1.04323 5.0733 -43.516
## - rate_nat_increase         1   1.23361 5.2637 -42.153
## - tot_deaths                1   1.25948 5.2896 -41.972
##
## Step:  AIC=-51.92
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Mortality_homicide_rateT + Adult_obesity_rate + Tobacco_use_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths + cpi_scoreT
##
##                            Df Sum of Sq    RSS     AIC
## - Tobacco_use_rate          1   0.02767 4.0701 -53.668
## - cpi_scoreT                1   0.09827 4.1408 -53.032
## - Univ_hc                   1   0.17728 4.2198 -52.332
## - death_rate                1   0.17855 4.2210 -52.321
## - Mortality_homicide_rateT  1   0.21878 4.2613 -51.970
## <none>                                  4.0425 -51.920
## - Mortality_suicide_rateT   1   0.28643 4.3289 -51.387
## - Expenditure_health_perc   1   0.45574 4.4982 -49.968
## - Adult_obesity_rate        1   0.54914 4.5916 -49.207
## - Clean_energy_access_prop  1   0.66904 4.7115 -48.254
## - tot_fert_rateT            1   0.76209 4.8046 -47.530
## - life_exp_males            1   0.77270 4.8152 -47.448
## - life_exp_females          1   1.03097 5.0735 -45.515
## - rate_nat_increase         1   1.25839 5.3009 -43.893
## - tot_deaths                1   1.27148 5.3140 -43.801
##
## Step:  AIC=-53.67
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Mortality_homicide_rateT + Adult_obesity_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Univ_hc + tot_deaths + cpi_scoreT
##
##                            Df Sum of Sq    RSS     AIC
## - cpi_scoreT                1   0.07941 4.1496 -54.953
## - Univ_hc                   1   0.18273 4.2529 -54.043
## - Mortality_homicide_rateT  1   0.20710 4.2772 -53.831
## <none>                                  4.0701 -53.668
## - death_rate                1   0.25266 4.3228 -53.439
## - Mortality_suicide_rateT   1   0.29383 4.3640 -53.089
## - Expenditure_health_perc   1   0.43597 4.5061 -51.903
## - Clean_energy_access_prop  1   0.74313 4.8133 -49.463
## - life_exp_males            1   0.76367 4.8338 -49.305
## - tot_fert_rateT            1   0.76823 4.8384 -49.271
## - life_exp_females          1   1.00854 5.0787 -47.477
## - Adult_obesity_rate        1   1.03241 5.1026 -47.303
## - rate_nat_increase         1   1.23074 5.3009 -45.893
## - tot_deaths                1   1.48280 5.5530 -44.174
##
## Step:  AIC=-54.95
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
```

```
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Mortality_homicide_rateT + Adult_obesity_rate + Expenditure_health_perc +
##     Mortality_suicide_rateT + Univ_hc + tot_deaths
##
##                             Df Sum of Sq    RSS     AIC
## - Mortality_homicide_rateT  1   0.21120 4.3608 -55.116
## - death_rate                1   0.22556 4.3751 -54.994
## <none>                                  4.1496 -54.953
## - Univ_hc                   1   0.32814 4.4777 -54.137
## - Expenditure_health_perc   1   0.38783 4.5374 -53.647
## - Mortality_suicide_rateT   1   0.40273 4.5523 -53.526
## - life_exp_males            1   0.72598 4.8755 -50.987
## - tot_fert_rateT            1   0.81486 4.9644 -50.319
## - Clean_energy_access_prop  1   0.84947 4.9990 -50.062
## - life_exp_females          1   0.94525 5.0948 -49.360
## - Adult_obesity_rate        1   1.15514 5.3047 -47.866
## - rate_nat_increase         1   1.32304 5.4726 -46.713
## - tot_deaths                1   1.45417 5.6037 -45.837
##
## Step:  AIC=-55.12
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + death_rate + Clean_energy_access_prop +
##     Adult_obesity_rate + Expenditure_health_perc + Mortality_suicide_rateT +
##     Univ_hc + tot_deaths
##
##                             Df Sum of Sq    RSS     AIC
## - death_rate                1   0.18576 4.5465 -55.573
## <none>                                  4.3608 -55.116
## - Univ_hc                   1   0.26877 4.6295 -54.903
## - Mortality_suicide_rateT   1   0.29633 4.6571 -54.684
## - Expenditure_health_perc   1   0.32181 4.6826 -54.482
## - life_exp_males            1   0.55242 4.9132 -52.703
## - life_exp_females          1   0.74782 5.1086 -51.260
## - tot_fert_rateT            1   1.22700 5.5878 -47.943
## - Clean_energy_access_prop  1   1.37697 5.7377 -46.963
## - tot_deaths                1   1.39343 5.7542 -46.857
## - Adult_obesity_rate        1   1.67351 6.0343 -45.098
## - rate_nat_increase         1   1.78715 6.1479 -44.408
##
## Step:  AIC=-55.57
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + Univ_hc +
##     tot_deaths
##
##                             Df Sum of Sq    RSS     AIC
## - Univ_hc                   1   0.17679 4.7233 -56.161
## - Expenditure_health_perc   1   0.23956 4.7861 -55.673
## <none>                                  4.5465 -55.573
## - Mortality_suicide_rateT   1   0.29882 4.8453 -55.217
## - life_exp_females          1   0.56207 5.1086 -53.260
## - life_exp_males            1   0.90045 5.4470 -50.887
## - tot_fert_rateT            1   1.22152 5.7680 -48.768
## - tot_deaths                1   1.23720 5.7837 -48.667
```

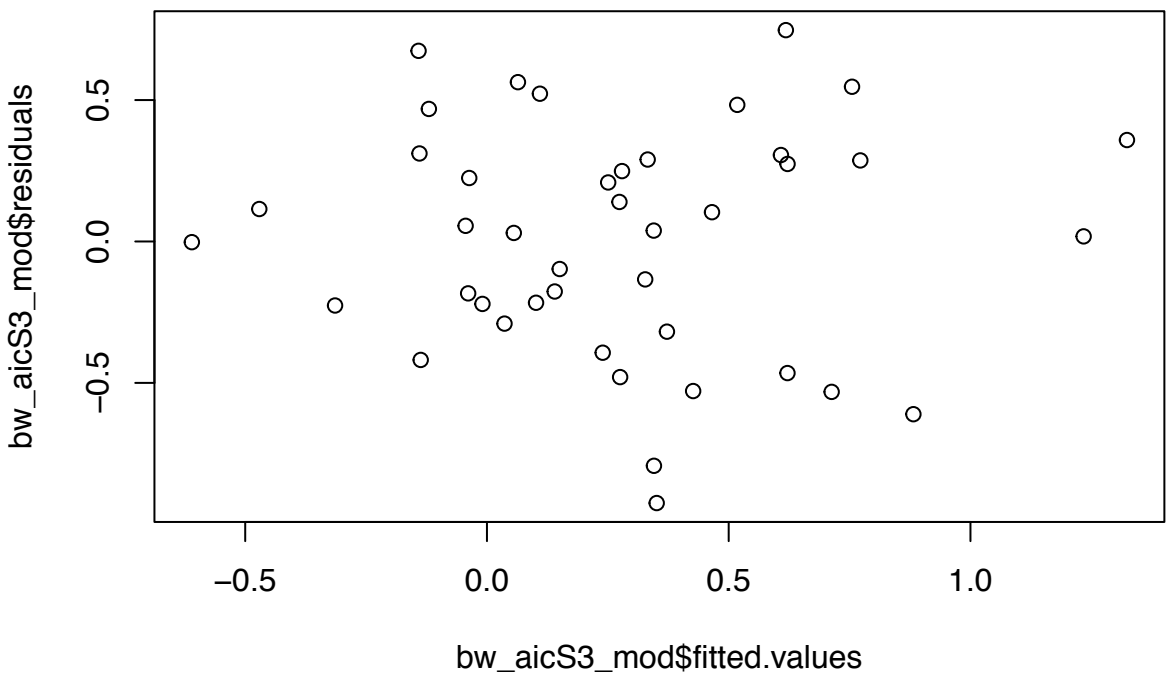
```
## - Adult_obesity_rate        1   1.56510 6.1116 -46.627
## - rate_nat_increase         1   1.69796 6.2445 -45.831
## - Clean_energy_access_prop  1   2.87404 7.4206 -39.447
##
## Step:  AIC=-56.16
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     Expenditure_health_perc + Mortality_suicide_rateT + tot_deaths
##
##                            Df Sum of Sq    RSS     AIC
## - Expenditure_health_perc   1   0.13824 4.8615 -57.094
## - Mortality_suicide_rateT   1   0.21601 4.9393 -56.507
## <none>                                  4.7233 -56.161
## - life_exp_females          1   0.48483 5.2081 -54.546
## - life_exp_males            1   0.76471 5.4880 -52.609
## - tot_fert_rateT            1   1.05613 5.7794 -50.695
## - tot_deaths                1   1.06088 5.7842 -50.664
## - rate_nat_increase         1   1.52467 6.2480 -47.810
## - Adult_obesity_rate        1   1.55771 6.2810 -47.615
## - Clean_energy_access_prop  1   2.93800 7.6613 -40.265
##
## Step:  AIC=-57.09
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     Mortality_suicide_rateT + tot_deaths
##
##                            Df Sum of Sq    RSS     AIC
## - Mortality_suicide_rateT   1   0.20612 5.0677 -57.557
## <none>                                  4.8615 -57.094
## - life_exp_females          1   0.49157 5.3531 -55.530
## - life_exp_males            1   0.83934 5.7009 -53.201
## - tot_deaths                1   0.94089 5.8024 -52.548
## - tot_fert_rateT            1   1.27079 6.1323 -50.502
## - Adult_obesity_rate        1   1.75914 6.6207 -47.667
## - rate_nat_increase         1   1.78164 6.6432 -47.541
## - Clean_energy_access_prop  1   2.86251 7.7241 -41.963
##
## Step:  AIC=-57.56
## DIF_rank ~ rate_nat_increase + tot_fert_rateT + life_exp_males +
##     life_exp_females + Clean_energy_access_prop + Adult_obesity_rate +
##     tot_deaths
##
##                            Df Sum of Sq    RSS     AIC
## <none>                                  5.0677 -57.557
## - life_exp_females          1   0.42997 5.4976 -56.544
## - tot_deaths                1   0.82446 5.8921 -53.980
## - life_exp_males            1   0.85349 5.9212 -53.798
## - tot_fert_rateT            1   1.34302 6.4107 -50.859
## - Adult_obesity_rate        1   1.58088 6.6485 -49.511
## - rate_nat_increase         1   1.75892 6.8266 -48.533
## - Clean_energy_access_prop  1   2.67314 7.7408 -43.883
```

```
# ---- Final Model: Mortality_suicide_rateT, life_exp_females, life_exp_males, tot_deaths,
# rate_nat_increase, tot_fert_rateT, Adult_obesity_rate, Clean_energy_access_prop
```

```
bw_aicS3_mod <- lm(DIF_rank~rate_nat_increase + tot_fert_rateT + life_exp_males + life_exp_females + Cl
summary(bw_aicS3_mod)
```

```
##
## Call:
## lm(formula = DIF_rank ~ rate_nat_increase + tot_fert_rateT +
##     life_exp_males + life_exp_females + Clean_energy_access_prop +
##     Adult_obesity_rate + tot_deaths, data = df_merge_third)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.92482 -0.27439  0.03433  0.28891  0.74720
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                3.815e+00  1.856e+00   2.056 0.047567 *
## rate_nat_increase          1.886e+00  4.727e-01   3.989 0.000334 ***
## tot_fert_rateT            -4.038e+00  1.080e+00  -3.739 0.000679 ***
## life_exp_males            -1.367e-01  5.904e-02  -2.315 0.026769 *
## life_exp_females           9.013e-02  5.658e-02   1.593 0.120472
## Clean_energy_access_prop   1.497e-02  4.374e-03   3.421 0.001638 **
## Adult_obesity_rate        -3.407e-02  1.560e-02  -2.184 0.035961 *
## tot_deaths                -1.768e-06  1.032e-06  -1.713 0.095816 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4453 on 34 degrees of freedom
## Multiple R-squared:  0.4968, Adjusted R-squared:  0.3932
## F-statistic: 4.795 on 7 and 34 DF,  p-value: 0.00078
```

```
plot(bw_aicS3_mod$residuals ~ bw_aicS3_mod$fitted.values)
```



```
vif(bw_aicS3_mod)
```

```
##        rate_nat_increase           tot_fert_rateT           life_exp_males
##                28.478025                31.615191                20.731520
##         life_exp_females Clean_energy_access_prop       Adult_obesity_rate
##                22.406557                 3.446352                 2.094697
##              tot_deaths
##                 1.475007
```

```
df_merge_second
```

```
##                    country Population rate_nat_increase tot_fert_rate
## 2                  Albania    3101621             0.512        1.5459
## 4                Argentina   46621847             0.810        2.1680
## 5                  Armenia    2989091             0.126        1.6520
## 8               Azerbaijan   10420515             0.628        1.8587
## 11                 Belarus    9383853            -0.394        1.5169
## 14  Bosnia and Herzegovina    3807764            -0.195        1.3718
## 15                Botswana    2417596             1.097        2.3660
## 16                  Brazil  218689757             0.654        1.7500
## 17                Bulgaria    6827736            -0.634        1.5073
## 25                   China 1413142846             0.187        1.4500
## 26                Colombia   49336454             0.722        1.9434
## 28              Costa Rica    5256612             0.906        1.8565
## 32      Dominican Republic   10790744             1.149        2.1980
## 33                 Ecuador   17483326             1.101        2.0180
## 34                   Egypt  109546720             1.616        2.7620
## 35             El Salvador    6602370             1.157        2.0360
## 37                Eswatini    1130043             1.330        2.4060
## 41                   Gabon    2397368             2.030        3.2600
## 42                 Georgia    4936390             0.003        1.7494
## 46               Guatemala   17980803             1.699        2.5700
## 53               Indonesia  279476346             0.828        1.9860
## 54                    Iraq   41266109             2.034        3.1740
## 58                 Jamaica    2820982             0.833        2.0520
## 60                  Jordan   11086716             1.890        2.9140
## 61              Kazakhstan   19543464             0.687        2.0820
## 69                   Libya    7252573             1.743        3.0400
## 74                Malaysia   34219975             0.867        1.7403
## 75                Maldives     389568             1.113        1.7040
## 79               Mauritius    1309448             0.087        1.3530
## 80                  Mexico  129875529             0.688        1.7348
## 81                Mongolia    3255468             0.904        1.8900
## 82              Montenegro     602445             0.074        1.8073
## 85                 Namibia    2777232             1.804        2.9380
## 92         North Macedonia    2133410             0.072        1.5197
## 96                Paraguay    7439863             1.125        1.8849
## 97                    Peru   32440172             0.592        2.1760
## 105                 Serbia    6693375            -0.625        1.4629
## 110           South Africa   58048332             0.899        2.1660
## 112              Sri Lanka   23326272             0.707        1.9679
## 116               Thailand   69794997             0.218        1.5415
## 119           Turkmenistan    5690818             1.120        2.0280
## 121                Ukraine   43306477            -0.491        1.5664
```

```
##     life_exp_males life_exp_females death_rate Clean_energy_access_prop
## 2            77.04            82.55       7.36                       81
## 4            75.49            81.81       7.28                      100
## 5            73.13            79.91       9.54                       98
## 8            71.36            77.66       6.92                       97
## 11           69.20            80.20      12.81                      100
## 14           75.28            81.38      10.26                       45
## 15           63.98            68.16       8.98                       65
## 16           72.56            79.81       6.90                       96
## 17           72.64            79.21      14.31                       NA
## 25           75.50            81.20       7.82                       79
## 26           71.27            78.69       7.84                       93
## 28           77.23            82.65       4.97                       96
## 32           71.15            74.60       6.31                       92
## 33           75.32            81.32       5.18                       94
## 34           73.53            75.98       4.32                      100
## 35           72.16            79.27       5.92                       92
## 37           58.17            62.33       9.53                       55
## 41           68.30            71.81       5.59                       88
## 42           73.72            81.96      10.76                       89
## 46           71.17            75.30       4.89                       50
## 53           71.10            75.68       6.77                       84
## 54           71.58            75.42       3.88                       99
## 58           74.25            77.85       7.44                       83
## 60           74.77            77.84       3.47                      100
## 61           67.73            77.56       8.05                       93
## 69           75.20            79.76       3.45                       NA
## 74           74.77            78.12       5.72                       96
## 75           74.84            79.66       4.20                       99
## 79           72.32            78.13       8.95                       97
## 80           70.29            76.79       7.07                       85
## 81           67.49            76.02       6.33                       52
## 82           75.57            80.50      10.30                       62
## 85           65.00            69.14       6.64                       47
## 92           74.99            79.32       9.61                       78
## 96           75.97            81.38       4.90                       69
## 97           65.38            72.67      11.04                       85
## 105          72.46            77.85      15.12                       80
## 110          64.26            66.96       9.25                       87
## 112          74.83            81.78       6.54                       32
## 116          74.92            81.05       7.86                       84
## 119          69.10            75.26       5.96                      100
## 121          69.10            78.64      13.70                       95
##     Harmful_air_mean_conc Mortality_homicide_rate Adult_obesity_rate
## 2                    19.3                     3.6               21.7
## 4                    12.3                     6.1               28.3
## 5                    45.5                     3.8               20.2
## 8                    23.2                     2.5               19.9
## 11                   18.1                     2.7               24.5
## 14                   30.7                     1.5               17.9
## 15                   25.0                    16.9               18.9
## 16                   11.8                    32.6               22.1
## 17                   21.1                     1.2               25.0
## 25                   48.8                     0.8                6.2
```

```
## 26                  19.0                  38.3                 22.3
## 28                  18.6                  12.6                 25.7
## 32                  16.5                  17.8                 27.6
## 33                  19.7                   7.0                 19.9
## 34                  73.0                   4.1                 32.0
## 35                  29.3                  85.0                 24.6
## 37                  19.8                  18.5                 16.5
## 41                  41.5                   8.5                 15.0
## 42                  27.0                   2.3                 21.7
## 46                  30.9                  25.1                 21.2
## 53                  20.7                   4.3                  6.9
## 54                  56.4                  14.4                 30.4
## 58                  15.4                  50.3                 24.7
## 60                  32.8                   2.7                 35.5
## 61                  25.6                   5.1                 21.0
## 69                  46.4                   2.1                 32.5
## 74                  17.1                   2.7                 15.6
## 75                  10.4                   1.9                  8.6
## 79                   9.5                   2.3                 10.8
## 80                  22.8                  25.4                 28.9
## 81                  60.0                   6.1                 20.6
## 82                  19.4                   2.8                 23.3
## 85                  20.5                  18.0                 17.2
## 92                  33.6                   1.5                 22.4
## 96                  12.0                   8.0                 20.3
## 97                  33.3                   9.3                 19.7
## 105                 25.1                   1.2                 21.5
## 110                 29.4                  35.9                 28.3
## 112                 16.8                   2.3                  5.2
## 116                 31.9                   4.3                 10.0
## 119                 33.3                   2.8                 18.6
## 121                 14.9                   6.3                 24.1
##     Tobacco_use_rate Expenditure_health_perc Mortality_suicide_rate
## 2               22.4                     NA                    4.3
## 4               24.5                   15.5                    8.4
## 5               25.5                    5.7                    3.3
## 8               24.0                    3.9                    4.1
## 11              30.5                   11.0                   21.2
## 14              35.0                   15.4                   10.9
## 15              19.4                   14.3                   16.1
## 16              12.8                   10.5                    6.9
## 17              39.0                   11.6                    9.7
## 25              25.6                    8.8                    8.1
## 26               8.5                   16.9                    3.9
## 28               8.8                   24.1                    8.1
## 32              10.6                   16.3                    4.9
## 33              11.3                   13.3                    7.6
## 34              24.3                    4.7                    3.0
## 35               7.9                   16.9                    6.0
## 37               9.2                   10.0                   29.4
## 41                NA                    9.6                    8.4
## 42              31.7                    9.4                    9.2
## 46              10.9                   17.6                    5.9
## 53              37.6                    8.7                    2.4
```

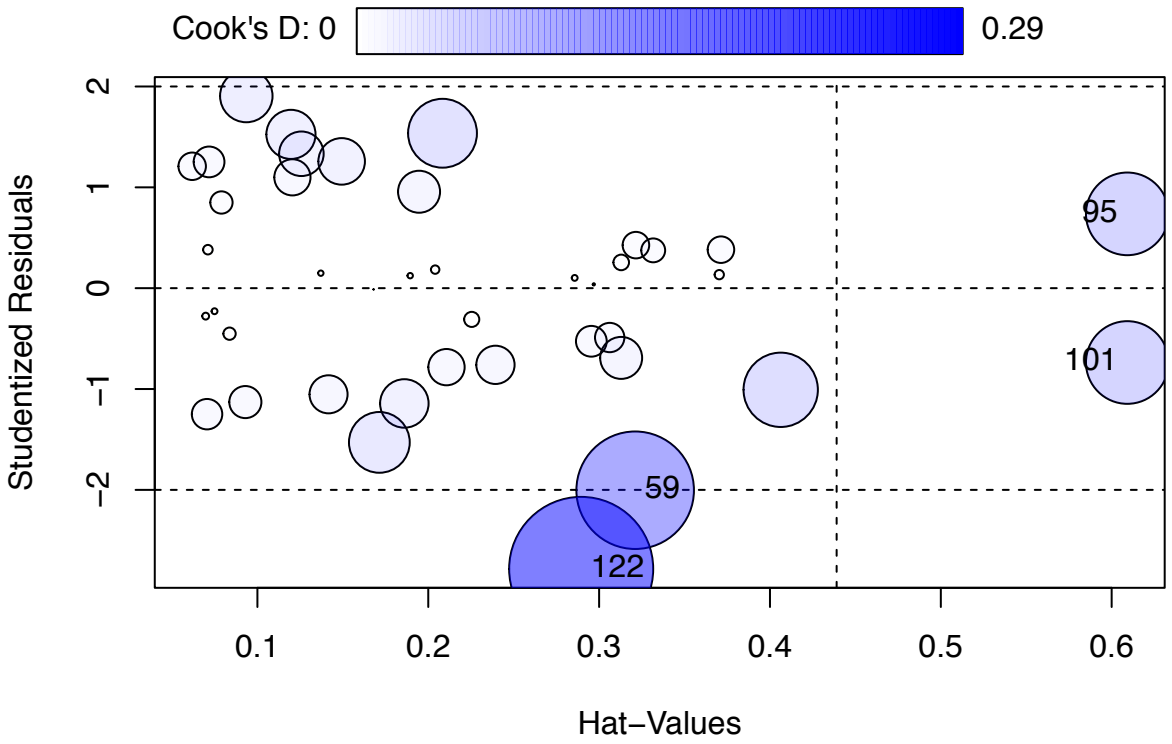
```
## 54              18.5                   6.0                   3.6
## 58               9.4                  13.3                   2.4
## 60              34.8                  12.8                   1.6
## 61              23.2                   8.2                  17.6
## 69                NA                    NA                   4.5
## 74              22.5                   8.5                   5.7
## 75              25.2                  19.1                   2.7
## 79              20.2                  10.2                   9.5
## 80              13.1                  10.3                   5.3
## 81              29.4                   6.8                  17.9
## 82              31.4                  11.3                  21.0
## 85              15.1                  10.7                   9.7
## 92                NA                  13.6                   9.4
## 96              11.5                  14.4                   6.0
## 97               8.1                  15.4                   2.8
## 105             39.8                  12.0                  11.4
## 110             20.3                  15.3                  23.5
## 112             22.0                   9.2                  14.0
## 116             22.1                  13.9                   8.8
## 119              5.5                   8.7                   5.7
## 121             25.8                   7.7                  21.6
##     Alcohol_consuption_liters Univ_hc tot_deaths cpi_score GDP_rank WH_rank
## 2                         6.8       1       3596        36      109      91
## 4                         9.5       1     130124        38       84      56
## 5                         4.7       0       8710        46      121      84
## 8                         1.0       0      10008        23      117      88
## 11                       11.0       0       7118        39      103      73
## 14                        7.8       0      16234        34      102      63
## 15                        6.6       1       2786        60      106     143
## 16                        7.3       1     693734        38      101      34
## 17                       12.5       1      38106        43       79      86
## 25                        6.0       1      48738        45       76      82
## 26                        5.5       1     142179        39      112      51
## 28                        4.1       1       9085        54       75      16
## 32                        6.7       0       4384        32       96      72
## 33                        3.3       0      35948        36      114      65
## 34                        0.1       1      24802        30      137     129
## 35                        4.1       0       4230        33      127      48
## 37                        8.8       0       1422        30      133     127
## 41                        8.1       0        306        29       98     110
## 42                        9.5       1      16903        56      120     106
## 46                        1.6       0      19998        24      122      30
## 53                        0.2       1     160612        34      131      80
## 54                        0.4       0      25374        23      124     109
## 58                        4.2       0       3463        44      119      36
## 60                        0.5       0      14122        47      132     124
## 61                        5.0       0      19058        36       86      44
## 69                        0.0       0       6437        17      115      78
## 74                        0.9       1      36853        47       83      79
## 75                        2.8       1        311        40       85      87
## 79                        4.8       1       1040        50       93      49
## 80                        5.0       1     331494        31       87      35
## 81                        5.9       0       2136        33      128      69
## 82                       12.2       0       2791        45       90      71
```

```
## 85                       3.1       0       4082        49      123      122
## 92                       6.4       0       9614        40      108       92
## 96                       7.0       0      19688        28      113       70
## 97                       6.8       1     218178        36      107       62
## 105                      8.9       1      17515        36       94       47
## 110                      9.5       1     102568        43      105      101
## 112                      2.9       1      16817        36      136      126
## 116                      8.5       1      33669        36      104       53
## 119                      3.1       0          0        19       95       95
## 121                      8.3       0     110813        33      126      108
##     GDP_rank_std WH_rank_std    DIF_rank PopulationT tot_fert_rateT
## 2     0.03294622  0.41251058 -0.37956435    14.94744      0.4356063
## 4    -0.37888157 -0.39667279  0.01779122    17.65758      0.7738051
## 5     0.23062356  0.25067390 -0.02005034    14.91048      0.5019867
## 8     0.16473112  0.34315200 -0.17842089    16.15929      0.6198773
## 11   -0.06589245 -0.00364087 -0.06225158    16.05450      0.4166688
## 14   -0.08236556 -0.23483612  0.15247056    15.15255      0.3161237
## 15   -0.01647311  1.61472587 -1.63119898    14.69828      0.8612008
## 16   -0.09883867 -0.90530234  0.80646367    19.20316      0.5596158
## 17   -0.46124713  0.29691295 -0.75816008    15.73650      0.4103200
## 25   -0.51066646  0.20443485 -0.71510131    21.06908      0.3715636
## 26    0.08236556 -0.51227042  0.59463597    17.71417      0.6644390
## 28   -0.52713957 -1.32145378  0.79431421    15.47500      0.6186930
## 32   -0.18120423 -0.02676039 -0.15444383    16.19420      0.7875479
## 33    0.11531178 -0.18859707  0.30390885    16.67676      0.7021069
## 34    0.49419335  1.29105252 -0.79685917    18.51186      1.0159551
## 35    0.32946223 -0.58162899  0.91109122    15.70294      0.7109871
## 37    0.42830090  1.24481347 -0.81651257    13.93777      0.8779656
## 41   -0.14825800  0.85178155 -1.00003955    14.68988      1.1817272
## 42    0.21415045  0.75930345 -0.54515300    15.41214      0.5592729
## 46    0.24709667 -0.99778044  1.24487711    16.70482      0.9439059
## 53    0.39535468  0.15819580  0.23715888    19.44843      0.6861226
## 54    0.28004290  0.82866202 -0.54861912    17.53555      1.1549926
## 58    0.19767734 -0.85906329  1.05674063    14.85260      0.7188149
## 60    0.41182779  1.17545490 -0.76362710    16.22126      1.0695267
## 61   -0.34593534 -0.67410709  0.32817174    16.78815      0.7333290
## 69    0.13178489  0.11195675  0.01982814    15.79687      1.1118575
## 74   -0.39535468  0.13507628 -0.53043096    17.34832      0.5540575
## 75   -0.36240846  0.32003248 -0.68244093    12.87279      0.5329784
## 79   -0.23062356 -0.55850947  0.32788590    14.08512      0.3023243
## 80   -0.32946223 -0.88218281  0.55272058    18.68209      0.5508921
## 81    0.34593534 -0.09611897  0.44205431    14.99585      0.6365768
## 82   -0.28004290 -0.04987992 -0.23016298    13.30875      0.5918340
## 85    0.26356979  1.12921585 -0.86564606    14.83697      1.0777291
## 92    0.01647311  0.43563010 -0.41915699    14.57323      0.4185129
## 96    0.09883867 -0.07299944  0.17183811    15.82236      0.6338748
## 97    0.00000000 -0.25795564  0.25795564    17.29491      0.7774883
## 105  -0.21415045 -0.60474852  0.39059806    15.71663      0.3804208
## 110  -0.03294622  0.64370582 -0.67665205    17.87679      0.7728821
## 112   0.47772024  1.22169394 -0.74397371    16.96509      0.6769670
## 116  -0.04941933 -0.46603137  0.41661203    18.06107      0.4327560
## 119  -0.19767734  0.50498868 -0.70266602    15.55436      0.7070501
## 121   0.31298912  0.80554250 -0.49255338    17.58381      0.4487800
##     Harmful_air_mean_concT Mortality_homicide_rateT Mortality_suicide_rateT
```

```
## 2                2.960105              1.2809338              1.4586150
## 4                2.509599              1.8082888              2.1282317
## 5                3.817712              1.3350011              1.1939225
## 8                3.144152              0.9162907              1.4109870
## 11               2.895912              0.9932518              3.0540012
## 14               3.424263              0.4054651              2.3887628
## 15               3.218876              2.8273136              2.7788193
## 16               2.468100              3.4843123              1.9315214
## 17               3.049273              0.1823216              2.2721259
## 25               3.887730             -0.2231436              2.0918641
## 26               2.944439              3.6454499              1.3609766
## 28               2.923162              2.5336968              2.0918641
## 32               2.803360              2.8791985              1.5892352
## 33               2.980619              1.9459101              2.0281482
## 34               4.290459              1.4109870              1.0986123
## 35               3.377588              4.4426513              1.7917595
## 37               2.985682              2.9177707              3.3809947
## 41               3.725693              2.1400662              2.1282317
## 42               3.295837              0.8329091              2.2192035
## 46               3.430756              3.2228678              1.7749524
## 53               3.030134              1.4586150              0.8754687
## 54               4.032469              2.6672282              1.2809338
## 58               2.734368              3.9180051              0.8754687
## 60               3.490429              0.9932518              0.4700036
## 61               3.242592              1.6292405              2.8678989
## 69               3.837299              0.7419373              1.5040774
## 74               2.839078              0.9932518              1.7404662
## 75               2.341806              0.6418539              0.9932518
## 79               2.251292              0.8329091              2.2512918
## 80               3.126761              3.2347492              1.6677068
## 81               4.094345              1.8082888              2.8848007
## 82               2.965273              1.0296194              3.0445224
## 85               3.020425              2.8903718              2.2721259
## 92               3.514526              0.4054651              2.2407097
## 96               2.484907              2.0794415              1.7917595
## 97               3.505557              2.2300144              1.0296194
## 105              3.222868              0.1823216              2.4336134
## 110              3.380995              3.5807373              3.1570004
## 112              2.821379              0.8329091              2.6390573
## 116              3.462606              1.4586150              2.1747517
## 119              3.505557              1.0296194              1.7404662
## 121              2.701361              1.8405496              3.0726933
##     cpi_scoreT
## 2     3.583519
## 4     3.637586
## 5     3.828641
## 8     3.135494
## 11    3.663562
## 14    3.526361
## 15    4.094345
## 16    3.637586
## 17    3.761200
## 25    3.806662
## 26    3.663562
```

```
## 28    3.988984
## 32    3.465736
## 33    3.583519
## 34    3.401197
## 35    3.496508
## 37    3.401197
## 41    3.367296
## 42    4.025352
## 46    3.178054
## 53    3.526361
## 54    3.135494
## 58    3.784190
## 60    3.850148
## 61    3.583519
## 69    2.833213
## 74    3.850148
## 75    3.688879
## 79    3.912023
## 80    3.433987
## 81    3.496508
## 82    3.806662
## 85    3.891820
## 92    3.688879
## 96    3.332205
## 97    3.583519
## 105   3.583519
## 110   3.761200
## 112   3.583519
## 116   3.583519
## 119   2.944439
## 121   3.496508
```

```
## Looking at remaining outliers from individual models

influencePlot(bw_aicS1_mod, col=c(1,1))
```




```
##        StudRes       Hat      CookD
## 59  -2.0035781 0.3211073 0.19280719
## 95   0.7369986 0.6091450 0.09542023
## 101 -0.7369986 0.6091450 0.09542023
## 122 -2.7836429 0.2894979 0.28970627
```

```
"High Residual, high cooks distance"
```

```
## [1] "High Residual, high cooks distance"
```

```
df_merge[122, 1]
```

```
## [1] "United Arab Emirates"
```

```
df_merge[59, 1]
```

```
## [1] "Japan"
```

```
"High Leverage, low residual, low studentized residual"
```

```
## [1] "High Leverage, low residual, low studentized residual"
```

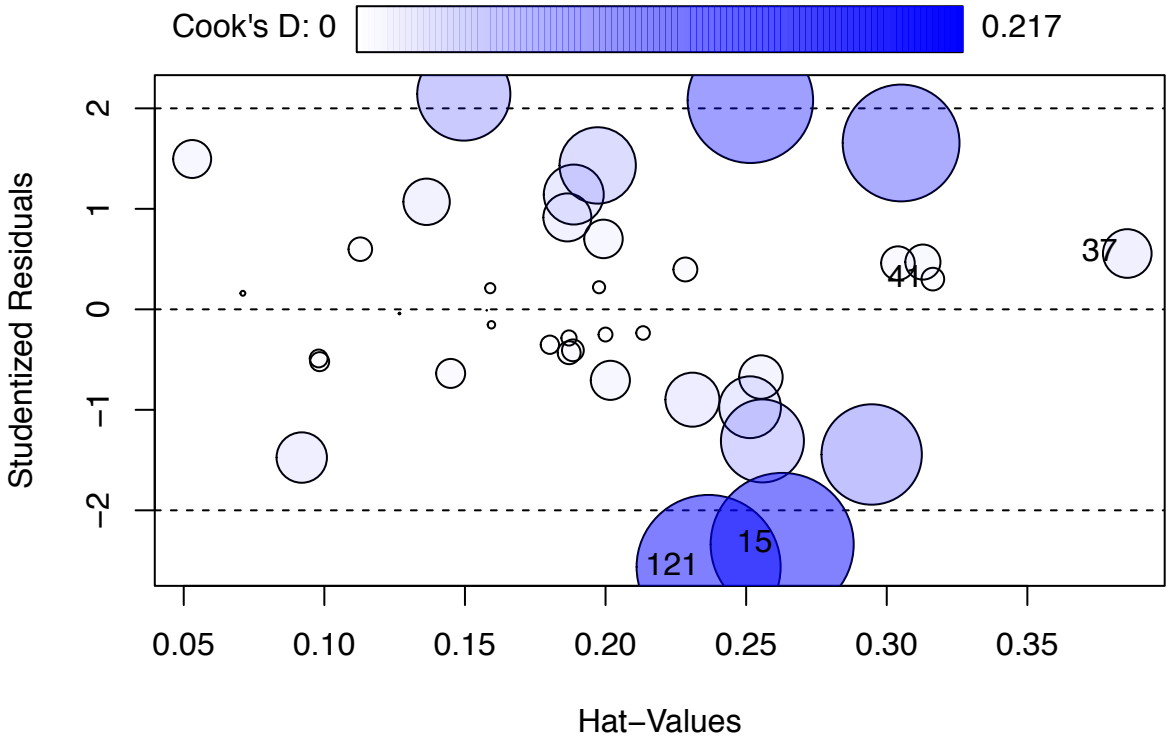
```
df_merge[95, 1]
```

```
## [1] "Panama"
```

```
df_merge[101, 1]
```

```
## [1] "Romania"
```

```
influencePlot(bw_aicS2_mod, col=c(1,1))
```




```
##         StudRes       Hat       CookD
## 15  -2.3395278 0.2628064 0.213990552
## 37   0.5555602 0.3855372 0.024741654
## 41   0.3006099 0.3163881 0.005380854
## 121 -2.5635556 0.2366514 0.216904887
```

```
"High Residual, high cooks distance"
```

```
## [1] "High Residual, high cooks distance"
```

```
df_merge[121, 1]
```

```
## [1] "Ukraine"
```

```
df_merge[15, 1]
```

```
## [1] "Botswana"
```

```
"High Leverage, low residual, low studentized residual"
```

```
## [1] "High Leverage, low residual, low studentized residual"
```

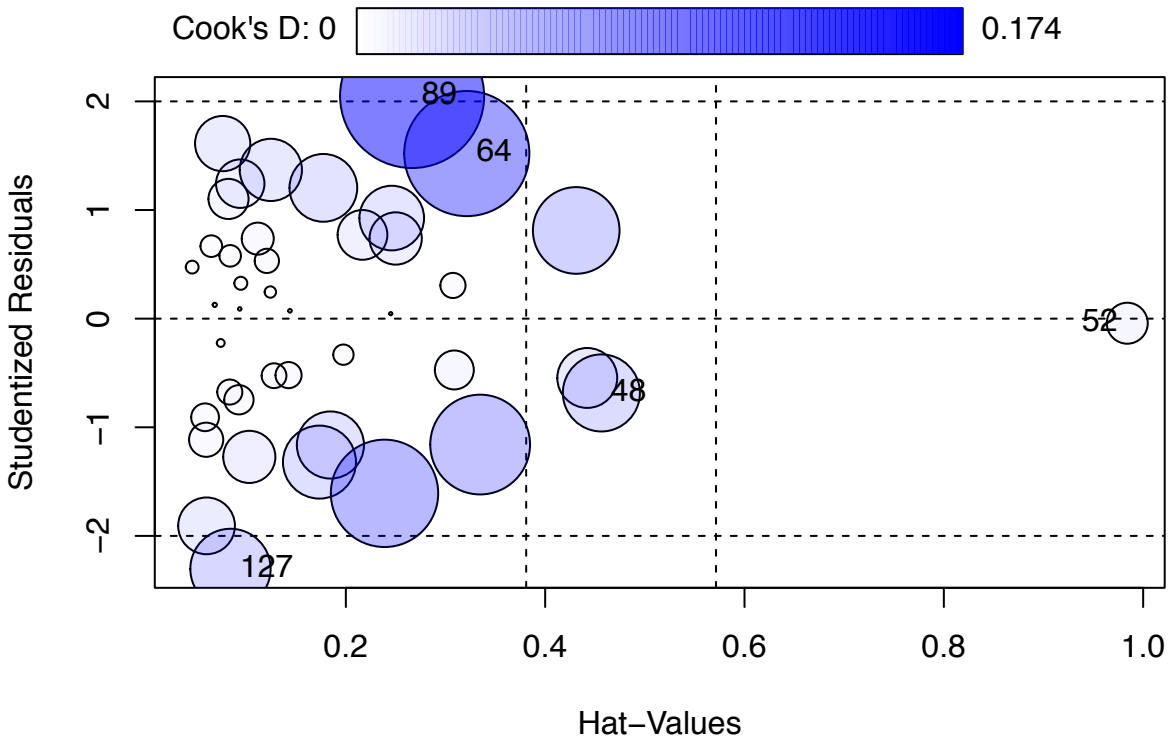
```
df_merge[37, 1]
```

```
## [1] "Eswatini"
```

```
df_merge[41, 1]
```

```
## [1] "Gabon"
```

```
influencePlot(bw_aicS3_mod, col=c(1,1))
```




```
##         StudRes        Hat      CookD
## 48  -0.68397958 0.45641117 0.04988080
## 52  -0.04211378 0.98406973 0.01410921
## 64   1.51970045 0.32136960 0.13163912
## 89   2.04938591 0.26649790 0.17433562
## 127 -2.30370653 0.08425636 0.05417428
```

```
"High Residual, high cooks distance, low leverage"
```

```
## [1] "High Residual, high cooks distance, low leverage"
```

```
df_merge[127, 1]
```

```
## [1] "Zimbabwe"
```

```
df_merge[89, 1]
```

```
## [1] "Nicaragua"
```

```
df_merge[64, 1]
```

```
## [1] "Kyrgyzstan"
```

```
"High Leverage, low residual, low studentized residual"
```

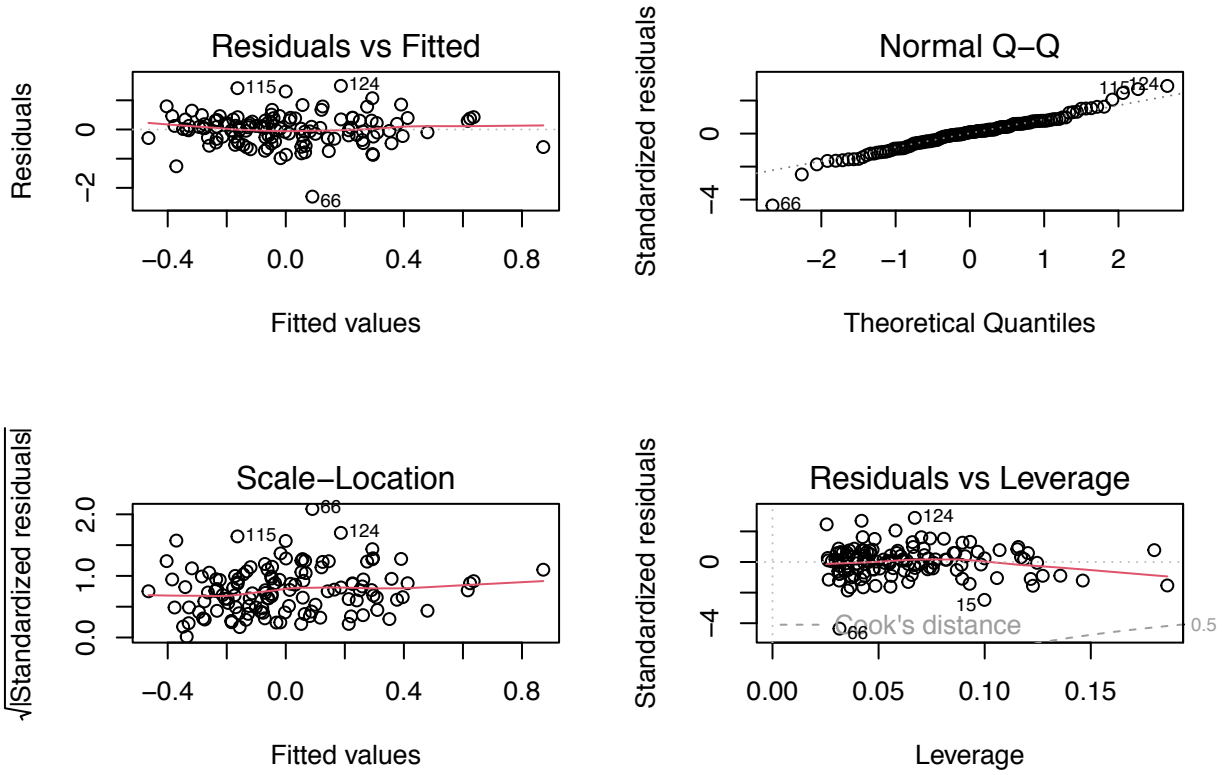
```
## [1] "High Leverage, low residual, low studentized residual"
```

```
df_merge[52, 1]
```

```
## [1] "India"
```

Model Diagnostics

```
par(mfrow=c(2,2))
plot(mod_bwAIC)
```


Residuals vs Fitted
Residuals
Fitted values
115
124
66
Normal Q–Q
Standardized residuals
Theoretical Quantiles
Scale–Location
√|Standardized residuals|
Fitted values
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
15