Analysis

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4/14/2021

Multiple Linear Regression

Data preview

Read in data

```
dt = read.csv("data&figures/dt.csv")
summary(dt)
```

```
##    State             County              HPI           Personal_Income
##  Length:2703        Length:2703        Min.   :  82.32   Min.   : 22440
##  Class :character   Class :character   1st Qu.: 184.81   1st Qu.: 38374
##  Mode  :character   Mode  :character   Median : 238.80   Median : 43578
##                                        Mean   : 311.45   Mean   : 45972
##                                        3rd Qu.: 367.36   3rd Qu.: 50469
##                                        Max.   :2266.07   Max.   :229825
##  Poverty_Percentage   Population       HighSchoolLess  HighSchoolOnly
##  Min.   : 2.70      Min.   :     728   Min.   : 1.40   Min.   : 7.80
##  1st Qu.:10.10      1st Qu.:   15785   1st Qu.: 8.20   1st Qu.:29.40
##  Median :13.10      Median :   32924   Median :11.40   Median :34.30
##  Mean   :13.83      Mean   :  167666   Mean   :12.49   Mean   :33.89
##  3rd Qu.:16.70      3rd Qu.:   90870   3rd Qu.:15.80   3rd Qu.:38.90
##  Max.   :41.10      Max.   :10039107   Max.   :46.70   Max.   :54.50
##   SomeCollege   BachelorAndHigher Unemployment_Rate
##  Min.   :11.2   Min.   : 7.20     Min.   : 1.600
##  1st Qu.:27.7   1st Qu.:15.80     1st Qu.: 3.050
##  Median :31.0   Median :20.20     Median : 3.700
##  Mean   :31.0   Mean   :22.62     Mean   : 3.928
##  3rd Qu.:34.2   3rd Qu.:27.40     3rd Qu.: 4.600
##  Max.   :47.3   Max.   :75.30     Max.   :18.300
```

Correlation Check

```
cor(scale(as.matrix(dt[,c(7,8,9,10)])))
```

Education parameters

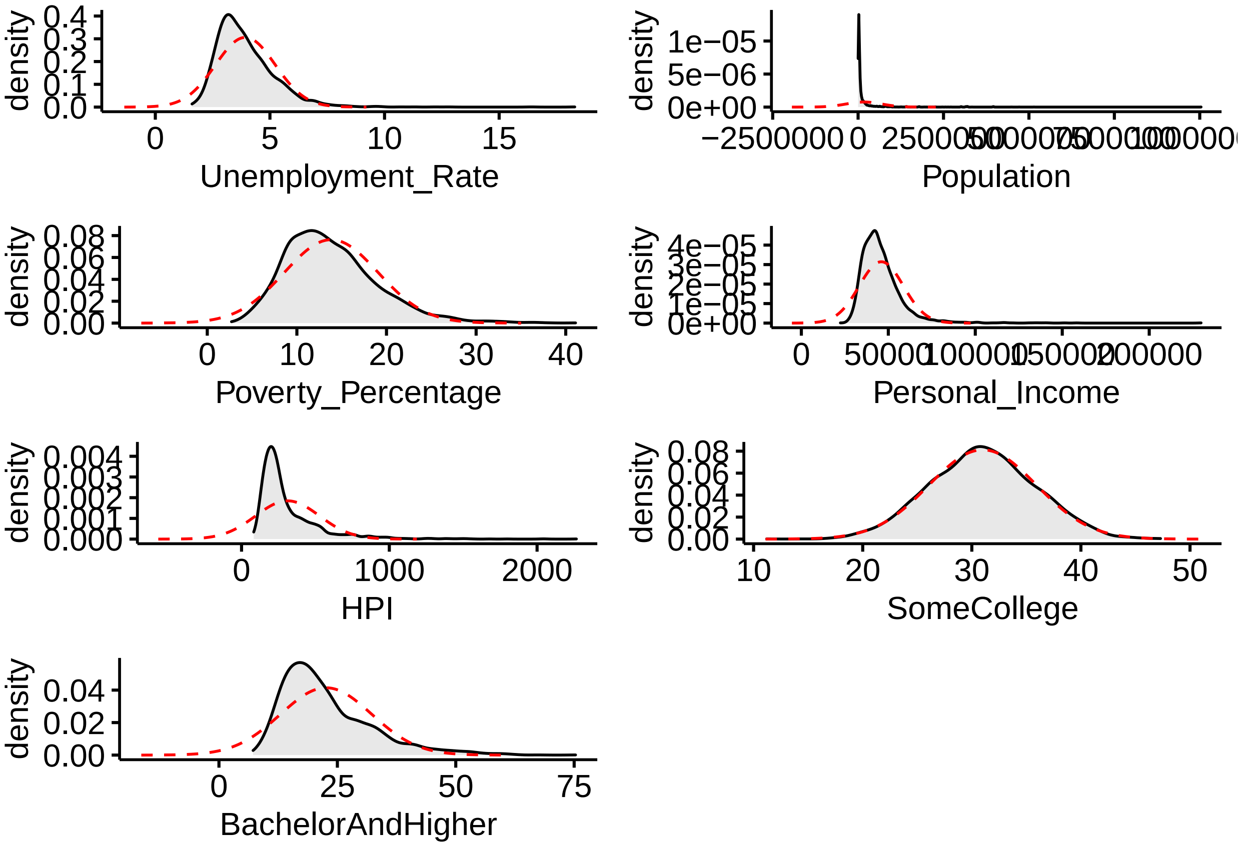
```
##                   HighSchoolLess HighSchoolOnly SomeCollege BachelorAndHigher
## HighSchoolLess         1.0000000      0.3066823 -0.41862584       -0.61009423
## HighSchoolOnly         0.3066823      1.0000000 -0.27129305       -0.80308215
## SomeCollege           -0.4186258     -0.2712931  1.00000000       -0.05682677
## BachelorAndHigher     -0.6100942     -0.8030821 -0.05682677        1.00000000
```

Histogram

```
library(ggpubr)
```

```
## Loading required package: ggplot2
```

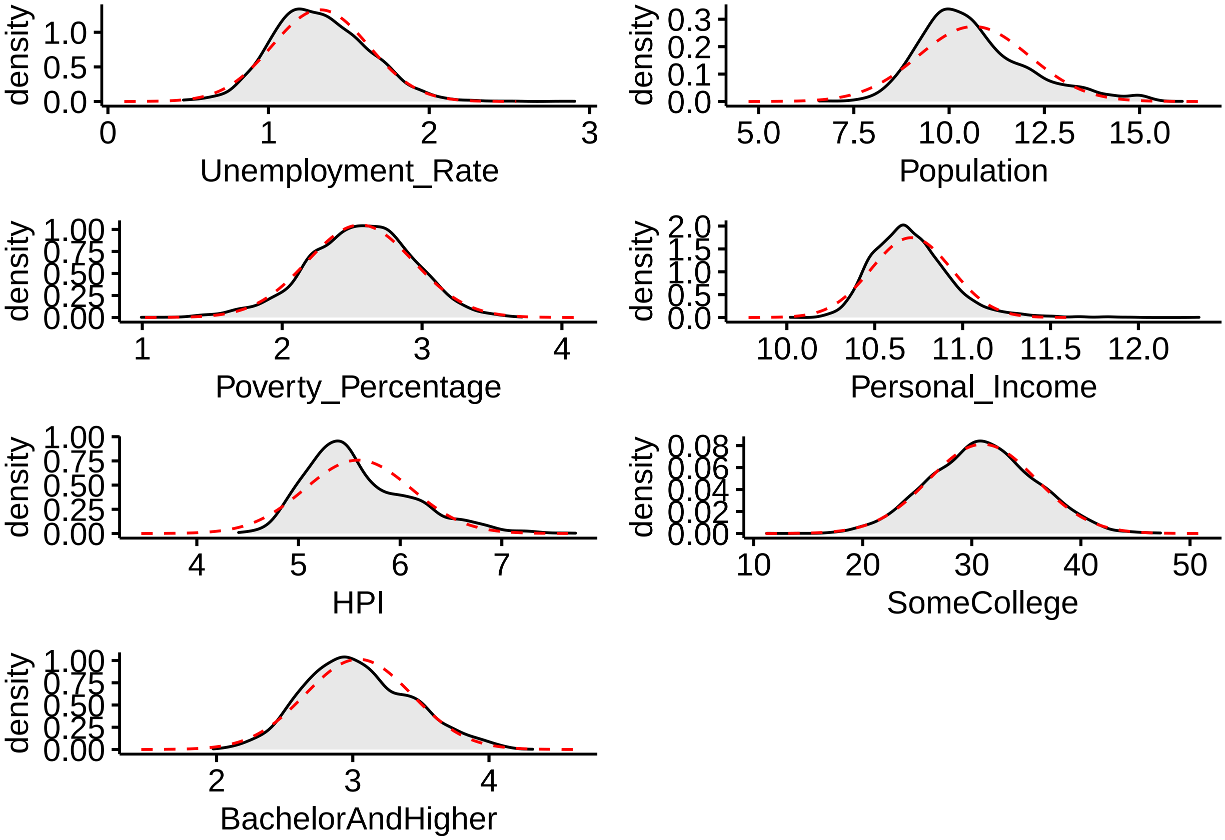
```
a<-ggdensity(dt, x = "Unemployment_Rate", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
b<-ggdensity(dt, x = "Population", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
c<-ggdensity(dt, x = "Poverty_Percentage", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
d<-ggdensity(dt, x = "Personal_Income", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
e<-ggdensity(dt, x = "HPI", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
f<-ggdensity(dt, x = "SomeCollege", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
g<-ggdensity(dt, x = "BachelorAndHigher", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
ggarrange(a,b,c,d,e,f,g, ncol = 2, nrow = 4)
```



### Histogram for logtransformation

```
temp=dt
temp$HPI <- log(dt$HPI)
temp$Personal_Income <- log(dt$Personal_Income)
temp$Poverty_Percentage <- log(dt$Poverty_Percentage)
temp$Population <- log(dt$Population)
temp$HighSchoolLess <- log(dt$HighSchoolLess)
temp$BachelorAndHigher <- log(dt$BachelorAndHigher)
temp$Unemployment_Rate <- log(dt$Unemployment_Rate)
```

```
library(ggpubr)
a<-ggdensity(temp, x = "Unemployment_Rate", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
b<-ggdensity(temp, x = "Population", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
c<-ggdensity(temp, x = "Poverty_Percentage", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
d<-ggdensity(temp, x = "Personal_Income", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
e<-ggdensity(temp, x = "HPI", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
f<-ggdensity(temp, x = "SomeCollege", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
g<-ggdensity(temp, x = "BachelorAndHigher", fill = "lightgray") +
  stat_overlay_normal_density(color = "red", linetype = "dashed")
ggarrange(a,b,c,d,e,f,g, ncol = 2, nrow = 4)
```



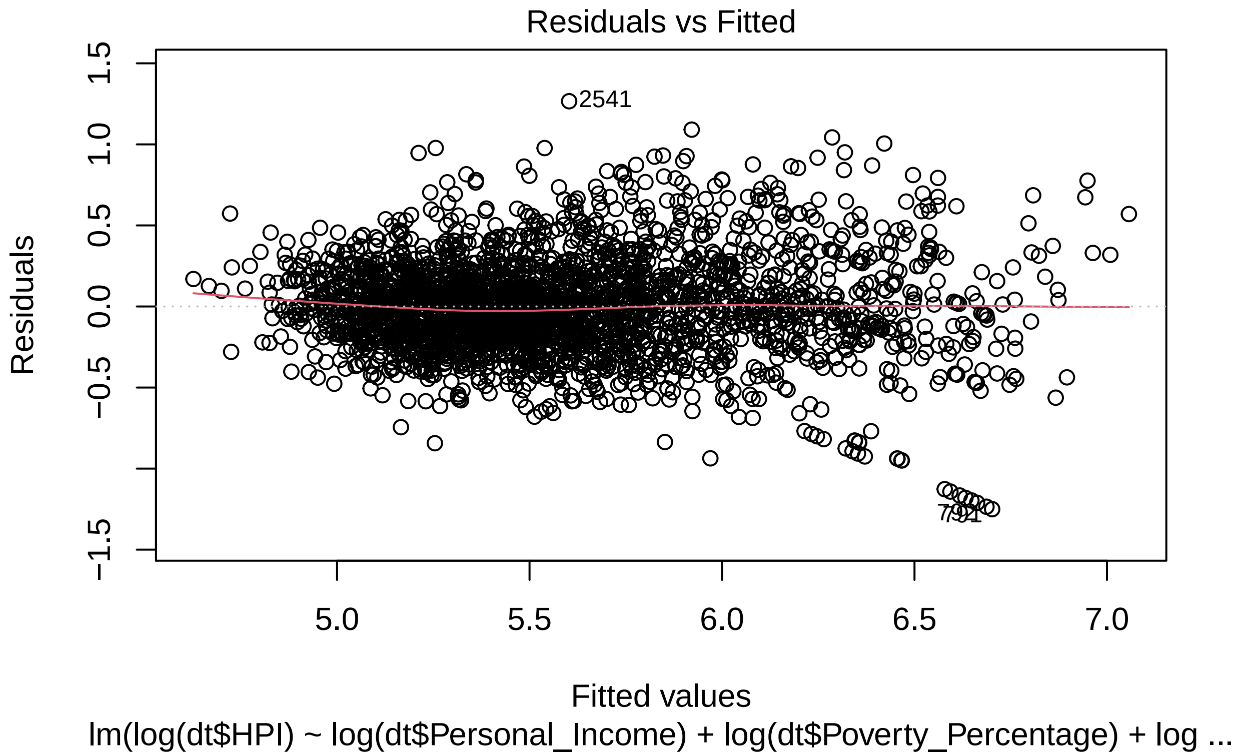
Model fitting

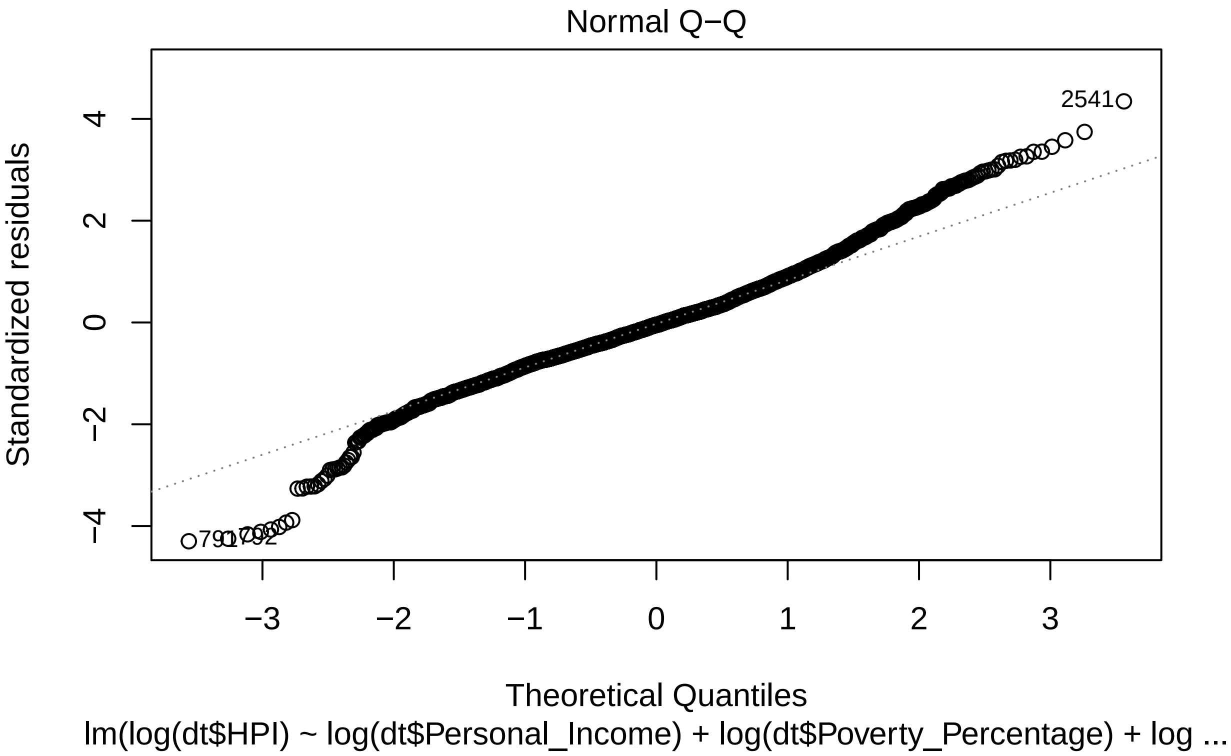
```
m1 = lm(log(dt$HPI)~log(dt$Personal_Income)+log(dt$Poverty_Percentage)+log(dt$Unemployment_Rate)+log(dt
summary(m1)
```

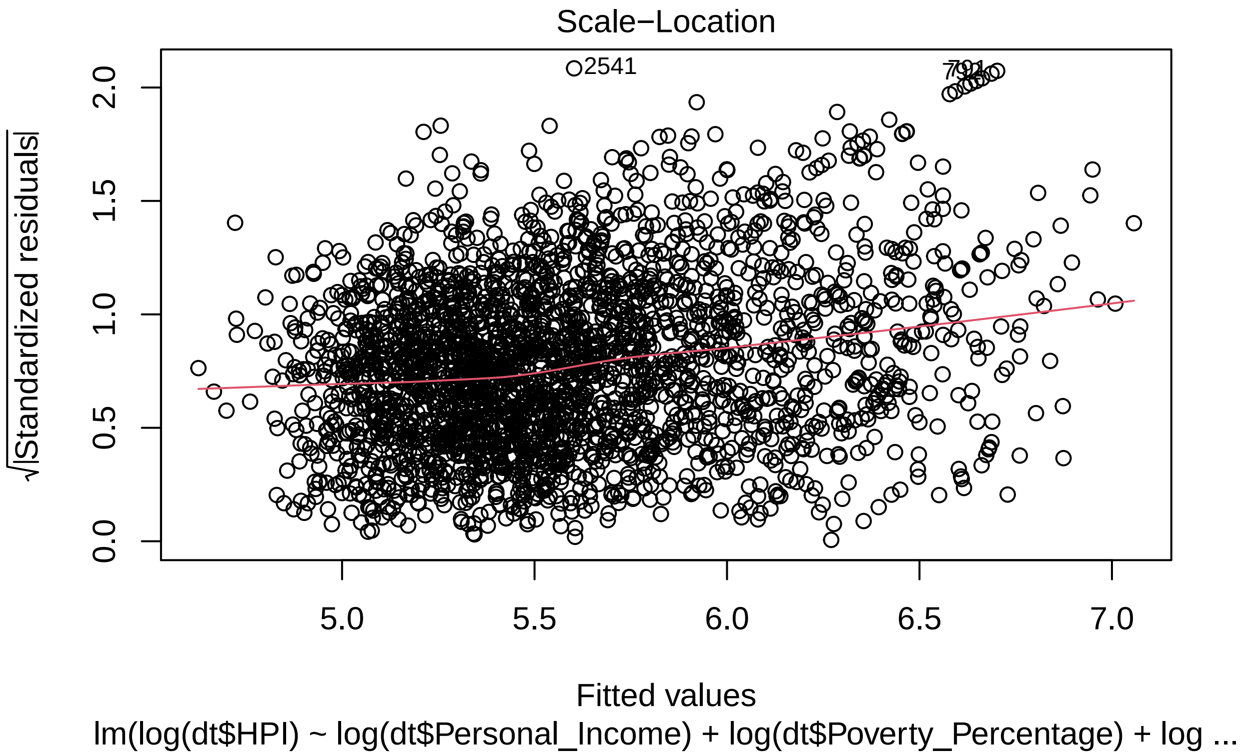
```
##
## Call:
## lm(formula = log(dt$HPI) ~ log(dt$Personal_Income) + log(dt$Poverty_Percentage) +
##     log(dt$Unemployment_Rate) + log(dt$Population) + dt$SomeCollege +
##     log(dt$BachelorAndHigher))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.25022 -0.17598 -0.01332  0.16097  1.26604
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -3.236569   0.447373  -7.235 6.06e-13 ***
## log(dt$Personal_Income)     0.526325   0.040401  13.027  < 2e-16 ***
## log(dt$Poverty_Percentage) -0.078788   0.022802  -3.455 0.000558 ***
## log(dt$Unemployment_Rate)   0.072500   0.022477   3.225 0.001273 **
## log(dt$Population)           0.199449   0.004604  43.321  < 2e-16 ***
## dt$SomeCollege               0.009598   0.001212   7.918 3.49e-15 ***
## log(dt$BachelorAndHigher)    0.286792   0.023175  12.375  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2917 on 2696 degrees of freedom
## Multiple R-squared:  0.684,  Adjusted R-squared:  0.6832
## F-statistic: 972.4 on 6 and 2696 DF,  p-value: < 2.2e-16
```

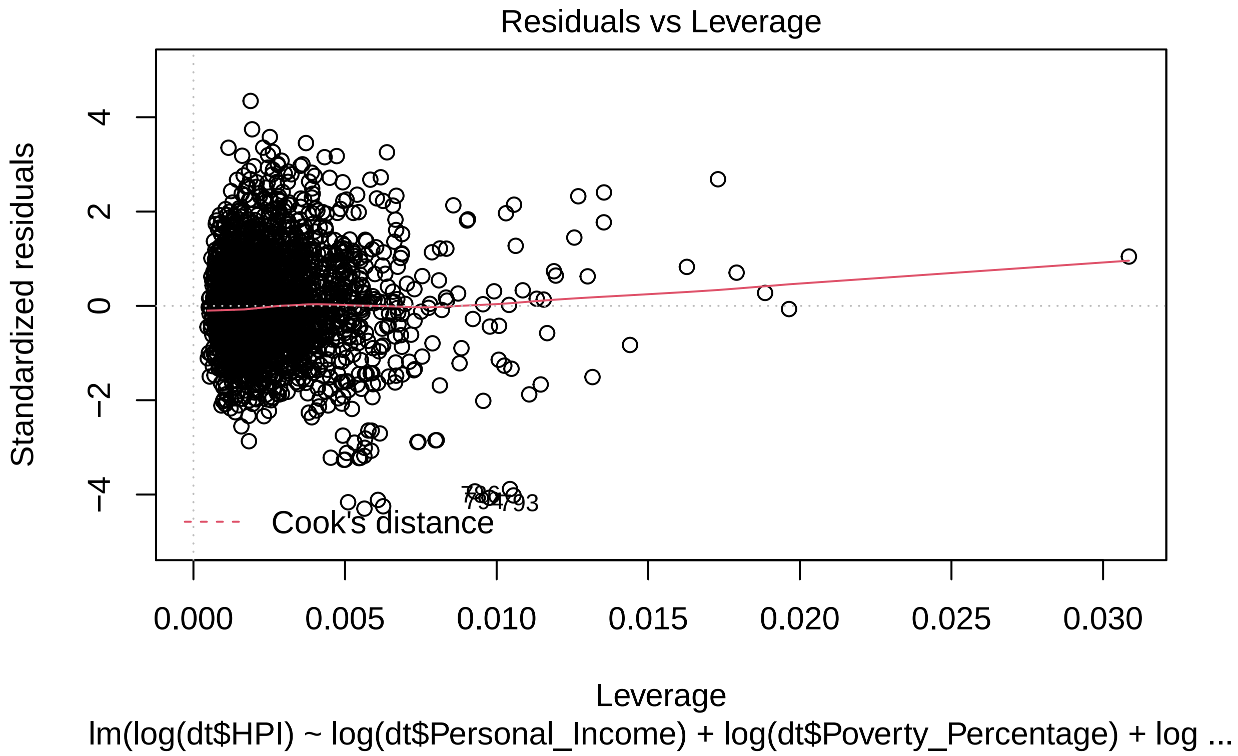
Diagnostic Plots

```r
plot(m1)
```




Normal Q−Q
Standardized residuals
4
2
0
−2
−4
2541
791
1792
−3
−2
−1
0
1
2
3
Theoretical Quantiles
lm(log(dt$HPI) ~ log(dt$Personal_Income) + log(dt$Poverty_Percentage) + log ...


Scale−Location
2541
791
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
5.0
5.5
6.0
6.5
7.0
Fitted values
lm(log(dt$HPI) ~ log(dt$Personal_Income) + log(dt$Poverty_Percentage) + log ...



```
car::vif(m1)
```

```
##    log(dt$Personal_Income) log(dt$Poverty_Percentage)
##                   2.623520                   2.307242
##  log(dt$Unemployment_Rate)         log(dt$Population)
##                   1.410572                   1.388636
##             dt$SomeCollege  log(dt$BachelorAndHigher)
##                   1.091027                   2.559650
```

correlation plot

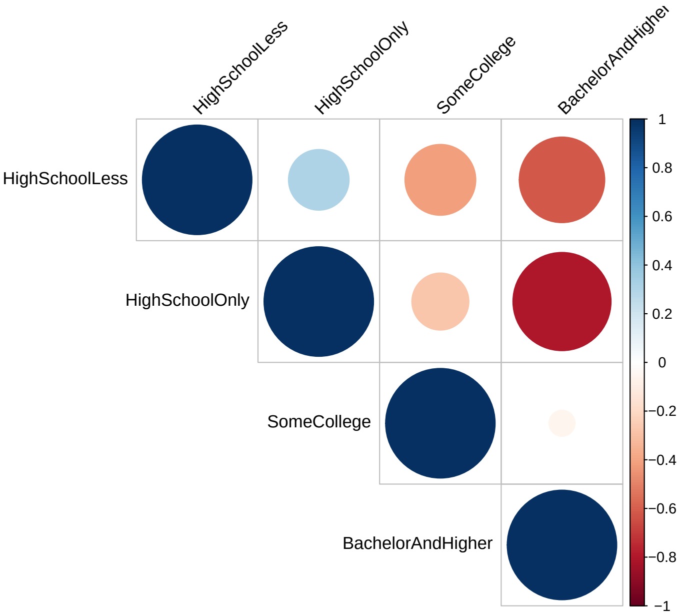
```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(corrplot)
```

```
## corrplot 0.84 loaded
```

```
df <- dt %>% dplyr::select(HighSchoolLess:BachelorAndHigher)
res <- cor(df)

corrplot(res, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 45)
```

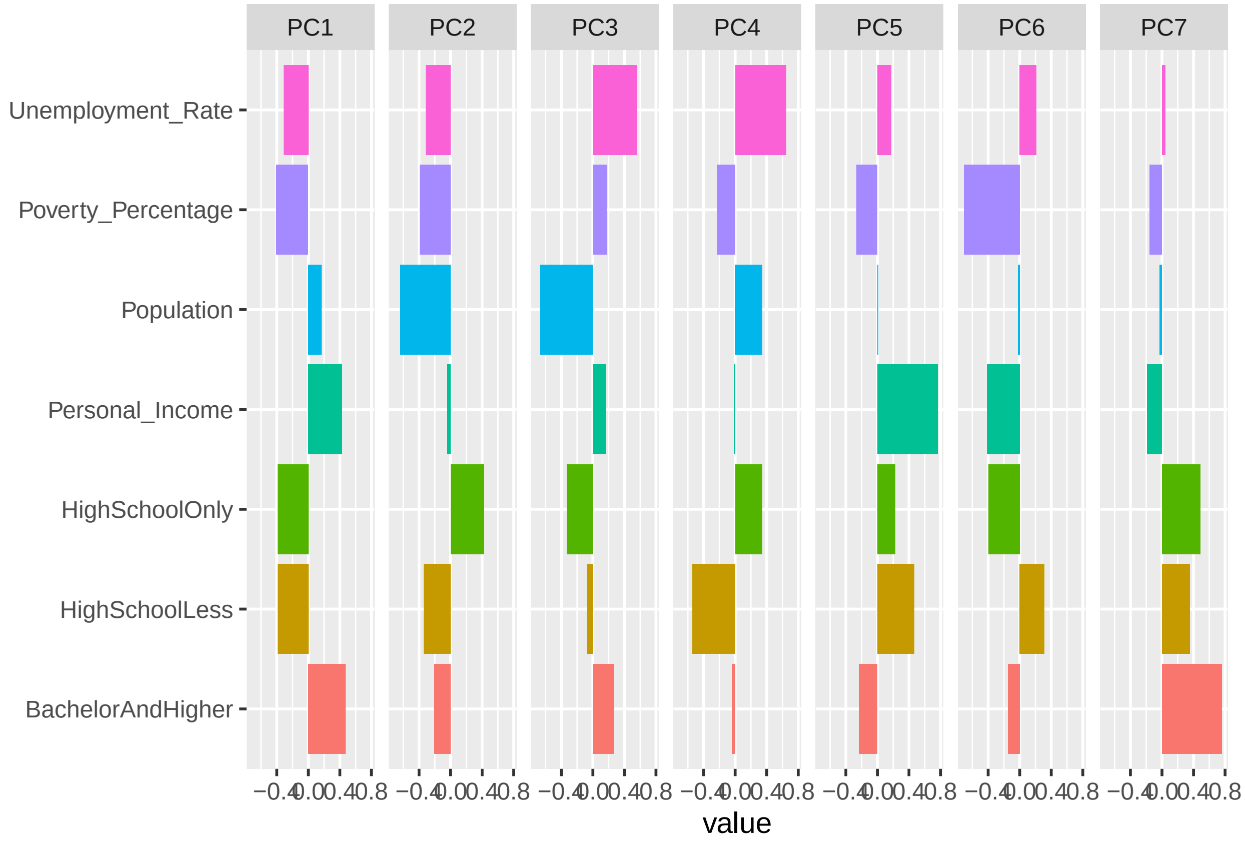


old pca

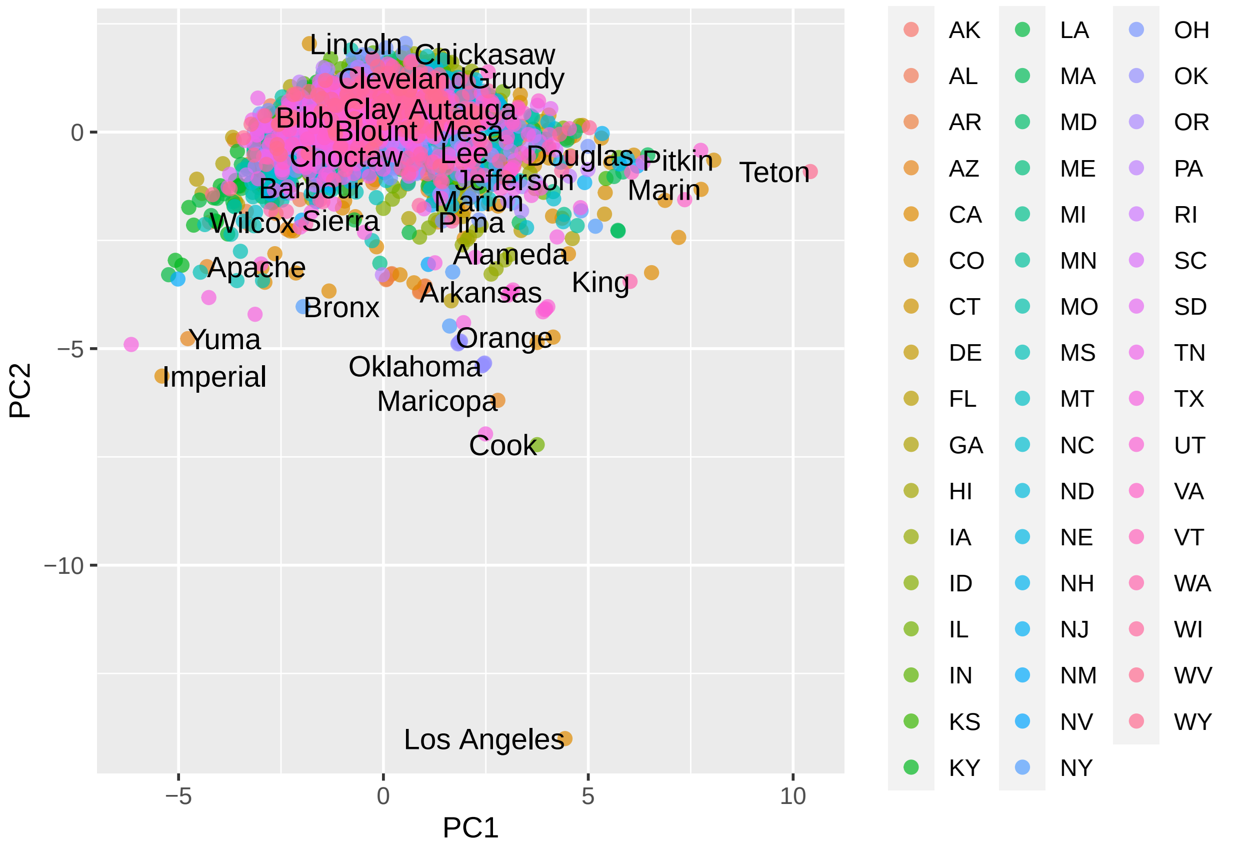
```
library("tidymodels")
```

```
## -- Attaching packages -------------------------------------- tidymodels 0.1.3 --

## v broom        0.7.6      v rsample      0.0.9
## v dials        0.0.9      v tibble       3.1.0
## v infer        0.5.4      v tidyr        1.1.3
## v modeldata    0.1.0      v tune         0.1.5
## v parsnip      0.1.5      v workflows    0.2.2
## v purrr        0.3.4      v workflowsets 0.0.2
## v recipes      0.1.16     v yardstick    0.0.8

## -- Conflicts ----------------------------------------- tidymodels_conflicts() --
## x purrr::discard() masks scales::discard()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## x recipes::step()  masks stats::step()
## * Use tidymodels_prefer() to resolve common conflicts.
```

```r
library(forcats)
pca_rec <- recipe(HPI ~., data = dt) %>%
  update_role(State, County, SomeCollege, new_role = "id") %>%
  step_normalize(all_predictors()) %>%
  step_pca(all_predictors())

pca_prep <- prep(pca_rec)
tidied_pca <- tidy(pca_prep, 2)

tidied_pca %>%
  filter(component %in% paste0("PC", 1:7)) %>%
  mutate(component = fct_inorder(component)) %>%
  ggplot(aes(value, terms, fill = terms)) +
  geom_col(show.legend = FALSE) +
  facet_wrap(~component, nrow = 1) +
  labs(y = NULL)
```



```r
juice(pca_prep) %>%
  ggplot(aes(PC1, PC2, label = County)) +
  geom_point(aes(color = State), alpha = 0.7, size = 2) +
  geom_text(check_overlap = TRUE, hjust = "inward") +
  labs(color = NULL)
```



stepwise regression

```
library(MASS)
```

```
##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##     select
```

```
# Fit the full model
full.model <- lm(HPI ~ Personal_Income + Poverty_Percentage + Population + HighSchoolLess + HighSchoolOr
# Stepwise regression model
step.model <- stepAIC(full.model, direction = "both",
                      trace = FALSE)
summary(step.model)
```

```
##
## Call:
## lm(formula = HPI ~ Personal_Income + Poverty_Percentage + Population +
##     HighSchoolLess + SomeCollege + BachelorAndHigher + Unemployment_Rate,
##     data = dt)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -543.63  -72.53  -13.70   49.97 1194.45
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)        -5.192e+02  3.937e+01 -13.188  < 2e-16 ***
## Personal_Income     3.105e-03  3.320e-04   9.352  < 2e-16 ***
## Poverty_Percentage -5.949e+00  8.334e-01  -7.138 1.21e-12 ***
## Population          9.522e-05  5.779e-06  16.478  < 2e-16 ***
## HighSchoolLess      1.312e+01  8.559e-01  15.334  < 2e-16 ***
## SomeCollege         6.434e+00  7.132e-01   9.022  < 2e-16 ***
## BachelorAndHigher   1.414e+01  5.075e-01  27.863  < 2e-16 ***
## Unemployment_Rate   1.806e+01  2.570e+00   7.027 2.67e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 146 on 2695 degrees of freedom
## Multiple R-squared:  0.5291, Adjusted R-squared:  0.5279
## F-statistic: 432.6 on 7 and 2695 DF,  p-value: < 2.2e-16
```

Collinearity Check

```r
car::vif(m1)
```

```
##    log(dt$Personal_Income) log(dt$Poverty_Percentage)
##                   2.623520                   2.307242
##  log(dt$Unemployment_Rate)         log(dt$Population)
##                   1.410572                   1.388636
##             dt$SomeCollege  log(dt$BachelorAndHigher)
##                   1.091027                   2.559650
```