# Pol Sci 630: Problem Set 4 - Regression Model Estimation

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Due Date: Tuesday, September 22nd, 2015, 10 AM (Beginning of Class)

Note 1: It is absolutely essential that you show all your work, including intermediary steps, and comment on your R code to earn full credit.

Note 2: Please use a *single* PDF file created through knitr to submit your answers. knitr allows you to combine R code and LaTeX code in one document, meaning that you can include both the answers to R programming and math problems. Also submit the source code that generates the PDF file (i.e. .Rnw file)

Note 3: Make sure that the PDF files you submit do not include any references to your identity. The grading will happen anonymously. You can submit your answer at the following website: `http://ps630-f15.herokuapp.com/`

## 1. Create a data frame (4 points)

### a)

First, `set.seed(2)`. Then, create a data frame with 1000 rows and 3 variables as follows:

1. `var_norm`: a normal variable with mean = 5, sd = 10
2. `var_binom`: a binomial variable with number of trial = 10, probability of success = 0.5
3. `var_poisson`: a Poisson variable with $\lambda = 4$

(Recall how to generate random sample from various distributions from previous labs.)

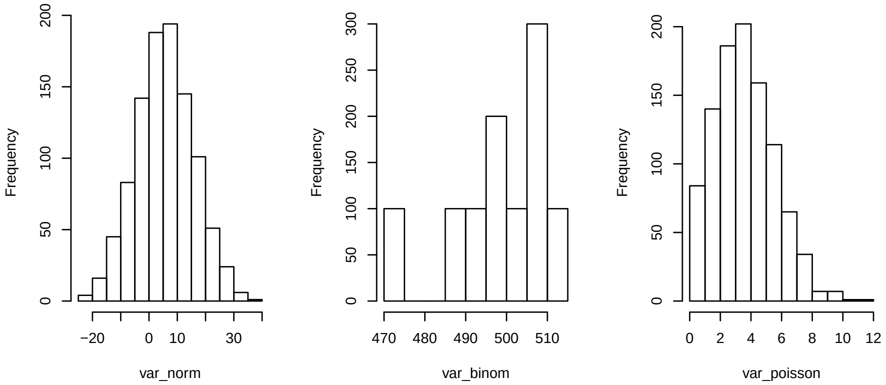
### b)

Plot the histograms of the three variables, arranging them nicely (with `fig.width()`, `fig.height()`, `par(mfrow)` as you see fit). Brownie point if you plot using a for loop instead of writing `hist` three times.

**Solution**

```r
# Create the data frame
set.seed(2)
my_dataframe <- data.frame(var_norm = rnorm(1000, mean = 5, sd = 10),
                           var_binom = rbinom(1000, n = 10, prob = 0.5),
                           var_poisson = rpois(1000, lambda = 4))
```

```r
# Plot the histogram (nicely)
par(mfrow = c(1, 3))
for (i in 1:3) {
  hist(my_dataframe[ , i],
       xlab = colnames(my_dataframe)[i], main = NULL)
}
```



## 2. Subset data frame (4 points)

### a)

Download the following data from `WDI` and clean it as follows. Briefly comment on what each command does.

```r
library(WDI)

## Loading required package:  RJSONIO

d_wdi <- WDI(indicator = c("NY.GDP.PCAP.CD", "SP.DYN.IMRT.IN", "SH.MED.PHYS.ZS"),
             start = 2005, end = 2010, extra = TRUE)
d_wdi <- d_wdi[d_wdi$region != "Aggregates",
       c("country", "year", "NY.GDP.PCAP.CD", "SP.DYN.IMRT.IN", "SH.MED.PHYS.ZS")]
colnames(d_wdi)[3:5] <- c('gdppc', 'infant_mortality', 'number_of_physician')
d_wdi <- na.omit(d_wdi)
```

`infant_mortality`: number of mortality per 1000 live births
`number_of_physician`: number of physician per 1000 people

## b)

Use subsetting techniques to do the following:

1. Show the GDP per capita of Brazil across years
2. Show the country-years where infant mortality > 100 per 1000 live birth
3. Show the country-years where GDP per capita is above average
4. Show the country-years where GDP per capita is above average, but number of physician is below average

**Solution**

```
library(WDI)

# Download data from WDI, specifying the indicators and start / end year
d_wdi <- WDI(indicator = c("NY.GDP.PCAP.CD", "SP.DYN.IMRT.IN", "SH.MED.PHYS.ZS"),
             start = 2008, end = 2010, extra = TRUE)

# Remove aggregates rows, selecting wanted columns by name
d_wdi <- d_wdi[d_wdi$region != "Aggregates",
       c("country", "year", "NY.GDP.PCAP.CD", "SP.DYN.IMRT.IN", "SH.MED.PHYS.ZS")]

# Rename some of the columns
colnames(d_wdi)[3:5] <- c('gdppc', 'infant_mortality', 'number_of_physician')

# Remove all rows that have missing data
d_wdi <- na.omit(d_wdi)
```

```
# 1. Show the GDP per capita of Brazil across years
d_wdi[d_wdi$country == "Brazil", c("country", "year", "gdppc")]

##    country year     gdppc
## 94  Brazil 2008  8700.613
## 95  Brazil 2010 11124.077

# 2. Show the country-years where infant mortality > 100 per 1000 live birth
d_wdi[d_wdi$infant_mortality > 100, c("country", "year", "infant_mortality")]

##                      country year infant_mortality
## 34                    Angola 2009            112.2
## 120 Central African Republic 2009            103.6
## 562             Sierra Leone 2010            107.0
## 563             Sierra Leone 2008            116.2
```

```r
# 3. Show the country-years where GDP per capita is above average
d_wdi[d_wdi$gdppc > mean(d_wdi$gdppc), c("country", "year", "gdppc")]
```

```
##                   country year    gdppc
## 16               Andorra 2010  39639.39
## 17               Andorra 2009  42701.45
## 20  United Arab Emirates 2010  34341.91
## 43               Austria 2010  46593.39
## 48             Australia 2010  51801.05
## 62              Barbados 2010  15901.43
## 67               Belgium 2010  44360.90
## 69               Belgium 2008  48561.36
## 76               Bahrain 2008  23043.03
## 77               Bahrain 2010  20386.02
## 88     Brunei Darussalam 2008  37799.28
## 89     Brunei Darussalam 2010  31453.01
## 99          Bahamas, The 2008  23657.37
## 113               Canada 2008  46400.44
## 114               Canada 2010  47463.63
## 124          Switzerland 2010  74277.12
## 154               Cyprus 2010  30438.90
## 155               Cyprus 2008  34950.35
## 157       Czech Republic 2008  22649.38
## 158       Czech Republic 2010  19763.96
## 160              Germany 2008  45632.84
## 162              Germany 2010  41725.85
## 167              Denmark 2009  57895.50
## 168              Denmark 2010  57647.67
## 182              Estonia 2008  18087.68
## 190                Spain 2010  30737.83
## 202              Finland 2009  47107.16
## 203              Finland 2010  46205.17
## 204              Finland 2008  53401.31
## 214               France 2008  45413.07
## 215               France 2010  40705.77
## 222       United Kingdom 2010  38362.22
## 245               Greece 2010  26863.01
## 246               Greece 2008  31700.49
## 267              Croatia 2008  15887.42
## 273              Hungary 2008  15598.32
## 278              Ireland 2008  60968.84
## 279              Ireland 2010  47903.68
## 280               Israel 2010  30551.12
## 295              Iceland 2008  55446.76
## 297              Iceland 2010  41695.89
## 298                Italy 2009  36995.11
## 299                Italy 2010  35877.87
## 300                Italy 2008  40659.67
## 310                Japan 2010  42909.23
## 312                Japan 2008  37865.62
## 334          Korea, Rep. 2008  20474.89
## 336          Korea, Rep. 2010  22151.21
## 337               Kuwait 2010  37724.27
## 338               Kuwait 2008  54478.55
## 339               Kuwait 2009  36756.81
## 367            Lithuania 2008  14961.72
## 371           Luxembourg 2010 102863.10
## 423                Malta 2010  19694.08
## 458          Netherlands 2010  50341.25
## 459          Netherlands 2008  56628.75
## 460               Norway 2009  80017.78
## 461               Norway 2010  87646.27
## 462               Norway 2008  96880.51
## 467          New Zealand 2010  33394.07
## 472                 Oman 2010  19920.65
## 474                 Oman 2008  22963.38
## 504             Portugal 2010  22539.99
## 512                Qatar 2010  70870.23
## 538         Saudi Arabia 2008  19436.86
## 539         Saudi Arabia 2010  18753.98
## 540         Saudi Arabia 2009  15655.08
## 550               Sweden 2008  55746.84
## 551               Sweden 2010  52076.43
## 552               Sweden 2009  46207.06
## 553            Singapore 2010  46569.69
## 556             Slovenia 2008  27501.82
## 558             Slovenia 2010  23417.64
## 560      Slovak Republic 2010  16509.90
## 626  Trinidad and Tobago 2010  15494.70
## 643        United States 2010  48374.06
## 644        United States 2009  47001.56
```

```
# 4. Show the country-years where GDP per capita is above average,
# but number of physician is below average
d_wdi[d_wdi$gdppc > mean(d_wdi$gdppc) &
        d_wdi$number_of_physician < mean(d_wdi$number_of_physician),
      c("country", "year", "gdppc")]
```

```
##                  country year    gdppc
## 76               Bahrain 2008 23043.03
## 77               Bahrain 2010 20386.02
## 88     Brunei Darussalam 2008 37799.28
## 89    Brunei Darussalam 2010 31453.01
## 538        Saudi Arabia 2008 19436.86
## 539        Saudi Arabia 2010 18753.98
## 540        Saudi Arabia 2009 15655.08
## 626 Trinidad and Tobago 2010 15494.70
```

# 3. Build linear model (4 points)

## a)

Download 2 variables of interest and build a linear model of their relationship using `lm()`. Show the `summary()` of results

## b)

Show the result with `stargazer`, customizing:

- The labels of the independent variables (i.e. the covariate)
- The label of the dependent variable
- Make the model name (i.e. OLS) show up

Hint: The options to do those things are in `help(stargazer)`. I have worded the task in a way that should help you find the relevant options.

**Solution**

```
m1 <- lm(infant_mortality ~ gdppc, data = d_wdi)
summary(m1)

##
## Call:
## lm(formula = infant_mortality ~ gdppc, data = d_wdi)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -28.721 -17.361  -5.818  11.914  78.797
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  3.774e+01  1.712e+00   22.05   <2e-16 ***
## gdppc       -7.423e-04  6.924e-05  -10.72   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 21.68 on 249 degrees of freedom
## Multiple R-squared:  0.3158,Adjusted R-squared:  0.3131
## F-statistic: 114.9 on 1 and 249 DF,  p-value: < 2.2e-16
```

```
library(stargazer)

##
## Please cite as:
##
##  Hlavac, Marek (2014).  stargazer:  LaTeX code and ASCII text for
well-formatted regression and summary statistics tables.
##  R package version 5.1.  http://CRAN.R-project.org/package=stargazer

stargazer(m1,
          covariate.labels = c("GDP per capita"),
          dep.var.labels = c("Infant Mortality (per 1000 births)"),
          model.names = TRUE)
```

Table 1:

| | *Dependent variable:* |
|---|---|
| | Infant Mortality (per 1000 births) |
| | *OLS* |
| GDP per capita | $-0.001^{***}$ |
| | (0.0001) |
| | |
| Constant | $37.740^{***}$ |
| | (1.712) |
| | |
| Observations | 251 |
| $R^2$ | 0.316 |
| Adjusted $R^2$ | 0.313 |
| Residual Std. Error | 21.679 (df = 249) |
| F Statistic | $114.931^{***}$ (df = 1; 249) |
| *Note:* | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 |

## 4. Calculate sum of squares and RMSE (4 points)

1. Extract the residuals and predicted values (fitted values) from the model object (from Question 3)
2. Calculate three "sum of squares" (TSS, RegSS, RSS)

3. Calculate the root mean square error and compare with R. (In R and stargazer, RMSE is called “Residual standard error”.)

Note: the data you feed to `lm()` may have missing data, so R has to modify the data a little before using it. To extract the data that are actually used by `lm()`, use `my_model$model`. Use this data to calculate $\bar{y}$ in the sum of squares.

**Solution**

```r
res <- m1$residuals # Residuals
pred <- m1$fitted.values # Predicted values
y <- m1$model$infant_mortality # Data of Y that is used by lm()

# Calculate 3 sum of squares
TSS <- sum( (y - mean(y)) ** 2)
RegSS <- sum( (pred - mean(y)) ** 2)
RSS <- sum( res ** 2 )

# Calculate root mean square error
N <- nrow(d_wdi)
k <- 1 # We only have 1 predictor, which is log_gdppc
rmse <- sqrt(RSS / (N - k - 1))
```

The calculated root mean square error is 21.6789142, the same as reported by R in `summary(m1)`.