Pol Sci 630: Problem Set 4 Solution - 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)

Insert your comments on the assignment that you are grading above the solution in bold and red text. For example write: "GRADER COMMENT: everything is correct! - 4/4 Points" Also briefly point out which, if any, problems were not solved correctly and what the mistake was. See below for more examples.

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.)

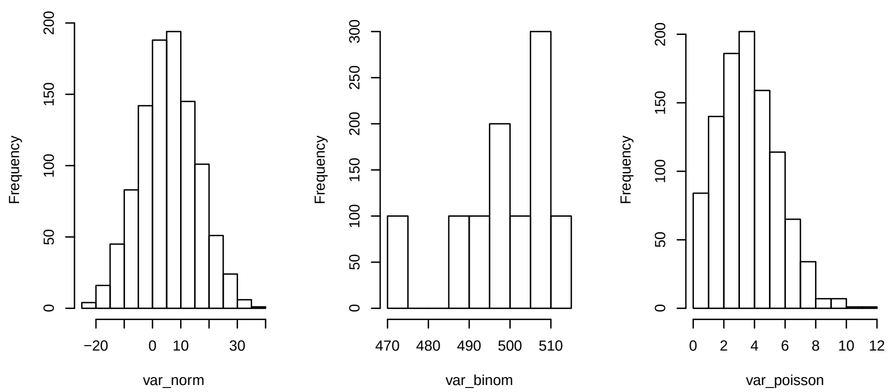
b)

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

```
# 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))
```

```
# 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)

GRADER COMMENT: everything is correct! - 4/4 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
```

```r
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

```r
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)
```

```r
# 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

# 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
```

```r
# 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)

GRADER COMMENT: everything is correct! - 4/4 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

```r
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
```

```r
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)
```

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

GRADER COMMENT: everything is correct! - 4/4 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)

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

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)`.