Literate programming with Python, R, Julia and Stata**

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Abstract

In this presentation I will discuss how we can enhance the workflow by using literate programming to combine key features of different statistical packages, namely Stata, R, Julia and Python, on the one hand, and Latex as the typesetting system on the other. The goal is to demonstrate and share a template aiming at producing a highly automated report, or research paper, within the same framework. The tasks will run from exploratory data analysis to regression analysis, where the output, from summary to regression tables and figures, is seamlessly included in the final document. Furthermore, important elements of Latex editing, such as automatic referencing, will be highlighted. We aim at freeing the researcher form repetitive tasks to focus on critical and creative writing. Efficiency and replicability will be at the core of the discussion. RStudio will be used to edit and compile R Markdown. The focus will be on producing PDF outputs. In the presentation I will make use of packages such as bookdown, knitr, stargazer, dlookr, ggplot2, plotly, Statamarkdown, reticulate, JuliaCall, pandas, numpy, matplotlib or FixedEffectModels.

**Corresponding address: miguel.portela@eeg.uminho.pt. The current template adapts part of the Rmd code by Paul C. Bauer, Mannheim Centre for European Social Research.

1 Exploratory data analysis

I start by exploring the data **NLSWORK** (National Longitudinal Survey. Young Women 14-26 years of age in 1968).

2 A tibble: 6 x 21

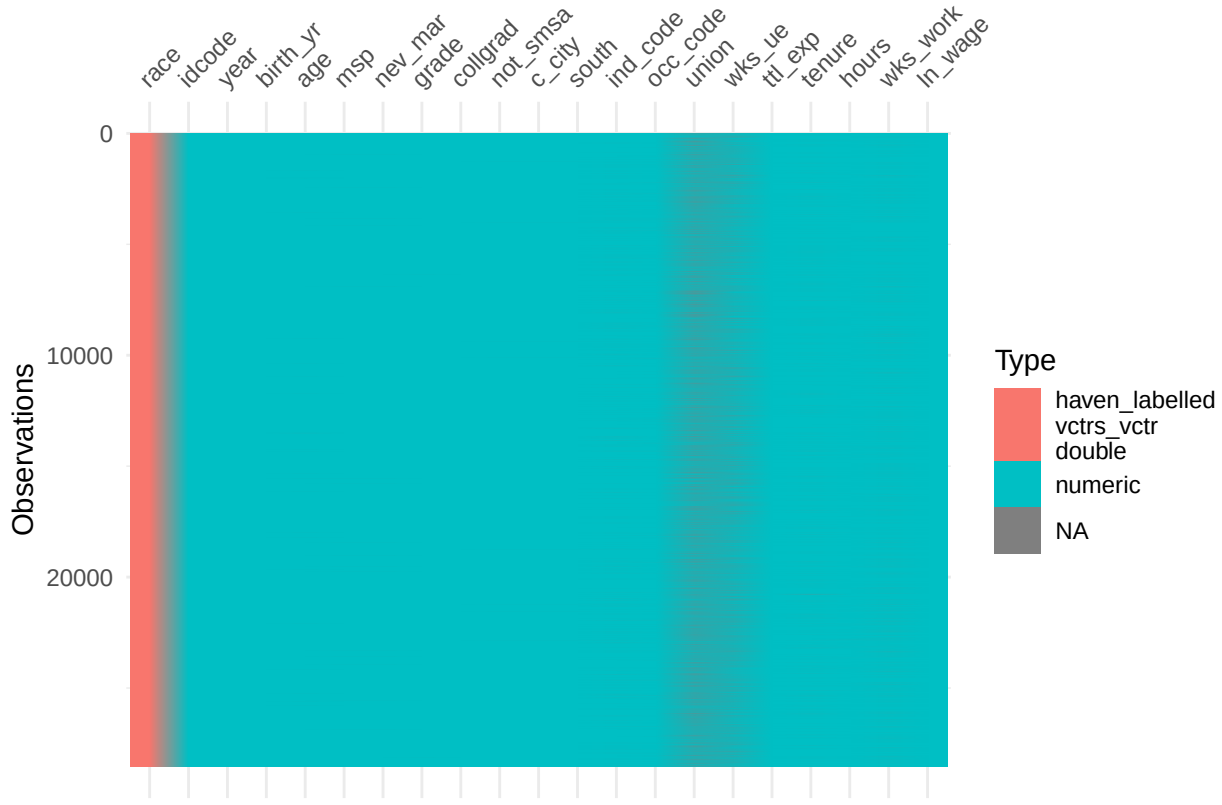
idcode year birth_yr age race msp nev_mar grade collgrad not_smsa <dbl+lbl> 1 1 70 51 18 2 [black] 0 1 12 0 0 2 1 71 51 19 2 [black] 1 0 12 0 0 3 1 72 51 20 2 [black] 1 0 12 0 0 4 1 73 51 21 2 [black] 1 0 12 0 0 5 1 75 51 23 2 [black] 1 0 12 0 0 6 1 77 51 25 2 [black] 0 0 12 0 0 # … with 11 more variables: c_city , south , ind_code , # occ_code , union , wks_ue , ttl_exp , tenure , # hours , wks_work , ln_wage

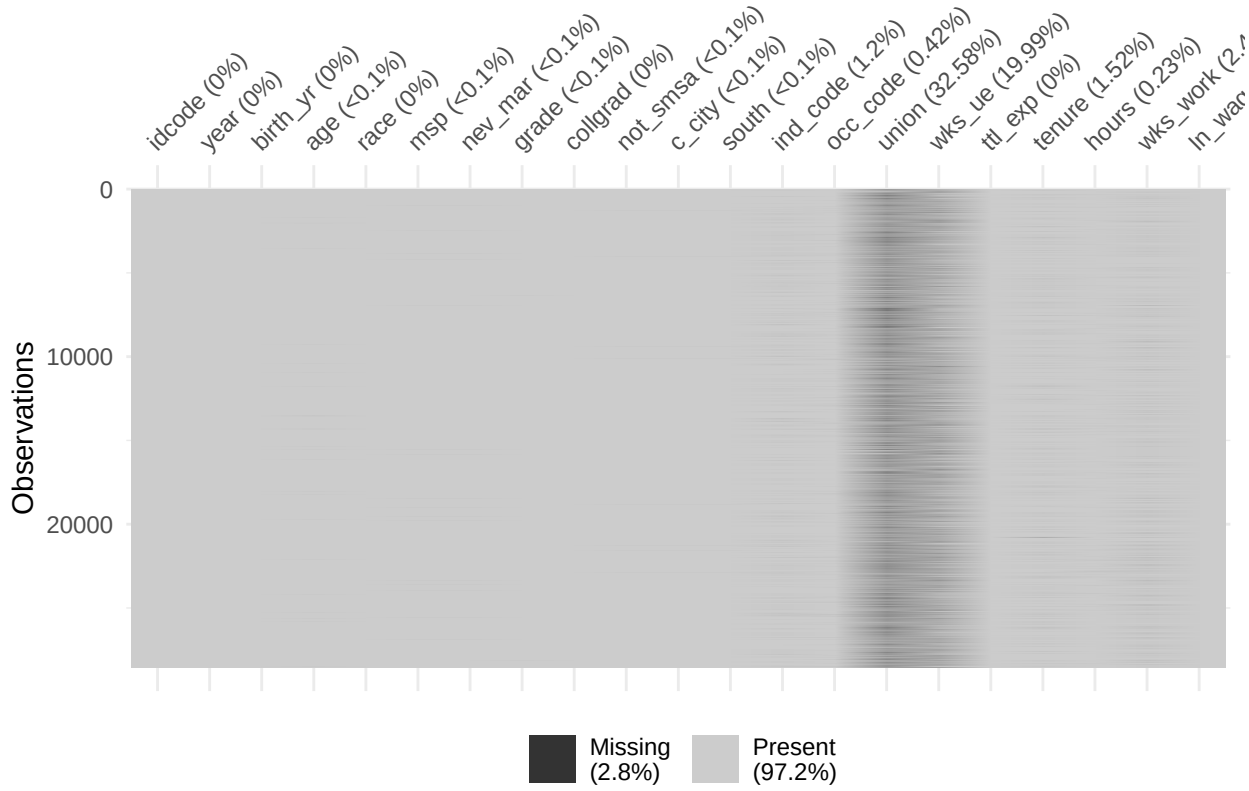
Table 1: Summary statistics

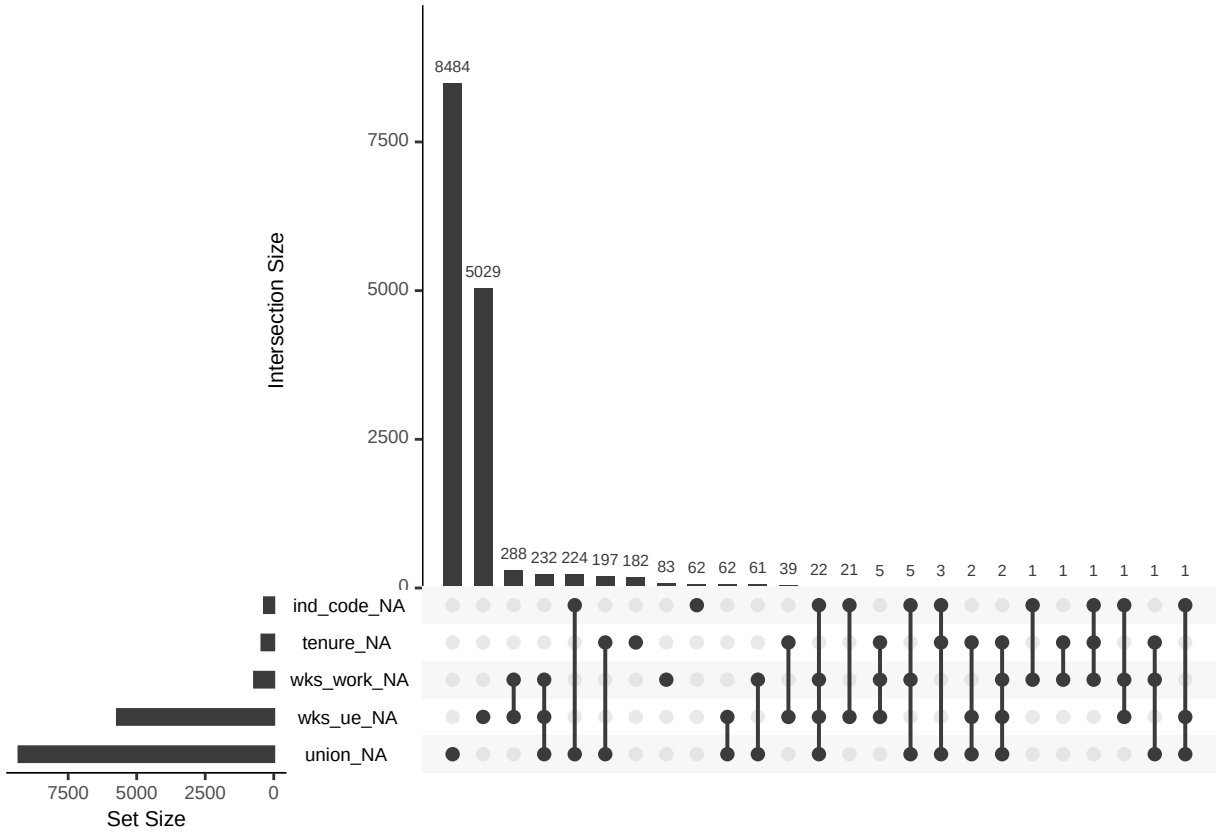
Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
idcode	28,534	2,601.284	1,487.359	1	1,327	3,881	5,159
year	28,534	77.959	6.384	68	72	83	88
birth_yr	28,534	48.085	3.013	41	46	51	54
age	28,510	29.045	6.701	14.000	23.000	34.000	46.000
race	28,534	1.303	0.482	1	1	2	3
msp	28,518	0.603	0.489	0.000	0.000	1.000	1.000
nev_mar	28,518	0.230	0.421	0.000	0.000	0.000	1.000
grade	28,532	12.533	2.324	0.000	12.000	14.000	18.000
collgrad	28,534	0.168	0.374	0	0	0	1
not_smsa	28,526	0.282	0.450	0.000	0.000	1.000	1.000
c_city	28,526	0.357	0.479	0.000	0.000	1.000	1.000
south	28,526	0.410	0.492	0.000	0.000	1.000	1.000
ind_code	28,193	7.693	2.994	1.000	5.000	11.000	12.000
occ_code	28,413	4.778	3.065	1.000	3.000	6.000	13.000
union	19,238	0.234	0.424	0.000	0.000	0.000	1.000
wks_ue	22,830	2.548	7.294	0.000	0.000	0.000	76.000
ttl_exp	28,534	6.215	4.652	0.000	2.462	9.128	28.885
tenure	28,101	3.124	3.751	0.000	0.500	4.167	25.917
hours	28,467	36.560	9.870	1.000	35.000	40.000	168.000
wks_work	27,831	53.989	29.032	0.000	36.000	72.000	104.000
ln_wage	28,534	1.675	0.478	0.000	1.361	1.964	5.264

```
[1] "idcode"   "year"     "birth_yr" "age"      "race"     "msp"
[7] "nev_mar"  "grade"    "collgrad" "not_smsa" "c_city"   "south"
```

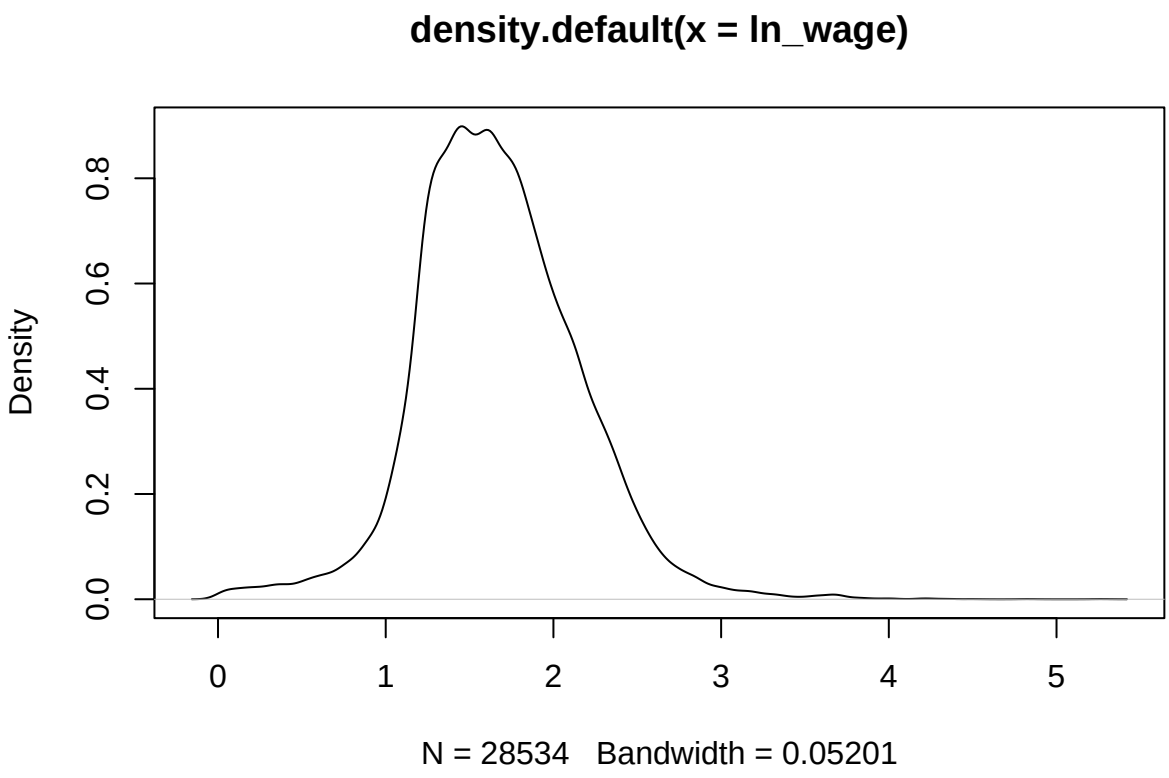
```
[13] "ind_code" "occ_code" "union"    "wks_ue"   "ttl_exp"  "tenure"
[19] "hours"    "wks_work" "ln_wage"
```

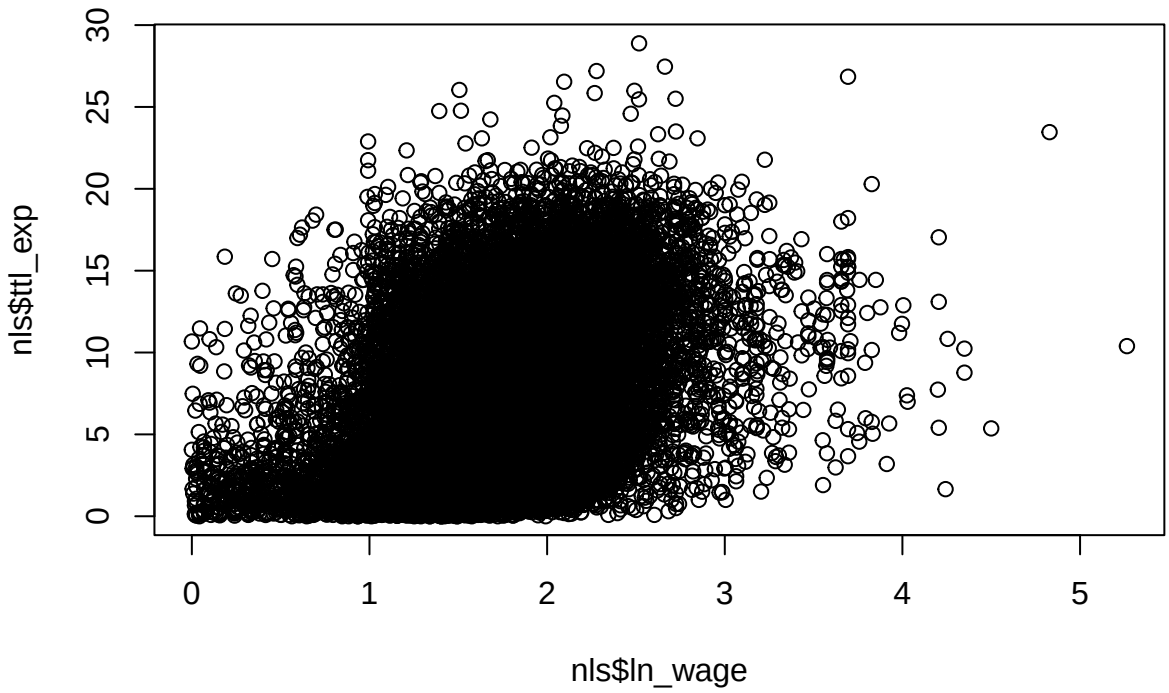


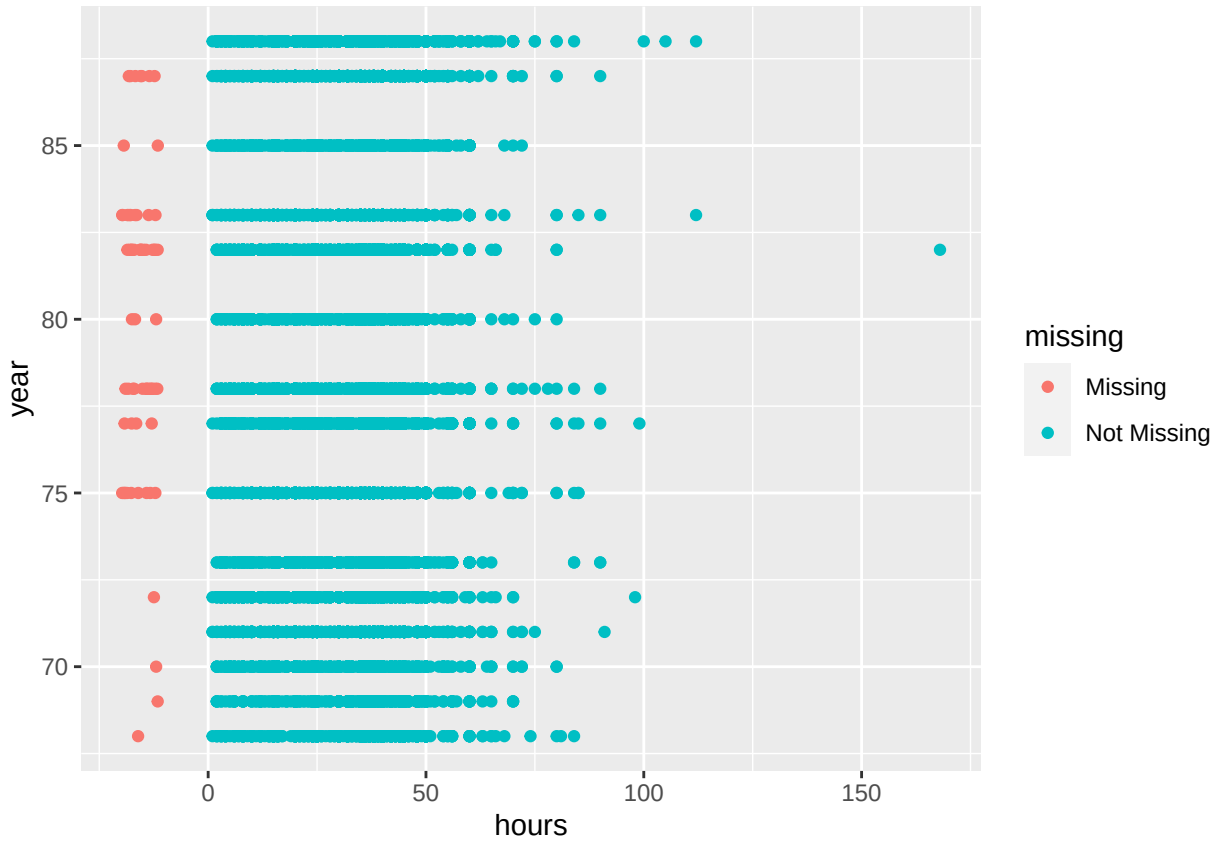

idcode (0%)
year (0%)
birth_yr (0%)
age (<0.1%)
race (0%)
msp (<0.1%)
nev_mar (<0.1%)
grade (<0.1%)
collgrad (0%)
not_smsa (<0.1%)
c_city (<0.1%)
south (<0.1%)
ind_code (1.2%)
occ_code (0.42%)
union (32.58%)
wks_ue (19.99%)
ttl_exp (0%)
tenure (1.52%)
hours (0.23%)
wks_work (2.
ln_wa
Observations
0
10000
20000
Missing
(2.8%)
Present
(97.2%)

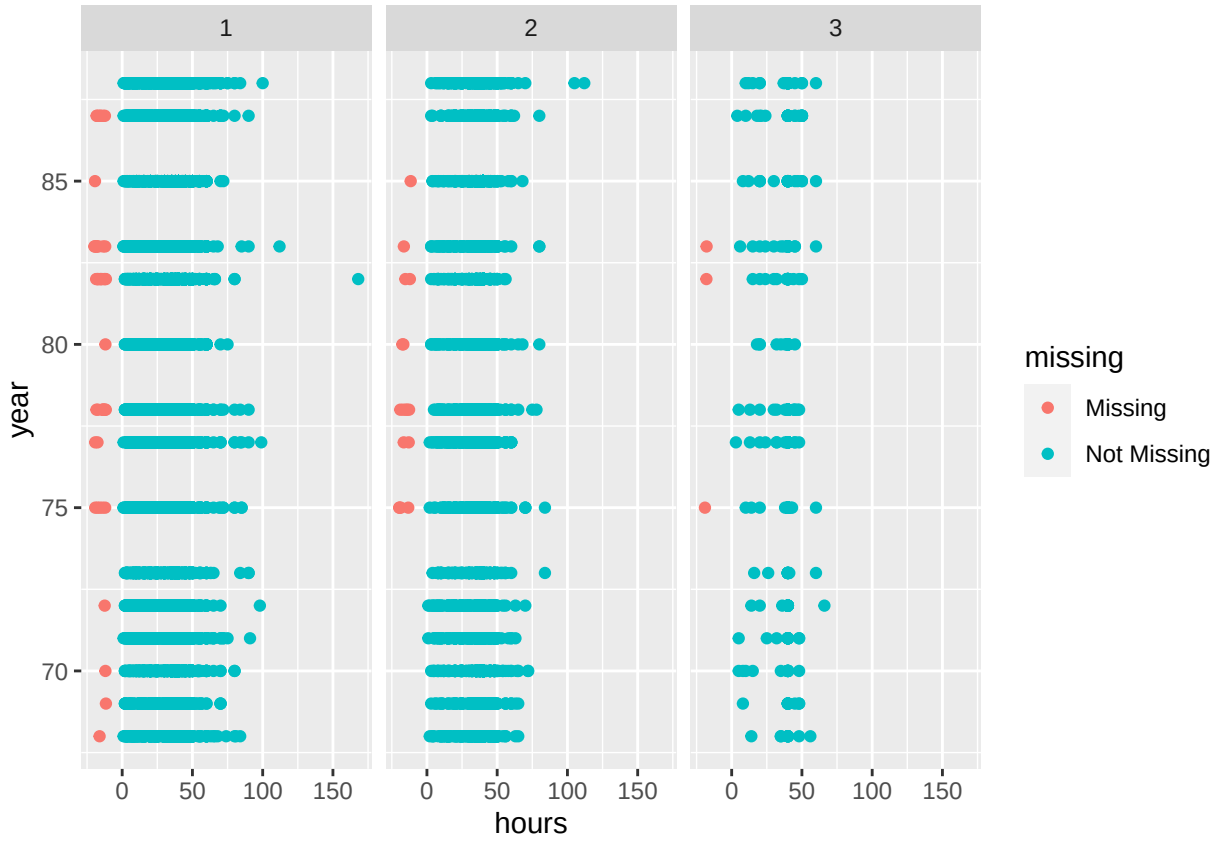



```
num [1:28534] 1.45 1.03 1.59 1.78 1.78 ...
- attr(*, "label")= chr "ln(wage/GNP deflator)"
- attr(*, "format.stata")= chr "%9.0g"
```


density.default(x = ln_wage)
Density
0.0
0.2
0.4
0.6
0.8
0
1
2
3
4
5
N = 28534 Bandwidth = 0.05201


nls$ttl_exp
0
5
10
15
20
25
30
0
1
2
3
4
5
nls$ln_wage


year
85
80
75
70
0
50
100
150
hours
missing
Missing
Not Missing



The average age in our data is 29.

3 Tables

R Markdown PDF is now able to produce good tables with our output. For `stargazer` the label is contained in the function, while for `kable` it's contained in the chunk name.

3.1 stargazer(): Summary and regression tables

Table 1 shows data's summary statistics.[1] `stargazer()` is and excellent solution to export outputs.

```
library(stargazer)
stargazer(cars,
          title = "Summary table with stargazer",
          label="tab1cars",
          table.placement = "H",
          header=FALSE)
```

[1] You can reference the table as 2.

Table 2: Summary table with stargazer

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
speed	50	15.400	5.288	4	12	19	25
dist	50	42.980	25.769	2	26	56	120

Table 3 reports regression outputs. Name the models as you can refer to their names in the text (M1, M2, M3).

```
library(stargazer)
model1 <- lm(speed ~ dist, data = cars)
model2 <- lm(speed ~ dist, data = cars)
model3 <- lm(dist ~ speed, data = cars)
stargazer(model1, model2, model3,
          title = "Regression table with stargazer",
          label="tab2",
          table.placement = "H",
          column.labels = c("M1", "M2", "M3"),
          model.numbers = FALSE,
          header=FALSE)
```

Table 3: Regression table with stargazer

	Dependent variable:		
	speed		dist
	M1	M2	M3
dist	0.166***	0.166***	
	(0.017)	(0.017)	
speed			3.932***
			(0.416)
Constant	8.284***	8.284***	−17.579**
	(0.874)	(0.874)	(6.758)
Observations	50	50	50
R^2	0.651	0.651	0.651
Adjusted R^2	0.644	0.644	0.644
Residual Std. Error (df = 48)	3.156	3.156	15.380
F Statistic (df = 1; 48)	89.567***	89.567***	89.567***
Note:			*p<0.1; **p<0.05; ***p<0.01

4 Figures

4.1 Graphs with R

You can insert figures like this. One would like to produce and insert them on the fly in the `.rmd` file. Figure **??** is such an example.

```
plot(cars$speed, cars$dist)
```

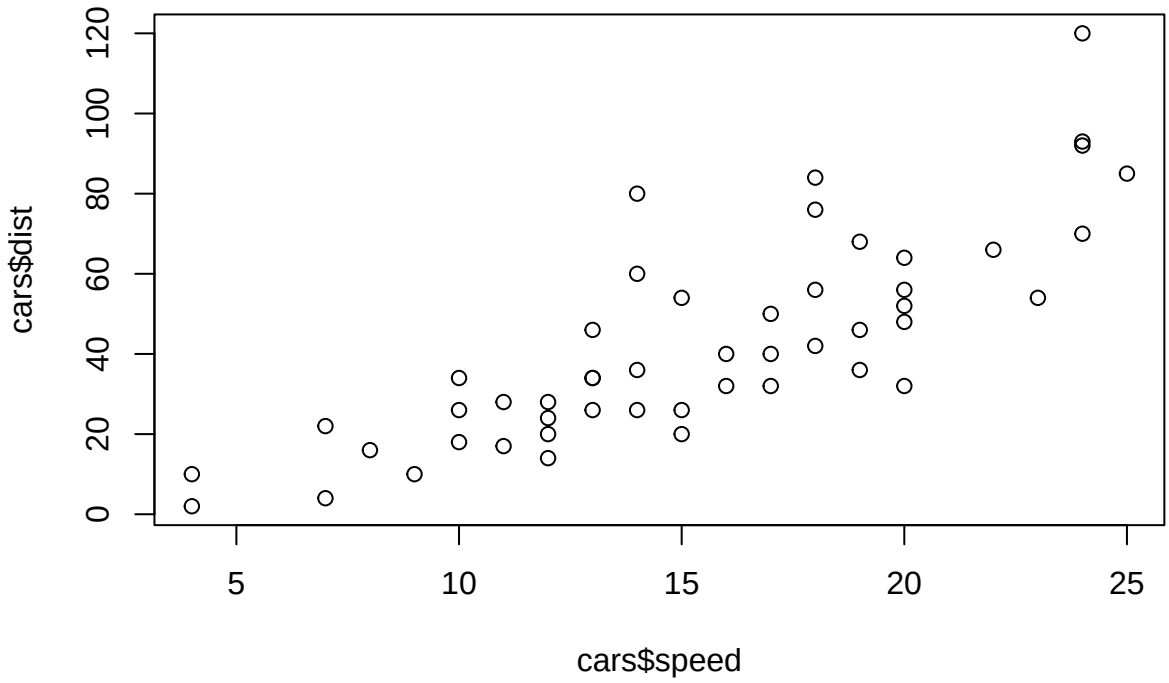


Figure 1: Scatterplot of Speed and Distance
(#fig:Figures 1, fig-1)

However, in some cases it does not work.

4.2 Example: ggplot2 graphs

See the ggplot2 output reported in Figure **??**.

```
mtcars$cyl <- as.factor(mtcars$cyl) # Convert cyl to factor
library(ggplot2)
ggplot(mtcars, aes(x=wt, y=mpg, shape=cyl)) + geom_point() +
  labs(x="Weight (lb/1000)", y = "Miles/(US) gallon",
       shape="Number of \n Cylinders") + theme_classic()
```

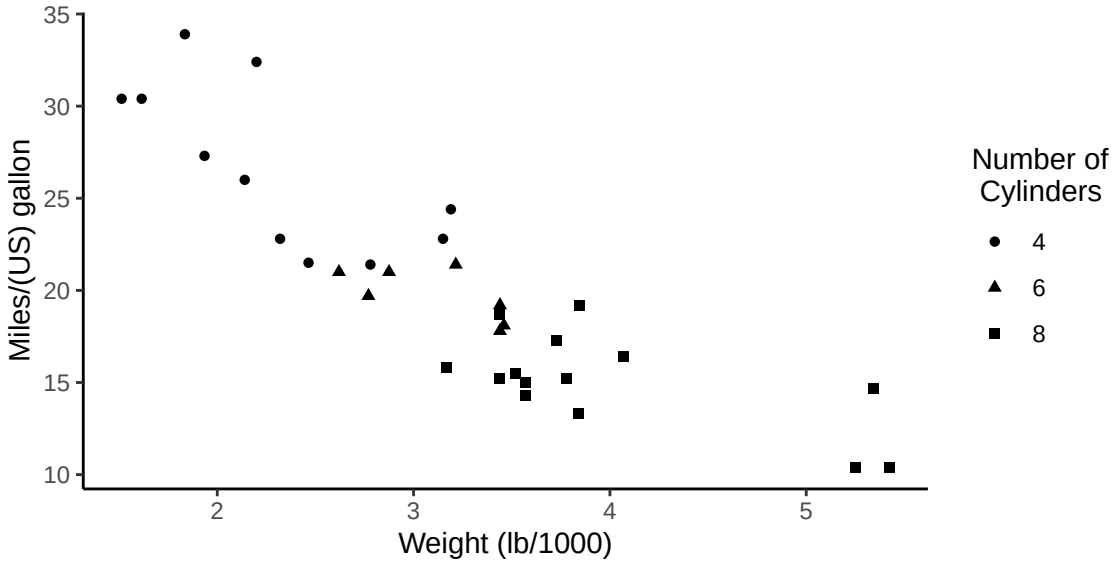


Figure 2: Miles per gallon according to the weight

4.3 Another example using Plotly

With `Plotly` we can produce interactive graphs which play well, for example, once can embeded in html webpages (drop by here for an example). One can insert this type of graphs in R Markdown PDF using `Orca` (it generates static images from Plotly graphs). Go here to check how to install it. See Figure 3 for an example.

```
library(plotly)
p <- plot_ly(cars, type = "scatter", mode="markers",
        x=~speed,
        y=~dist)
#Sys.setenv('MAPBOX_TOKEN' = '12423423') # set arbitrary token
#orca(p, "logs/plotly-plot.pdf")
```

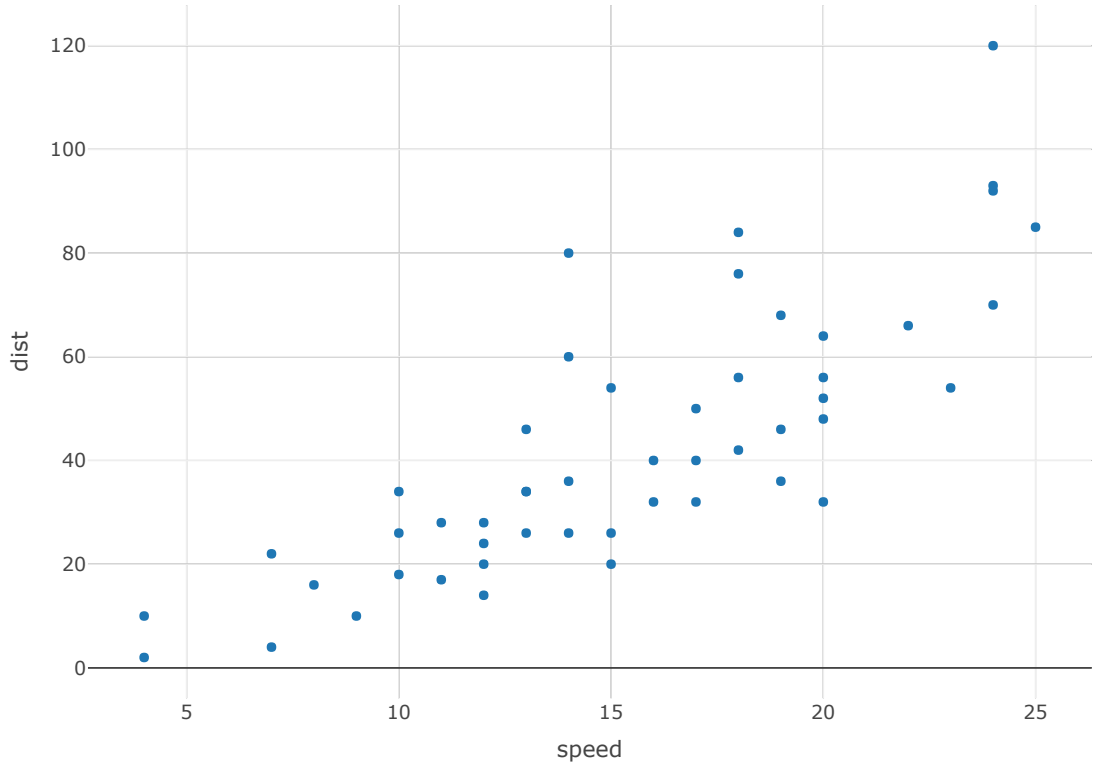
5 Python

5.1 API data download using Python

```
import sys
print(sys.version)
```

```
3.9.4 (tags/v3.9.4:1f2e308, Apr  6 2021, 13:40:21) [MSC v.1928 64 bit (AMD64)]
```

Figure 3: Example: export a Plotly figure using ‘orca‘




```
import json
##from json.decoder import JSONDecodeError
import requests
import numpy as np
import pandas as pd

## INE: https://www.ine.pt/ine/json_indicador/pindica.jsp?
## op=2&varcd=0008074&Dim1=S7A2015&Dim2=200&Dim3=3&lang=PT

# api-endpoint

URL = "https://www.ine.pt/ine/json_indicador/pindica.jsp"

# define parameters

OP="2"
```

```
VARCD="0008074"
DIM1="S7A2015"
DIM2="200"
DIM3="3"
LANG="PT"


# defining a params dict for the parameters to be sent to the API
PARAMS = {'op':OP,'varcd':VARCD,'Dim1':DIM1,'Dim2':DIM2,'Dim3':DIM3,'lang':LANG}

# sending get request and saving the response as response object
r = requests.get(url = URL,params=PARAMS)

# extracting data in json format
data = r.json()

valor = data[0]['Dados']['2015'][0]['valor']

valor
```

```
'1.8'
```

The criminal rate is 1.8‰.

5.2 Import data from PDF files

```
  cd C:/Users/mangelo.EEG/Documents/GitHub/prjs/pdfs
    find . -name '*.pdf' -print0 | xargs -0 -n1 pdfsandwich -gray
    find . -name '*ocr.pdf' -print0 | xargs -0 -n1 pdftotext
```

```
['ORNALOFICIAL', 'Tercba-feira, 2 de julho de 2019', '', 'IDY', 'Série', 'Numero 30', ''

FILE:  s/IVSerie-030-2019-07-02_ocr

Empty DataFrame
Columns: [linha, output, outra, source]
Index: []
```

And now we use Stata to explore the data.

```
quiet cd "C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs"
quiet import delimited "C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/PE.csv", encodin
tab source
```

```
no observations
```

5.3 Run a Python script to read a PDF using the shell to run the commands wget, pdfsandwich and pdftotext

```
python3 "C:/Users/mangelo.EEG/Documents/GitHub/prjs/chunks/python_chunk.py"
```

```
python3: can't open file 'C:/Users/mangelo.EEG/Documents/GitHub/prjs/chunks/python_chunk
```

5.4 Use Stata to list the fiscal numbers (read the data produced with Python)

```
quietly{
cd C:/Users/mangelo.EEG/Documents/GitHub/prjs/chunks

use C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/nipcs, clear
compress
contract nipc
drop _freq
drop if nipc == .
format %12.0f nipc
}

//codebook nipc

tab nipc
```

```
       nipc |      Freq.     Percent        Cum.
------------+-----------------------------------
  510649068 |          1        4.35        4.35
```

```
  510779174 |          1        4.35        8.70
  511056737 |          1        4.35       13.04
  511117060 |          1        4.35       17.39
  511124899 |          1        4.35       21.74
  511240619 |          1        4.35       26.09
  511247478 |          1        4.35       30.43
  513208348 |          1        4.35       34.78
  513587128 |          1        4.35       39.13
  514118890 |          1        4.35       43.48
  514525657 |          1        4.35       47.83
  514532718 |          1        4.35       52.17
  514591889 |          1        4.35       56.52
  515002666 |          1        4.35       60.87
  515080985 |          1        4.35       65.22
  515092550 |          1        4.35       69.57
  515092649 |          1        4.35       73.91
  515464236 |          1        4.35       78.26
  515478377 |          1        4.35       82.61
  515484920 |          1        4.35       86.96
  515517135 |          1        4.35       91.30
  515518565 |          1        4.35       95.65
  515522988 |          1        4.35      100.00
------------+----------------------------------
      Total |         23      100.00
```

6 Julia experiments

6.1 Computations

```
v"1.6.1"
```

6.2 Grab results in R

```
Julia Object of type FixedEffectModel.
                          Fixed Effect Model
==========================================================================
Number of obs:                147715   Degrees of freedom:           67180
R2:                            0.978   R2 Adjusted:                  0.960
F-Stat:                       23.3618   p-value:                      0.000
```

```
R2 within:                      0.001   Iterations:                      250
================================================================================
lnrealwage |   Estimate   Std.Error t value Pr(>|t|)   Lower 95%  Upper 95%
--------------------------------------------------------------------------------
education  | 0.00155636 0.000597587 2.60441    0.009 0.000385093 0.00272763
lnsales    | 0.00622982 0.000987569 6.30824    0.000  0.00429419 0.00816545
================================================================================
```

6.3 Insert Julia's results

The estimated return to education is 0.2%. The model has an R^2 of 0.9782.

6.4 Computation time: run the HDFE with Stata and R and compare to Julia

```
use C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/data_short, clear

timer on 1

    reghdfe lnrealwage education lnsales,absorb(workerid firmid year)

timer off 1
timer list 1
timer clear 1
```

```
(MWFE estimator converged in 236 iterations)

HDFE Linear regression                            Number of obs   =    147,715
Absorbing 3 HDFE groups                           F(   2,  99667) =      28.91
                                                  Prob > F        =     0.0000
                                                  R-squared       =     0.9782
                                                  Adj R-squared   =     0.9677
                                                  Within R-sq.    =     0.0006
                                                  Root MSE        =     0.0943

------------------------------------------------------------------------------
  lnrealwage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
```

```
-------------+----------------------------------------------------------------
   education |   .0015563   .0005372     2.90   0.004      .0005034    .0026092
     lnsales |   .0062299   .0008877     7.02   0.000      .0044899    .0079698
       _cons |   1.577908   .0148587   106.19   0.000      1.548785     1.60703
------------------------------------------------------------------------------

Absorbed degrees of freedom:
-----------------------------------------------------+
 Absorbed FE | Categories  - Redundant  = Num. Coefs |
-------------+---------------------------------------|
    workerid |     44047           0       44047     |
      firmid |     23127       19131        3996     |
        year |         4           1           3    ?|
-----------------------------------------------------+
? = number of redundant parameters may be higher


   1:     20.90 /        1 =      20.9040
```

```
library(lfe)
data_short <- read_dta("C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/data_short.dta")

system.time(est_hdfe <- felm(data_short$lnrealwage ~ data_short$education + data_short$l

summary(est_hdfe)
```

6.5 Output Julia's table for HDFE

7 Miguel's tests

7.1 R

Table 5 … See Section 7.2

Example of an equation

$$\int_0^{2\pi} \sin x \, dx$$

Example of a matrix

	lnrealwage	
	(1)	(2)
education	0.006***	0.002**
	(0.000)	(0.001)
lnsales	0.013***	0.006***
	(0.001)	(0.001)
workerid	Yes	Yes
year	Yes	Yes
firmid		Yes
Estimator	OLS	OLS
N	147,715	147,715
R^2	0.970	0.978

$$\mathbf{X} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

or

$$f(k) = \binom{n}{k} p^k (1-p)^{n-k} \tag{1}$$

See Equation (1).

$$y_{ijt} = \beta x_{ijt} + \eta_i + \gamma_j + \lambda_t + \varepsilon_{ijt} \tag{2}$$

Table 4: Summary table

Statistic	N	Pctl(75)	St. Dev.
idcode	28,534	3,881	1,487.359
year	28,534	83	6.384
birth_yr	28,534	51	3.013
age	28,510	34.000	6.701
race	28,534	2	0.482
msp	28,518	1.000	0.489
nev_mar	28,518	0.000	0.421
grade	28,532	14.000	2.324
collgrad	28,534	0	0.374
not_smsa	28,526	1.000	0.450
c_city	28,526	1.000	0.479
south	28,526	1.000	0.492
ind_code	28,193	11.000	2.994
occ_code	28,413	6.000	3.065
union	19,238	0.000	0.424
wks_ue	22,830	0.000	7.294
ttl_exp	28,534	9.128	4.652
tenure	28,101	4.167	3.751
hours	28,467	40.000	9.870
wks_work	27,831	72.000	29.032
ln_wage	28,534	1.964	0.478

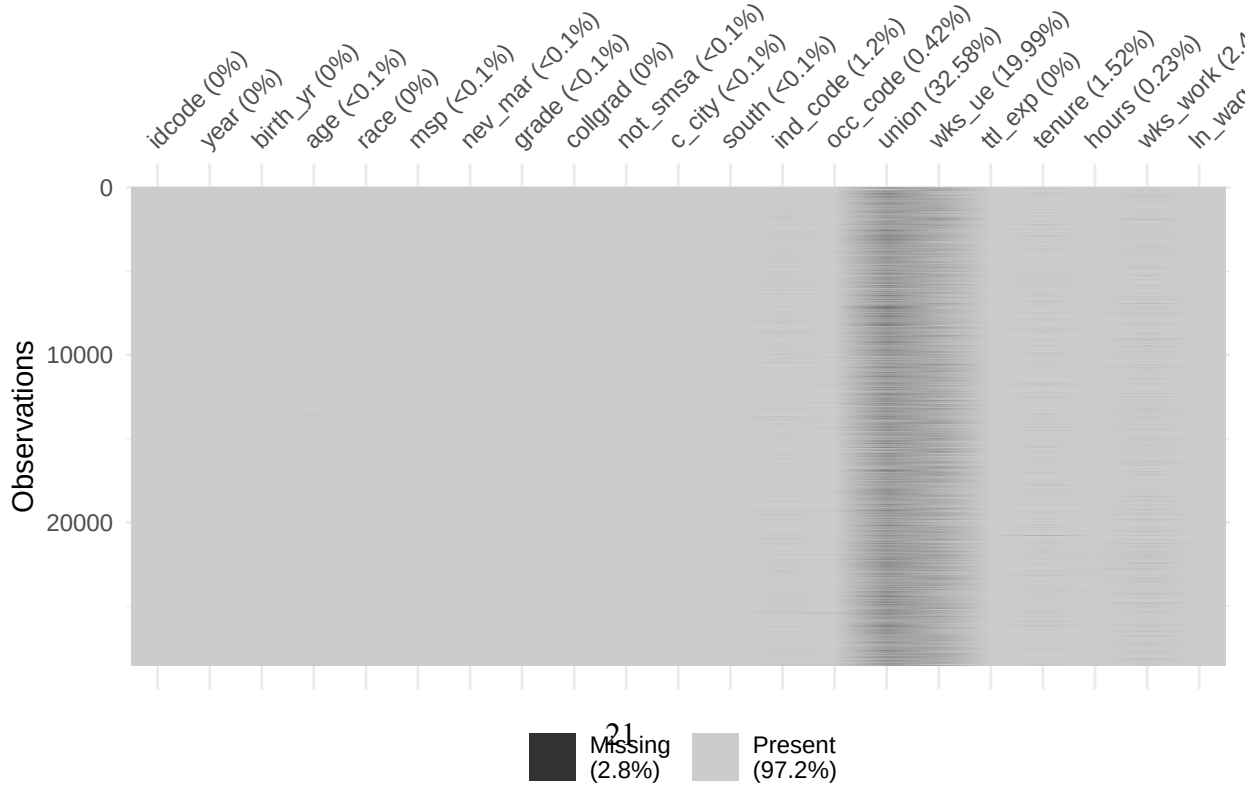


Table 5: Regression table with stargazer

	Dependent variable:		
	price		
	M1	M2	M3
mpg	−49.512	−52.217	−63.210
	(86.156)	(83.740)	(84.218)
weight	1.747***	2.111***	2.442***
	(0.641)	(0.619)	(0.688)
rep78			
Observations	74	69	69
R^2	0.293	0.365	0.376
Adjusted R^2	0.273	0.335	0.337
Residual Std. Error	2,514.029 (df = 71)	2,374.370 (df = 65)	2,370.832 (df = 64)
F Statistic	14.740*** (df = 2; 71)	12.437*** (df = 3; 65)	9.654*** (df = 4; 64)
Note:			*p<0.1; **p<0.05; ***p<0.01

```
library(stargazer)
stargazer(cars,
          title = "Summary 24",
          label="tab24",
          table.placement = "ht",
          header=FALSE)
```

Table 6: Summary 24

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
speed	50	15.400	5.288	4	12	19	25
dist	50	42.980	25.769	2	26	56	120

7.2 Stata

This a Stata example, Arellano (2003). See also Arellano and Bond (1991) and Blundell and Bond (1998). While … (check Arellano and Bover 1995).

```
    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       price |         74    6165.257    2949.496       3291      15906

     Repair |
Record 1978 |      Freq.     Percent        Cum.
------------+-----------------------------------
          1 |          2        2.90        2.90
          2 |          8       11.59       14.49
          3 |         30       43.48       57.97
          4 |         18       26.09       84.06
          5 |         11       15.94      100.00
------------+-----------------------------------
      Total |         69      100.00

(file C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs/density.pdf written in PD
> F format)

      Source |       SS           df       MS      Number of obs   =       234
-------------+----------------------------------   F(7, 226)       =     46.99
       Model |  145.879747         7  20.8399639   Prob > F        =    0.0000
    Residual |  100.230749       226  .443498888   R-squared       =    0.5927
-------------+----------------------------------   Adj R-squared   =    0.5801
       Total |  246.110496       233  1.05626822   Root MSE        =    .66596

------------------------------------------------------------------------------
       lngdp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   education |   .2136664   .0193553    11.04   0.000     .1755265    .2518063
         lnk |   .1978085   .0308039     6.42   0.000     .1371089    .2585082
       openk |   .0062439   .0011852     5.27   0.000     .0039085    .0085794
             |
        year |
       1975  |  -.0694608   .1387178    -0.50   0.617    -.3428064    .2038849
       1980  |   -.177992   .1401702    -1.27   0.205    -.4541996    .0982156
       1985  |  -.2226975   .1400607    -1.59   0.113    -.4986894    .0532943
       1990  |    -.34965   .1425169    -2.45   0.015    -.6304819   -.0688182
             |
```

```
       _cons |    3.38917   .7508785     4.51   0.000     1.909552    4.868789
------------------------------------------------------------------------------

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       lngdp |        857    9.302996    1.200567    5.983335   12.51058
```

7.3 Grab Stata's output

```
use C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/data_full, clear
        quiet generate lngdp = ln(rgdpwok)
      summarize lngdp
```

```
    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
       lngdp |        857    9.302996    1.200567    5.983335   12.51058
```

The mean ln GDP is 9.3.

See https://www.ssc.wisc.edu/~hemken/Stataworkshops/stata.html#stata-and-r-markdown-the-statamarkdown-package

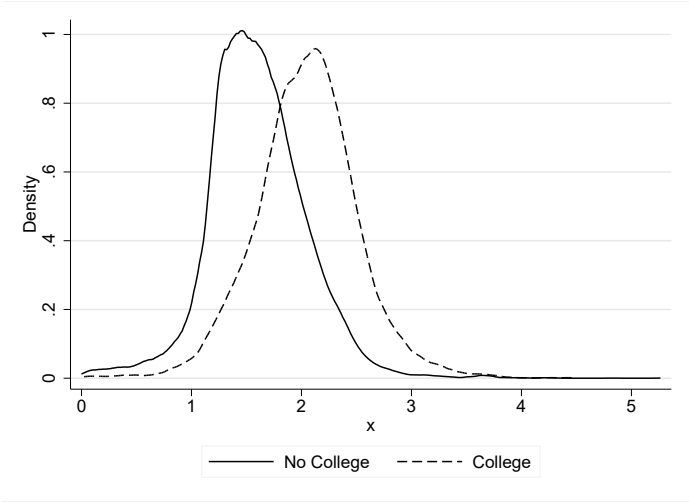


Figure 4: Wage density

Table 7: Regression analysis

	Simple model	Include capital	Full model
Education	0.3169***	0.212***	0.2***
	(0.0093)	(0.020)	(0.0)
Capital		0.125***	0.2***
		(0.029)	(0.0)
Openness degree			0.0***
			(0.0)
R^2	0.58	0.54	0.59
RMSE	0.78	0.70	0.67
N	857	234	234

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

7.4 Use Stata to export statistics to Excel

We now export a set of statistics to an Excel file.

```
version 16.1

c:\ado\plus/x/xtabond2.ado

Checksum for c:/ado/plus/x/xtabond2.ado = 3720163387, size = 40472

C:\Users\mangelo.EEG\Documents\GitHub\prjs\logs



Variable   Obs Unique      Mean       Min       Max  Label
-------------------------------------------------------------------------------
country    839    106         .         .         .  Country name
year       839      9  1980.906      1960      2000  Year of observation
education  839    574  4.794076       .04     12.25  Education
lngdp      839    838  9.308131  5.983335  12.51058  Log Real GDP per Worker
open       839      2  .4982122         0         1  1 = high degree of open...
gdp        839    838  20100.66  396.7612  271192.2  GDP level
-------------------------------------------------------------------------------
```

```
Note: file will be replaced when the first putexcel command is issued


`"a"' `"b"' `"c"' `"d"' `"e"' `"f"' `"g"' `"h"' `"i"' `"j"' `"k"' `"l"' `"m"' `
> "n"' `"p"' `"r"' `"s"' `"t"' `"u"' `"v"' `"z"'

  8.                         quietly {
  9.                                 collapse (mean) lngdp education,by(country
> )
 10.                                         putexcel set descriptives.xlsx, sh
> eet("FIRST LETTER `vv'") modify
 11.
 19.                                                 putexcel D3 = matrix(t),nf
> ormat("0.00")
 20.                                 }
 21.                          }
 22.



Country's first letter:     a

    Number of countries:    .




Country's first letter:     b

    Number of countries:    .




Country's first letter:     c

    Number of countries:    .
```

```
Country's first letter:     d

    Number of countries:    .



Country's first letter:     e

    Number of countries:    .



Country's first letter:     f

    Number of countries:    .



Country's first letter:     g

    Number of countries:    .



Country's first letter:     h

    Number of countries:    .



Country's first letter:     i

    Number of countries:    .
```

```
Country's first letter:     j

    Number of countries:    .



Country's first letter:     k

    Number of countries:    .



Country's first letter:     l

    Number of countries:    .



Country's first letter:     m

    Number of countries:    .



Country's first letter:     n

    Number of countries:    .



Country's first letter:     p

    Number of countries:    .
```

```
Country's first letter:     r

    Number of countries:    .



Country's first letter:     s

    Number of countries:    .



Country's first letter:     t

    Number of countries:    .



Country's first letter:     u

    Number of countries:    .



Country's first letter:     v

    Number of countries:    .

insufficient observations
r(2001);

end of do-file
r(2001);
```

See Figure 5.

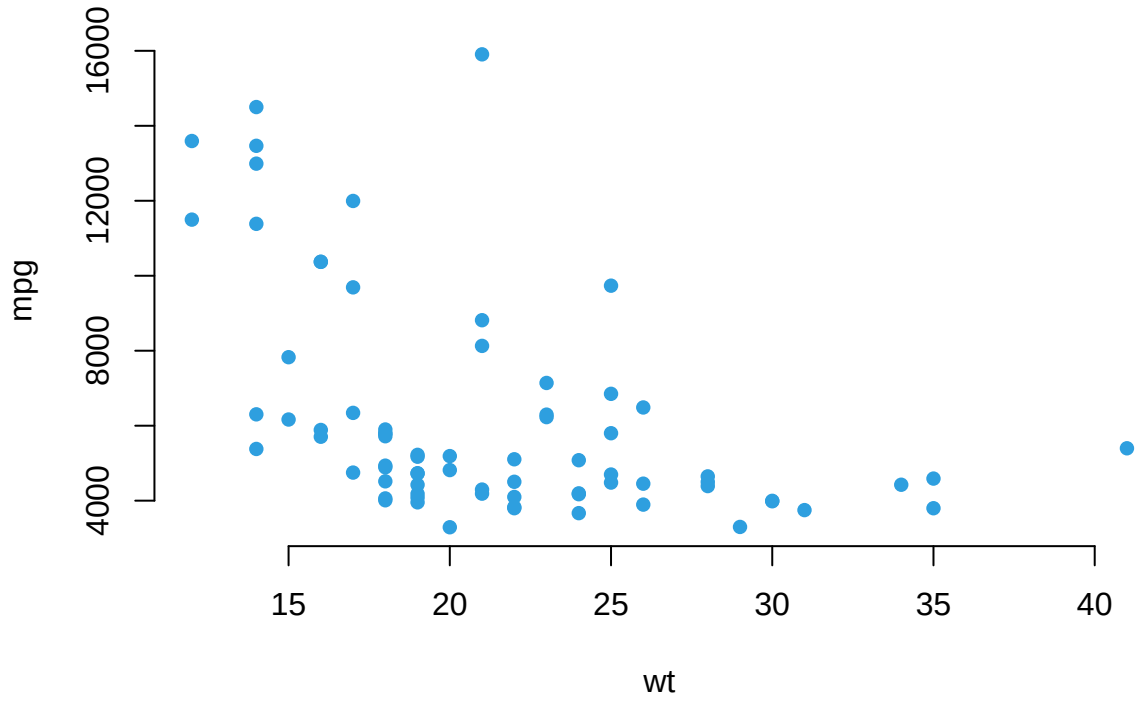


Figure 5: Scatterplot test MP

8 Final remarks

Check the replication package for Bonhomme, Lamadon and Manresa (2019): https://github.com/tlamadon/blm-replicate

References

Arellano, Manuel. 2003. *Panel Data Econometrics*. Oxford University Press.

Arellano, Manuel and Stephen Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *The Review of Economic Studies* 58(2):277–97.

Arellano, Manuel and Olympia Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models." *Journal of Econometrics* 68(1):29–51.

Blundell, Richard and Stephen Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics* 87(1):115–43.

Appendix: Chunk options

8.1 Software versioning

8.1.1 R

```
cat(paste("#", capture.output(sessionInfo()), "\n", collapse =""))
```

```
# R version 4.1.0 (2021-05-18)
# Platform: x86_64-w64-mingw32/x64 (64-bit)
# Running under: Windows 10 x64 (build 18363)
#
# Matrix products: default
#
# locale:
# [1] LC_COLLATE=Portuguese_Portugal.1252  LC_CTYPE=C
# [3] LC_MONETARY=Portuguese_Portugal.1252 LC_NUMERIC=C
# [5] LC_TIME=Portuguese_Portugal.1252
#
# attached base packages:
# [1] stats     graphics  grDevices utils     datasets  methods   base
#
# other attached packages:
#  [1] plotly_4.9.4.1      naniar_0.6.1        visdat_0.5.3
#  [4] dlookr_0.4.5        dplyr_1.0.6         ggplot2_3.3.3
#  [7] haven_2.4.1         ExPanDaR_0.5.3      JuliaCall_0.17.4
# [10] Statamarkdown_0.6.1 stargazer_5.2.2     reticulate_1.20
```

```
#
# loaded via a namespace (and not attached):
#   [1] colorspace_2.0-1      ellipsis_0.3.2        class_7.3-19
#   [4] rio_0.5.26            htmlTable_2.2.1       base64enc_0.1-3
#   [7] rstudioapi_0.13       proxy_0.4-25          farver_2.1.0
#  [10] DT_0.18               mvtnorm_1.1-1         fansi_0.4.2
#  [13] xml2_1.3.2            splines_4.1.0         extrafont_0.17
#  [16] libcoin_1.0-8         knitr_1.33            Formula_1.2-4
#  [19] jsonlite_1.7.2        Rttf2pt1_1.3.8        cluster_2.1.2
#  [22] png_0.1-7             shiny_1.6.0           readr_1.4.0
#  [25] compiler_4.1.0        httr_1.4.2            tictoc_1.0.1
#  [28] backports_1.2.1       lazyeval_0.2.2        assertthat_0.2.1
#  [31] Matrix_1.3-3          fastmap_1.1.0         cli_2.5.0
#  [34] later_1.2.0           hrbrthemes_0.8.0      htmltools_0.5.1.1
#  [37] tools_4.1.0           partykit_1.2-13       gtable_0.3.0
#  [40] glue_1.4.2            Rcpp_1.0.6            carData_3.0-4
#  [43] cellranger_1.1.0      vctrs_0.3.8           svglite_2.0.0
#  [46] extrafontdb_1.0       crosstalk_1.1.1       inum_1.0-4
#  [49] xfun_0.23             stringr_1.4.0         openxlsx_4.2.3
#  [52] rvest_1.0.0           mime_0.11             lifecycle_1.0.0
#  [55] shinycssloaders_1.0.0 RcmdrMisc_2.7-1       MASS_7.3-54
#  [58] zoo_1.8-9             scales_1.1.1          hms_1.1.0
#  [61] promises_1.2.0.1      sandwich_3.0-1        RColorBrewer_1.1-2
#  [64] yaml_2.2.1            curl_4.3.1            gridExtra_2.3
#  [67] UpSetR_1.4.0          gdtools_0.2.3         rpart_4.1-15
#  [70] latticeExtra_0.6-29   stringi_1.6.2         highr_0.9
#  [73] corrplot_0.88         nortest_1.0-4         e1071_1.7-7
#  [76] checkmate_2.0.0       zip_2.1.1             rlang_0.4.11
#  [79] pkgconfig_2.0.3       systemfonts_1.0.2     evaluate_0.14
#  [82] lattice_0.20-44       purrr_0.3.4           labeling_0.4.2
#  [85] htmlwidgets_1.5.3     tidyselect_1.1.1      plyr_1.8.6
#  [88] magrittr_2.0.1        bookdown_0.22         R6_2.5.0
#  [91] generics_0.1.0        Hmisc_4.5-0           DBI_1.1.1
#  [94] pillar_1.6.1          foreign_0.8-81        withr_2.4.2
#  [97] prettydoc_0.4.1       survival_3.2-11       abind_1.4-5
# [100] nnet_7.3-16           tibble_3.1.2          crayon_1.4.1
# [103] car_3.0-10            utf8_1.2.1            rmarkdown_2.8
# [106] jpeg_0.1-8.1          grid_4.1.0            readxl_1.3.1
# [109] data.table_1.14.0     forcats_0.5.1         webshot_0.5.2
# [112] digest_0.6.27         xtable_1.8-4          tidyr_1.1.3
# [115] httpuv_1.6.1          openssl_1.4.4         munsell_0.5.0
```

```
# [118] viridisLite_0.4.0     kableExtra_1.3.4      askpass_1.1
```

```
  # or use message() instead of cat()
```

8.1.2 Python

```
import sys
print(sys.version)
```

```
3.9.4 (tags/v3.9.4:1f2e308, Apr  6 2021, 13:40:21) [MSC v.1928 64 bit (AMD64)]
```

8.1.3 Julia

```
v"1.6.1"
```

8.1.4 Stata

```
version 16.1

c:\ado\plus/x/xtabond2.ado

Checksum for c:/ado/plus/x/xtabond2.ado = 3720163387, size = 40472
```

8.2 All the code in the paper

To simply attach all the code you used in the PDF file in the appendix see the R chunk in the underlying `.rmd` file:

```
knitr::opts_chunk$set(cache = FALSE)
# Use chache = TRUE if you want to speed up compilation

# A function to allow for showing some of the inline code
rinline <- function(code){
  html <- '<code  class="r">``` `r CODE` ```</code>'
  sub("CODE", code, html)

  ##https://opensource.com/article/19/5/python-3-default-mac
```

```
  Sys.setenv(RETICULATE_PYTHON = "C:/Users/mangelo.EEG/AppData/Local/Microsoft/WindowsAp

##install.packages("reticulate")
library(reticulate)
##use_python("/Library/Frameworks/Python.framework/Versions/3.8/bin/python3")

use_virtualenv("C:/Users/mangelo.EEG/Documents/python")

##knitr::opts_chunk$set(python.reticulate=FALSE)

# library(devtools) # before this you may need to install devtools
# install_github("hemken/Statamarkdown")

library(JuliaCall)

library(Statamarkdown)
stataexe <- "C:/Program Files/Stata16/StataMP-64.exe"
knitr::opts_chunk$set(engine.path=list(stata=stataexe))

}
Sys.setenv(RETICULATE_PYTHON = "C:/Program Files/Python39/python.exe")
library(reticulate)
use_virtualenv("C:/Users/mangelo.EEG/Documents/python")
library(stargazer)
library(Statamarkdown)
stataexe <- "C:/Program Files/Stata16/StataMP-64.exe"
#stataexe <- "/Applications/Stata15/StataMP.app/Contents/MacOS//stata-mp"
knitr::opts_chunk$set(engine.path=list(stata=stataexe))
library(JuliaCall)
options(JULIA_HOME = "C:/Users/mangelo.EEG/AppData/Local/Programs/Julia-1.6.1/bin")
julia_setup()

## ExPanDaR: Explore Panel Data Interactively

  library(ExPanDaR)

    ## type ExPanD() in the Console

setwd("C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs")
```

```r
library(haven)
library(ggplot2)

nlswork <- read_dta("C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/nlswork.dta")

nls<-data.frame(nlswork)

attach(nlswork)

head(nlswork)

library(stargazer)
stargazer(nls,
          title = "Summary statistics",
          label="tab1",
          table.placement = "ht",
          header=FALSE)

library(dplyr)
library(dlookr)
library(ggplot2)

##eda_report(nlswork,output_dir = "C:/Users/mangelo.EEG/Documents/GitHub/prjs/reports/

## The data

names(nlswork)
##summary(nlswork)

## Missing values

library("visdat")

  vis_dat(nlswork)

## https://cran.r-project.org/web/packages/naniar/vignettes/naniar-visualisation.html

library(naniar)

  vis_miss(nlswork)
```

```
  gg_miss_upset(nlswork)

## GRAPHS
dplyr::glimpse(nlswork$ln_wage)
d <- density(ln_wage)
plot(d)

plot(nls$ln_wage,nls$ttl_exp)

ggplot(nlswork,
       aes(x = hours,
           y = year)) +
geom_miss_point()

ggplot(nlswork,
       aes(x = hours,
           y = year)) +
geom_miss_point() +
facet_wrap(race)

stats <- summary(nlswork$age)

library(stargazer)
stargazer(cars,
          title = "Summary table with stargazer",
          label="tab1cars",
          table.placement = "H",
          header=FALSE)
library(stargazer)
model1 <- lm(speed ~ dist, data = cars)
model2 <- lm(speed ~ dist, data = cars)
model3 <- lm(dist ~ speed, data = cars)
stargazer(model1, model2, model3,
          title = "Regression table with stargazer",
          label="tab2",
          table.placement = "H",
          column.labels = c("M1", "M2", "M3"),
          model.numbers = FALSE,
          header=FALSE)
plot(cars$speed, cars$dist)
```

```
mtcars$cyl <- as.factor(mtcars$cyl) # Convert cyl to factor
library(ggplot2)
ggplot(mtcars, aes(x=wt, y=mpg, shape=cyl)) + geom_point() +
  labs(x="Weight (lb/1000)", y = "Miles/(US) gallon",
       shape="Number of \n Cylinders") + theme_classic()
library(plotly)
p <- plot_ly(cars, type = "scatter", mode="markers",
        x=~speed,
        y=~dist)
#Sys.setenv('MAPBOX_TOKEN' = '12423423') # set arbitrary token
#orca(p, "logs/plotly-plot.pdf")
import sys
print(sys.version)


import json
##from json.decoder import JSONDecodeError
import requests
import numpy as np
import pandas as pd

## INE: https://www.ine.pt/ine/json_indicador/pindica.jsp?
## op=2&varcd=0008074&Dim1=S7A2015&Dim2=200&Dim3=3&lang=PT

# api-endpoint

URL = "https://www.ine.pt/ine/json_indicador/pindica.jsp"

# define parameters

OP="2"
VARCD="0008074"
DIM1="S7A2015"
DIM2="200"
DIM3="3"
LANG="PT"


# defining a params dict for the parameters to be sent to the API
PARAMS = {'op':OP,'varcd':VARCD,'Dim1':DIM1,'Dim2':DIM2,'Dim3':DIM3,'lang':LANG}
```

```
# sending get request and saving the response as response object
r = requests.get(url = URL,params=PARAMS)

# extracting data in json format
data = r.json()

valor = data[0]['Dados']['2015'][0]['valor']

valor

  cd C:/Users/mangelo.EEG/Documents/GitHub/prjs/pdfs
    find . -name '*.pdf' -print0 | xargs -0 -n1 pdfsandwich -gray
    find . -name '*ocr.pdf' -print0 | xargs -0 -n1 pdftotext
import os
import numpy as np
import pandas as pd
import re

## CHECK PyPDF2

## wget -A pdf -m -p -E -k -K -np https://joram.madeira.gov.pt/joram/4serie/
## find . -name '*.pdf' -print0 | xargs -0 -n1 pdfsandwich -gray
## find . -name '*ocr.pdf' -print0 | xargs -0 -n1 pdftotext

# Create list with .txt files for the specified folder
files_list = list()
for (dirpath, dirnames, filenames) in os.walk('C:/Users/mangelo.EEG/Documents/GitHub/prj
    files_list += [os.path.join(dirpath, file)
                   for file in filenames if file.endswith('.txt')]


##print("START:FILES -- list")

##print(files_list)

##print("END:FILES -- list")

p1 = r'PORTARIA'
p2 = r'EXTENSAO'
p3 = r'Materiais'
```

```
p5 = r'PE das'

linha = []
output = []
other = []
palavra = []
source = []

for file in files_list:

    f = open(file, "r", encoding='latin8')
    data = f.read()
    f.close()

    line = []
    nh = 0

    tmp1 = str(data)
    #print(tmp1)
    tmp2 = tmp1.splitlines()
    #print(tmp2)
    for n,tmp3 in enumerate(tmp2):
        #print(tmp3)
        if (tmp3.find("PE das") == 0):
            tmp4 = tmp3 + tmp2[2]
            line.append(tmp4)
            #print(n)
            nh = 1
        elif (nh == 1):
            nh = 0
            continue
        elif (nh == 0):
            line.append(tmp3)

    print(line)

    print("   ")

    print("FILE: ", file[46:-4])
```

```
    for num, word in enumerate(line):
            if num == 0:
                continue
            else:
                match1 = re.search(p1, word)
                match2 = re.search(p2, word)
                match3 = re.search(p3, word)
                match4 = re.search(r'\d{9}', word)
                match5 = re.search(p5, word)
                ##print("   ")
                ##print("START: ",num)

                if match1:
                        ##print("   ")
                        print("match 1")
                        if match4:
                            ##print("   ")
                            print("match 4")
                            linha.append(num)
                            output.append(re.search(r'\d{9}', word).group())
                            other.append("vazio")
                            palavra.append(p1)
                            source.append(file[46:-4])
                elif match2:
                            ##print("   ")
                            print("match 2")
                            linha.append(num)
                            output.append(re.search(r'\d{9}', word).group())
                            other.append("vazio")
                            palavra.append(p2)
                            source.append(file[46:-4])
                elif match3:
                            ##print("   ")
                            print("match 3")
                            linha.append(num)
                            output.append(re.search(r'\d{9}', word).group())
                            other.append("vazio")
                            palavra.append(p3)
                            source.append(file[46:-4])
                elif match5:
```

```
                            ##print("   ")
                            print("-> match 5")
                            ##word.sub(" e o ", " e a ",1)
                            print(word)
                            linha.append(num)

                            if (word.find(" e o ") > 0):
                                print("11111")
                                output.append((word.split("re a", 1)[1]).split(" e o ",
                                other.append((word.split("re a", 1)[1]).split(" e o ", 1
                            elif (word.find(" e a ") > 0):
                                print("99999")
                                output.append((word.split("re a", 1)[1]).split(" e a ",
                                other.append((word.split("re a", 1)[1]).split(" e a ", 1

                            palavra.append(p5)
                            source.append(file[46:-4])
## o paragrafo tem de estar na mesma linha e temos de ter 'e a' em vez de 'e o'
df = pd.DataFrame({'linha': linha, 'output': output,
                   'outra': other, 'source': source})
print(df)

df.to_csv('data/PE.csv', index=False)
df.to_stata('data/PE.dta', write_index = False)


quiet cd "C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs"
quiet import delimited "C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/PE.csv", encodin
tab source

python3 "C:/Users/mangelo.EEG/Documents/GitHub/prjs/chunks/python_chunk.py"

quietly{
cd C:/Users/mangelo.EEG/Documents/GitHub/prjs/chunks

use C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/nipcs, clear
compress
contract nipc
drop _freq
drop if nipc == .
```

```
format %12.0f nipc
}

//codebook nipc

tab nipc
## This is a julia language chunk.
## In julia, the command without ending semicolon will trigger the display
## so is JuliaCall package.
## The julia display will follow immediately after the corresponding command
## just as the R code in R Markdown.

using ReadStat
using StatFiles
using StatsBase
using DataFrames
using FixedEffectModels

@time results_hdfe1 = reg(DataFrame(load("C:/Users/mangelo.EEG/Documents/GitHub/prjs/dat

@time results_hdfe2 = reg(DataFrame(load("C:/Users/mangelo.EEG/Documents/GitHub/prjs/dat

using RegressionTables
regtable(results_hdfe1,results_hdfe2; renderSettings = latexOutput("logs/hdfe_output.tex

VERSION
library(JuliaCall)

  julia_eval("results_hdfe2")

betas <- julia_eval("coef(results_hdfe2)")
r2 <- julia_eval("r2(results_hdfe2)")

use C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/data_short, clear

timer on 1

    reghdfe lnrealwage education lnsales,absorb(workerid firmid year)

timer off 1
```

```
timer list 1
timer clear 1
library(lfe)
data_short <- read_dta("C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/data_short.dta")

system.time(est_hdfe <- felm(data_short$lnrealwage ~ data_short$education + data_short$l

summary(est_hdfe)
library(stargazer)
library(Statamarkdown)
stataexe <- "C:/Program Files/Stata16/StataMP-64.exe"
knitr::opts_chunk$set(engine.path=list(stata=stataexe))

setwd("C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs")
rm(list = ls())
library(haven)
nlswork <- read_dta("../data/nlswork.dta")

auto <- read_dta("../data/auto.dta")

attach(nlswork)

regs1 <- lm(auto$price ~ auto$mpg + auto$weight)
regs2 <- lm(auto$price ~ auto$mpg + auto$weight + auto$rep78)
regs3 <- lm(auto$price ~ auto$mpg + auto$weight + auto$rep78 + auto$trunk)

regs4 <- lm(ln_wage ~ union)
regs5 <- lm(ln_wage ~ union + collgrad)
regs6 <- lm(ln_wage ~ union + collgrad + age)

##summary(auto)
##summary(regs1)

## https://www.jakeruss.com/cheatsheets/stargazer/

nls<-data.frame(nlswork)

stargazer(nls, summary.stat = c("n", "p75", "sd"), summary.logical = FALSE,
          title = "Summary table",
          label="tab23",
```

```
          table.placement = "ht",
          header=FALSE)


stargazer(regs1, regs2, regs3,
          title = "Regression table with stargazer",
          label="tab3",
          table.placement = "ht",
          column.labels = c("M1", "M2", "M3"),
          model.numbers = FALSE,
          header=FALSE,keep=c(0,1,2,3))

attach(auto)


library(naniar)
vis_miss(nlswork)

# plot(y=price,x=mpg)

library(stargazer)
stargazer(cars,
          title = "Summary 24",
          label="tab24",
          table.placement = "ht",
          header=FALSE)
quiet sysuse auto
sum price

tab rep78

quiet cd "C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs"

quiet use ../data/nlswork, clear

twoway (kdensity ln_wage if collgrad == 0) || (kdensity ln_wage if collgrad == 1), schem

graph export "C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs/density.pdf", replace

use ../data/data_full, clear
```

```
        quiet generate lngdp = ln(rgdpwok)
        quiet ge lnk = ln(capital)

        label var rgdpwok "Real GDP per worker"
        label var education "Education (in years)"
        label var capital "Capital"
        label var open "Degree of openness"

// # regression analysis

    quiet reg lngdp education
        estimates store r1

    quiet reg lngdp education lnk
        est store r2

    reg lngdp education lnk openk i.year
        est store r3

outreg, clear
    quiet estimates restore r1
        outreg using growth_analysis_frag, tex fragment replace rtitles("Education" \ ""
                */ drop(_cons) /*
                */ ctitle("","Simple model") /*
                */ nodisplay varlabels bdec(4) se starlevels(10 5 1) starloc(1) summstat

    quiet estimates restore r2
        outreg using growth_analysis_frag, tex fragment merge rtitles("Education" \ "" \
                */ drop(_cons) /*
                */ ctitle("","Include capital") /*
                */ nodisplay varlabels bdec(3) se starlevels(10 5 1) starloc(1) summstat

    quiet estimates restore r3
        outreg using growth_analysis_frag, tex fragment merge rtitles("Education" \ "" \
                */ drop(_cons 1975.year 1980.year 1985.year 1990.year) /*
                */ ctitle("","Full model") /*
                */ nodisplay varlabels bdec(1) se starlevels(10 5 1) starloc(1) summstat

sum lngdp
use C:/Users/mangelo.EEG/Documents/GitHub/prjs/data/data_full, clear
```

```
        quiet generate lngdp = ln(rgdpwok)
      summarize lngdp
file open myfile using example.txt, write replace
file write myfile `"`r(mean)'"'
file close myfile
unlink("example.txt")
version
//ado describe

findfile xtabond2.ado
checksum "c:/ado/plus/x/xtabond2.ado"

// PUTEXCEL

cd "C:/Users/mangelo.EEG/Documents/GitHub/prjs/logs"

quiet use ../data/graph_data, clear
    codebook, compact

            putexcel clear
            putexcel set descriptives.xlsx, sheet("Avg. Educ. & desc.") replace


gen first = substr(country,1,1)

    levelsof first,local(ff)

    foreach vv of local ff {

        di _new(3) "Country's first letter: `vv'"

        preserve
        quiet keep if first == "`vv'"

        quiet unique country

            if r(unique) > 5 {
            di _new(2) "    Number of countries:    " r(unique) _new(1)
            quietly {
                collapse (mean) lngdp education,by(country)
```

```
                    putexcel set descriptives.xlsx, sheet("FIRST LETTER `vv'") modify

                    regress lngdp education

                            matrix list r(table)

                        matrix results = r(table)
                            mat l results

                        mat b = results[1,1...]'
                        mat t = results[3,1...]'

                        putexcel C2="Coef." F2="t"
                        putexcel B3 = matrix(b), rownames nformat(number_d2) right
                        putexcel D3 = matrix(t),nformat("0.00")
                }
            }

            if r(unique) <= 5 {
                // di _new(2) " Insufficient number of countries; n countries = " r(uniq
            }

        restore
}

// tabulate, summarize() -- EXAMPLE

tabulate first year, summarize(education) nost nof noob

collapse (mean) education,by(first year)

reshape wide education,i(first) j(year)
mkmat education*,matrix(mean_educ) rownames(first)

putexcel set descriptives.xlsx, sheet("Mean Education") modify

    putexcel C2="1960" D2="1965" E2="1970" F2="1975" G2="1980" H2="1985" I2="1990" J2="1
    putexcel B3 = matrix(mean_educ), rownames nformat(number_d2) right
plot(x = mpg, y = price,
     pch = 16, frame = FALSE,
```

```
     xlab = "wt", ylab = "mpg", col = "#2E9FDF")
cat(paste("#", capture.output(sessionInfo()), "\n", collapse =""))
  # or use message() instead of cat()
import sys
print(sys.version)
VERSION
version
//ado describe

findfile xtabond2.ado
checksum "c:/ado/plus/x/xtabond2.ado"
```