R Notebook: Panel Data Models with R - June 2021

This is an R Markdown Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Cmd+Shift+Enter* (in Windows press *CTRL+Enter*).

Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Cmd+Option+I* (or *CTRL+Alt+I* in Windows).

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Cmd+Shift+K* to preview the HTML file).

The preview shows you a rendered HTML copy of the contents of the editor. Consequently, unlike *Knit*, *Preview* does not run any R code chunks. Instead, the output of the chunk when it was last run in the editor is displayed.

Package Management Tool

Here i am uploading my packages (code omitted).

Prepare the data

Here I am reading a Stata data file (code omitted).

Statistics

```
  names(nlswork)
```

```
##  [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"
```

```
  head(nlswork)
```

```
## # A tibble: 6 x 21
##   idcode  year birth_yr   age  race   msp nev_mar grade collgrad not_smsa c_city
##    <dbl> <dbl>    <dbl> <dbl> <dbl> <dbl>   <dbl> <dbl>    <dbl>    <dbl>  <dbl>
## 1      1    70       51    18     2     0       1    12        0        0      1
## 2      1    71       51    19     2     1       0    12        0        0      1
## 3      1    72       51    20     2     1       0    12        0        0      1
```

```
## 4      1    73       51    21     2     1       0    12        0        0      1
## 5      1    75       51    23     2     1       0    12        0        0      1
## 6      1    77       51    25     2     0       0    12        0        0      1
## # ... with 10 more variables: south <dbl>, ind_code <dbl>, occ_code <dbl>,
## #   union <dbl>, wks_ue <dbl>, ttl_exp <dbl>, tenure <dbl>, hours <dbl>,
## #   wks_work <dbl>, ln_wage <dbl>
```

```
  # str(nlswork)
  # dplyr::glimpse(nlswork)

  dplyr::glimpse(nlswork$ln_wage)
```

```
##  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"
```

```
  ExpData(nlswork,type=1)
```

```
##                                          Descriptions       Value
## 1                                   Sample size (nrow)       28534
## 2                              No. of variables (ncol)          21
## 3                      No. of numeric/interger variables          21
## 4                                No. of factor variables           0
## 5                                  No. of text variables           0
## 6                               No. of logical variables           0
## 7                            No. of identifier variables           0
## 8                                  No. of date variables           0
## 9              No. of zero variance variables (uniform)           0
## 10                %. of variables having complete cases  33.33% (7)
## 11   %. of variables having >0% and <50% missing cases 66.67% (14)
## 12 %. of variables having >=50% and <90% missing cases      0% (0)
## 13          %. of variables having >=90% missing cases      0% (0)
```

```
  ExpData(nlswork,type=2)
```

```
##    Index Variable_Name Variable_Type Sample_n Missing_Count Per_of_Missing
## 1      1        idcode       numeric    28534             0          0.000
## 2      2          year       numeric    28534             0          0.000
## 3      3      birth_yr       numeric    28534             0          0.000
## 4      4           age       numeric    28510            24          0.001
## 5      5          race       numeric    28534             0          0.000
## 6      6           msp       numeric    28518            16          0.001
## 7      7       nev_mar       numeric    28518            16          0.001
## 8      8         grade       numeric    28532             2          0.000
## 9      9      collgrad       numeric    28534             0          0.000
## 10    10      not_smsa       numeric    28526             8          0.000
## 11    11        c_city       numeric    28526             8          0.000
## 12    12         south       numeric    28526             8          0.000
## 13    13      ind_code       numeric    28193           341          0.012
## 14    14      occ_code       numeric    28413           121          0.004
## 15    15         union       numeric    19238          9296          0.326
## 16    16        wks_ue       numeric    22830          5704          0.200
```

```
## 17    17       ttl_exp       numeric    28534            0          0.000
## 18    18        tenure       numeric    28101          433          0.015
## 19    19         hours       numeric    28467           67          0.002
## 20    20      wks_work       numeric    27831          703          0.025
## 21    21       ln_wage       numeric    28534            0          0.000
##    No_of_distinct_values
## 1                   4711
## 2                     15
## 3                     14
## 4                     33
## 5                      3
## 6                      2
## 7                      2
## 8                     19
## 9                      2
## 10                     2
## 11                     2
## 12                     2
## 13                    12
## 14                    13
## 15                     2
## 16                    61
## 17                  4744
## 18                   270
## 19                    85
## 20                   105
## 21                  8173
```

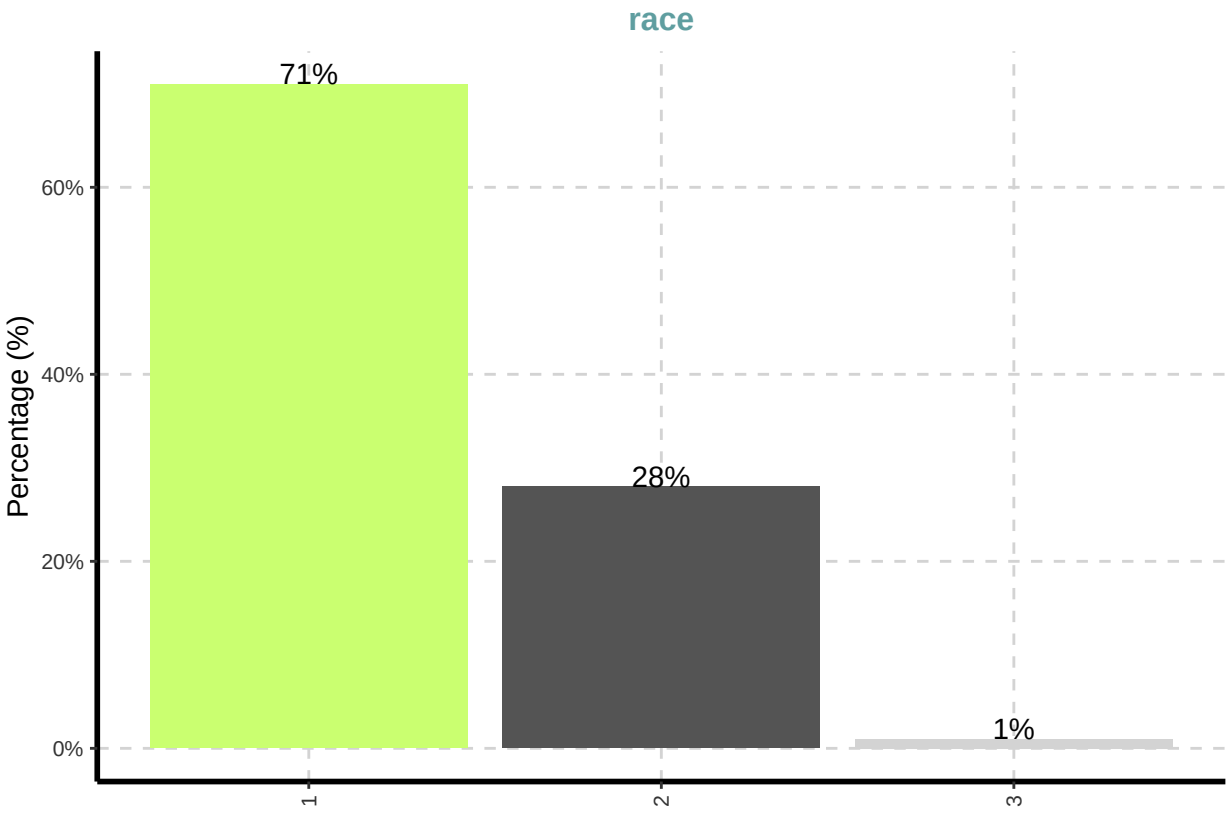
Exploratory data analysis

Start discussing the statistics and graphs.

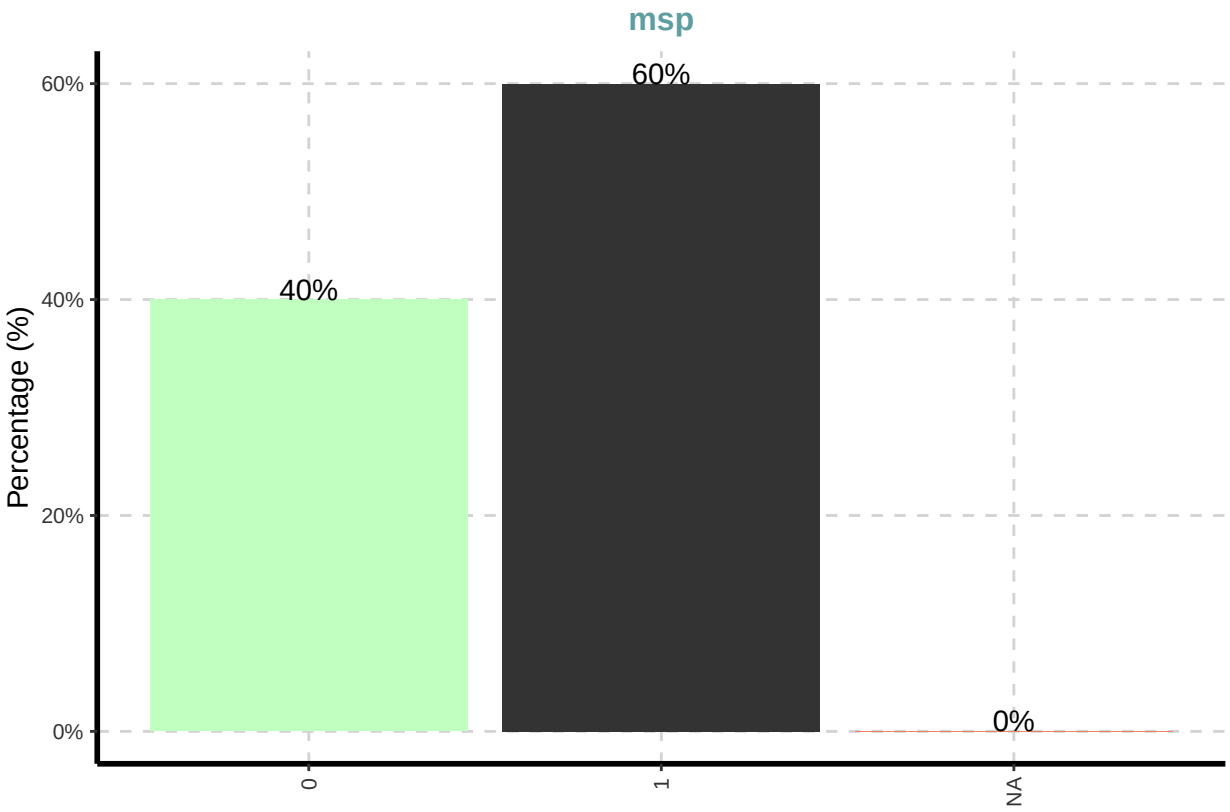
```
##      grade
##  Min.   : 0.00
##  1st Qu.:12.00
##  Median :12.00
##  Mean   :12.53
##  3rd Qu.:14.00
##  Max.   :18.00
##  NA's   :2
```

```
##       Vname Group    TN nNeg nZero  nPos NegInf PosInf NA_Value Per_of_Missing
## 4       age   All 28534    0     0 28510      0      0       24           0.08
## 3  birth_yr   All 28534    0     0 28534      0      0        0           0.00
## 5     grade   All 28534    0    21 28511      0      0        2           0.01
## 11    hours   All 28534    0     0 28467      0      0       67           0.23
## 1    idcode   All 28534    0     0 28534      0      0        0           0.00
## 6  ind_code   All 28534    0     0 28193      0      0      341           1.20
## 13  ln_wage   All 28534    0     2 28532      0      0        0           0.00
## 7  occ_code   All 28534    0     0 28413      0      0      121           0.42
## 10   tenure   All 28534    0  1248 26853      0      0      433           1.52
## 9   ttl_exp   All 28534    0    21 28513      0      0        0           0.00
## 8    wks_ue   All 28534    0 17394  5436      0      0     5704          19.99
```

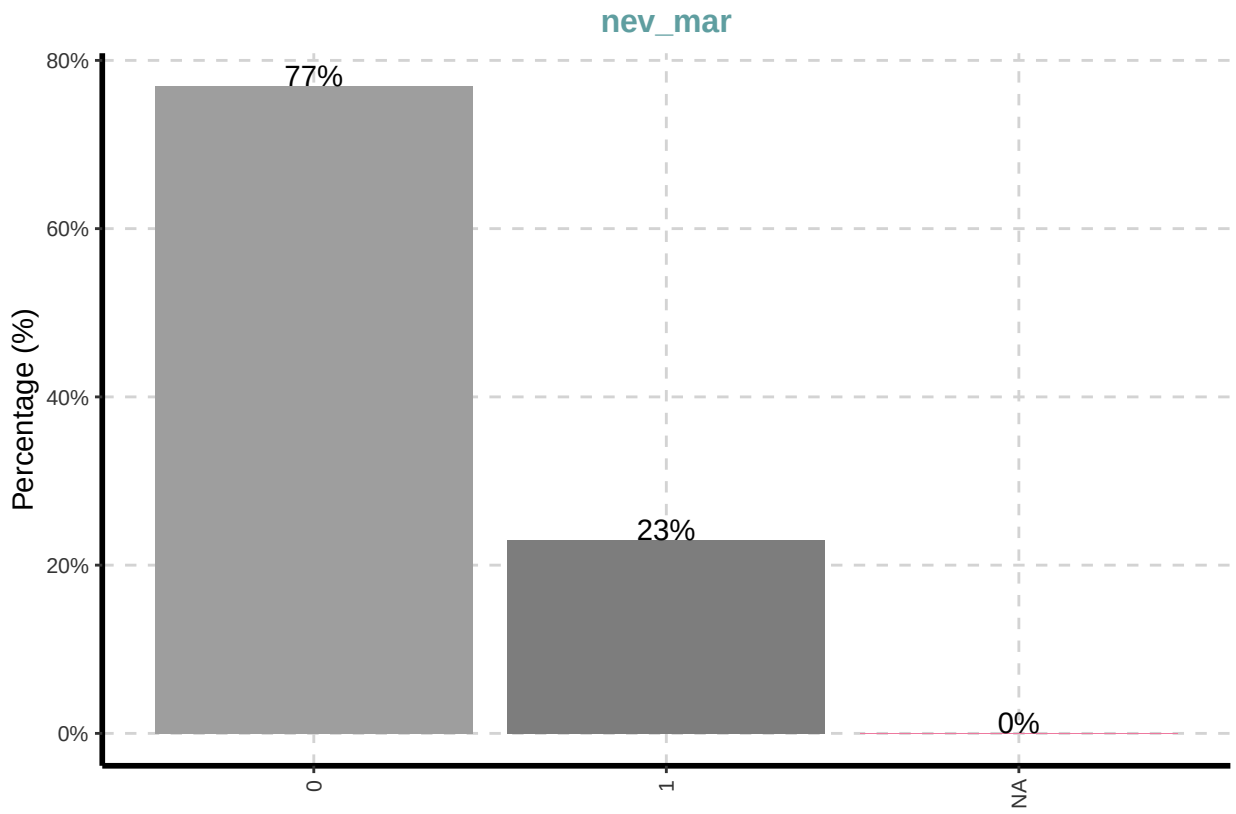
```
## 12 wks_work   All 28534    0   478 27353      0      0      703           2.46
## 2      year   All 28534    0     0 28534      0      0        0           0.00
##             sum min     max    mean  median      SD   CV     IQR Skewness
## 4    828076.00  14   46.00   29.05   28.00    6.70 0.23   11.00     0.26
## 3   1372060.00  41   54.00   48.09   48.00    3.01 0.06    5.00    -0.12
## 5    357580.00   0   18.00   12.53   12.00    2.32 0.19    2.00     0.10
## 11  1040741.00   1  168.00   36.56   40.00    9.87 0.27    5.00    -0.90
## 1  74225046.00   1 5159.00 2601.28 2606.00 1487.36 0.57 2554.00    -0.02
## 6    216888.00   1   12.00    7.69    7.00    2.99 0.39    6.00     0.00
## 13    47791.80   0    5.26    1.67    1.64    0.48 0.29    0.60     0.33
## 7    135748.00   1   13.00    4.78    3.00    3.07 0.64    3.00     1.08
## 10    87782.92   0   25.92    3.12    1.67    3.75 1.20    3.67     1.94
## 9    177347.83   0   28.88    6.22    5.06    4.65 0.75    6.67     0.86
## 8     58173.00   0   76.00    2.55    0.00    7.29 2.86    0.00     4.02
## 12  1502577.00   0  104.00   53.99   52.00   29.03 0.54   36.00     0.19
## 2   2224472.00  68   88.00   77.96   78.00    6.38 0.08   11.00     0.09
##    Kurtosis    10%     20%     50%   LB.25%  UB.75% nOutliers
## 4     -0.91  21.00   23.00   28.00     6.50   50.50         0
## 3     -0.99  44.00   45.00   48.00    38.50   58.50         0
## 5      1.37  10.00   12.00   12.00     9.00   17.00      2125
## 11     4.26  20.00   32.00   40.00    27.50   47.50      6100
## 1     -1.19 518.00 1051.00 2606.00 -2504.00 7712.00         0
## 6     -1.46   4.00    4.00    7.00    -4.00   20.00         0
## 13     1.67   1.17    1.30    1.64     0.46    2.87       660
## 7      0.68   1.00    3.00    3.00    -1.50   10.50      1846
## 10     3.90   0.17    0.42    1.67    -5.00    9.67      2138
## 9      0.06   1.04    2.00    5.06    -7.54   19.13       191
## 8     18.25   0.00    0.00    0.00     0.00    0.00      5436
## 12    -0.68  14.00   28.00   52.00   -18.00  126.00         0
## 2     -1.30  70.00   71.00   78.00    55.50   99.50         0

## [[1]]
```



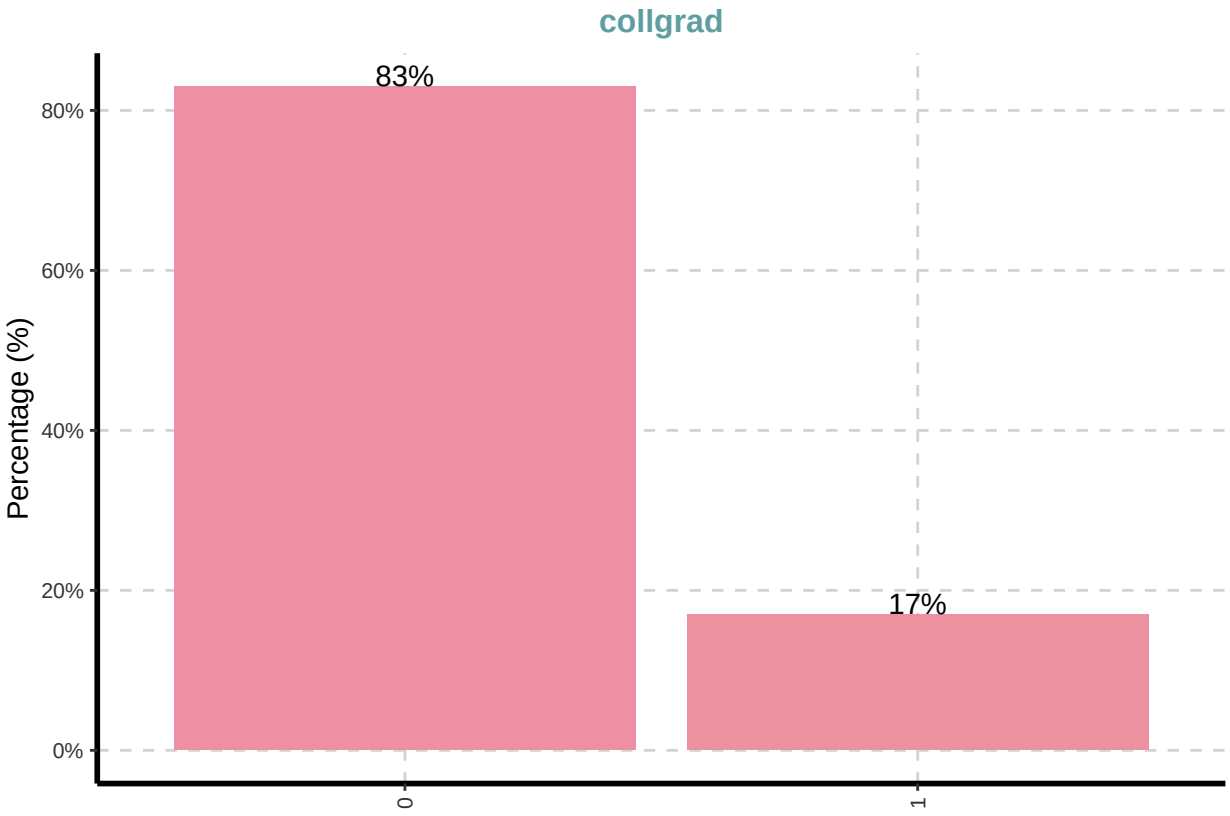

```
##
## [[2]]
```



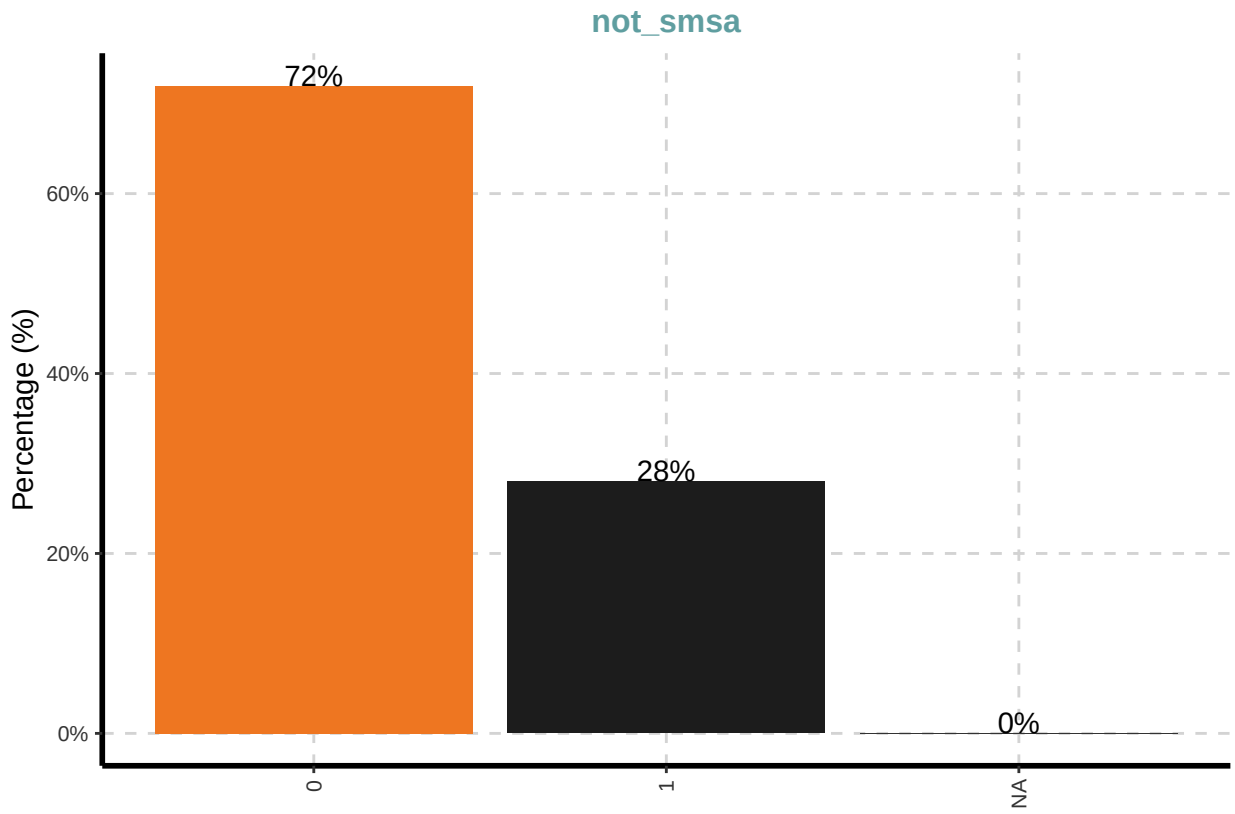

```
##
## [[3]]
```



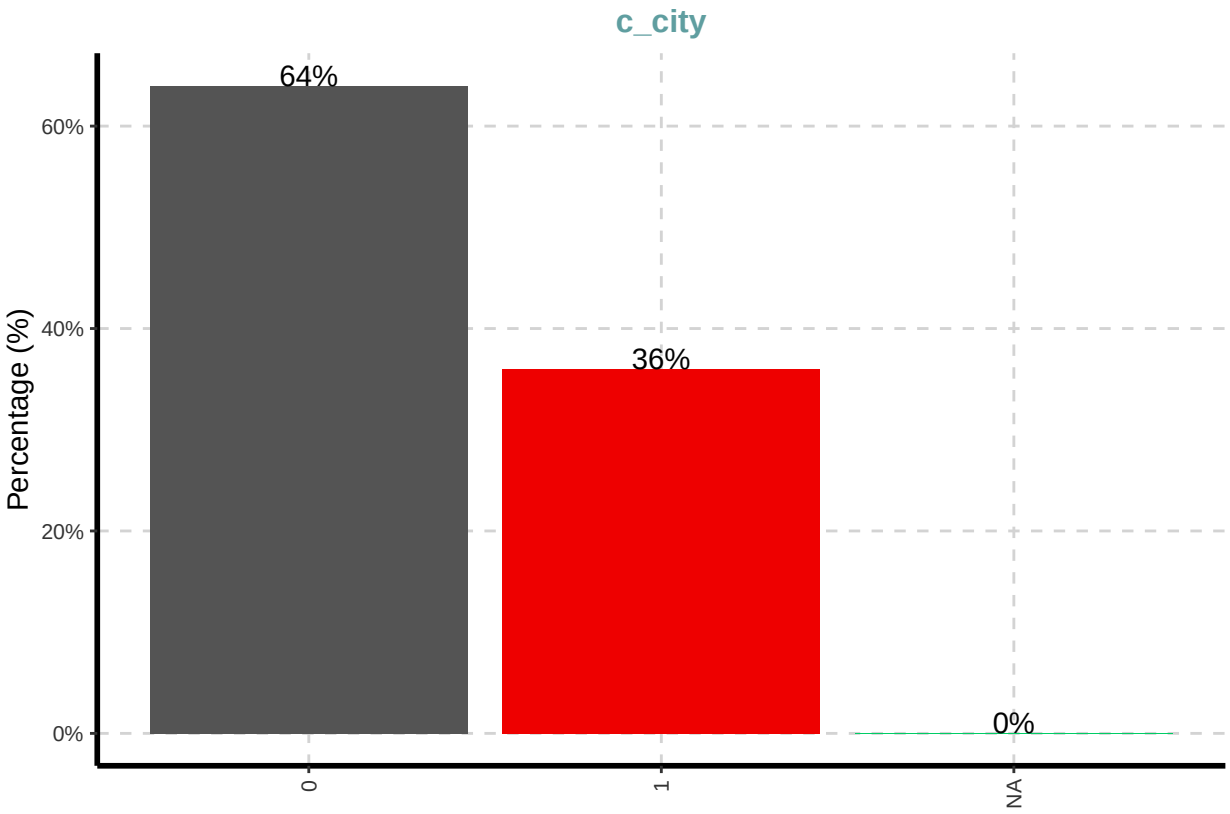

```
##
## [[4]]
```



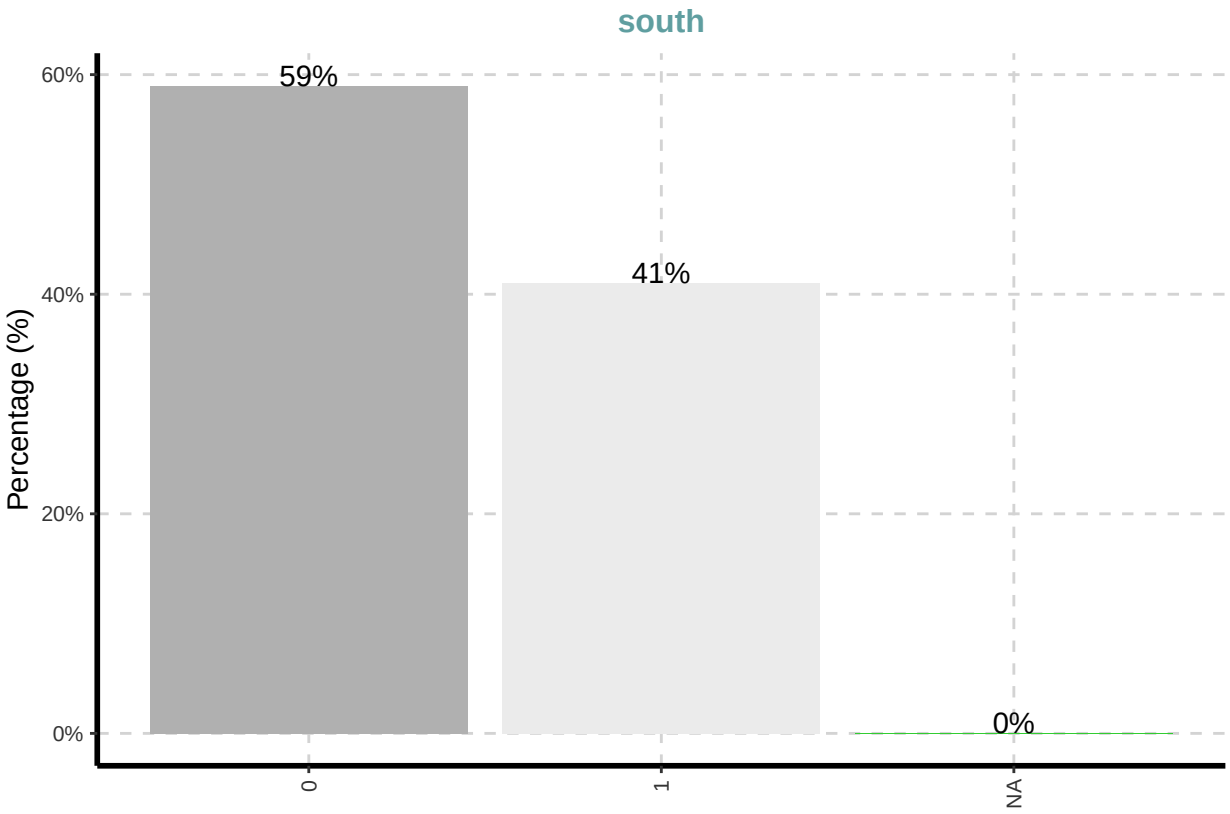

```
##
## [[5]]
```



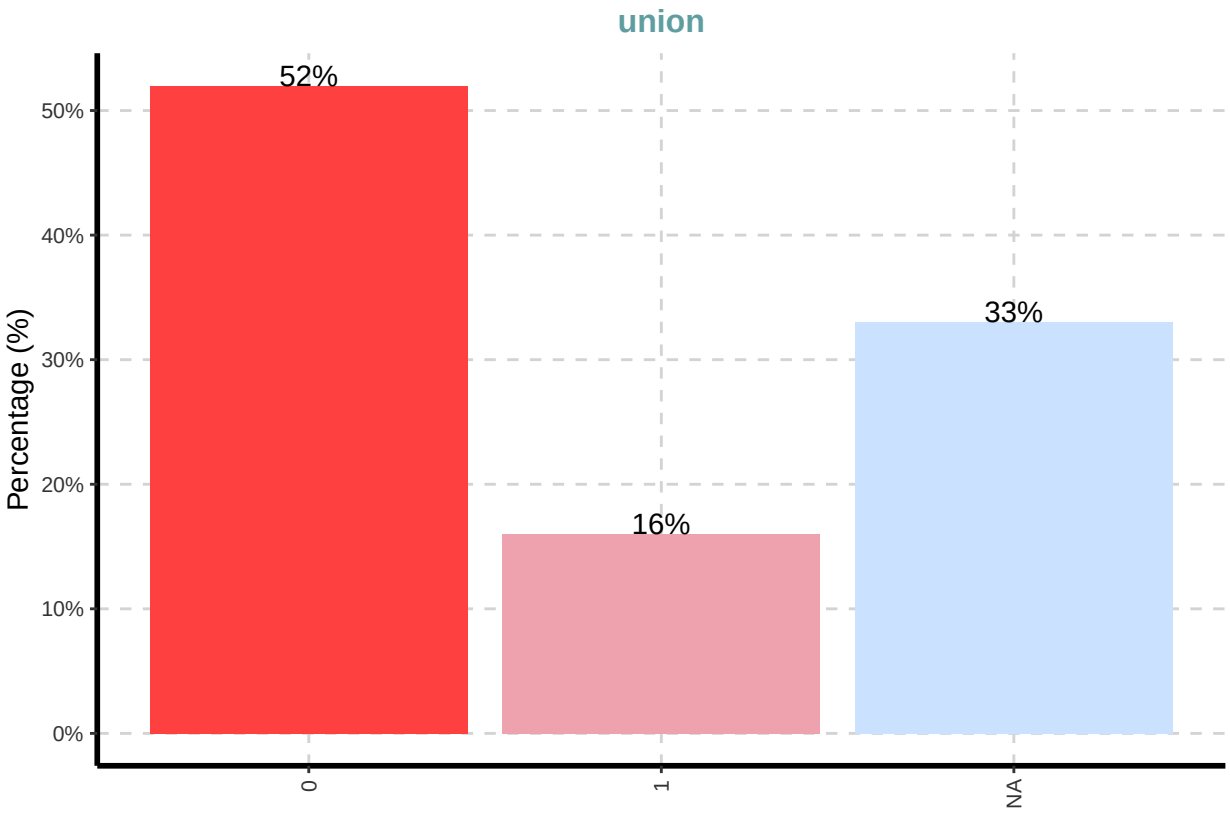

```
##
## [[6]]
```



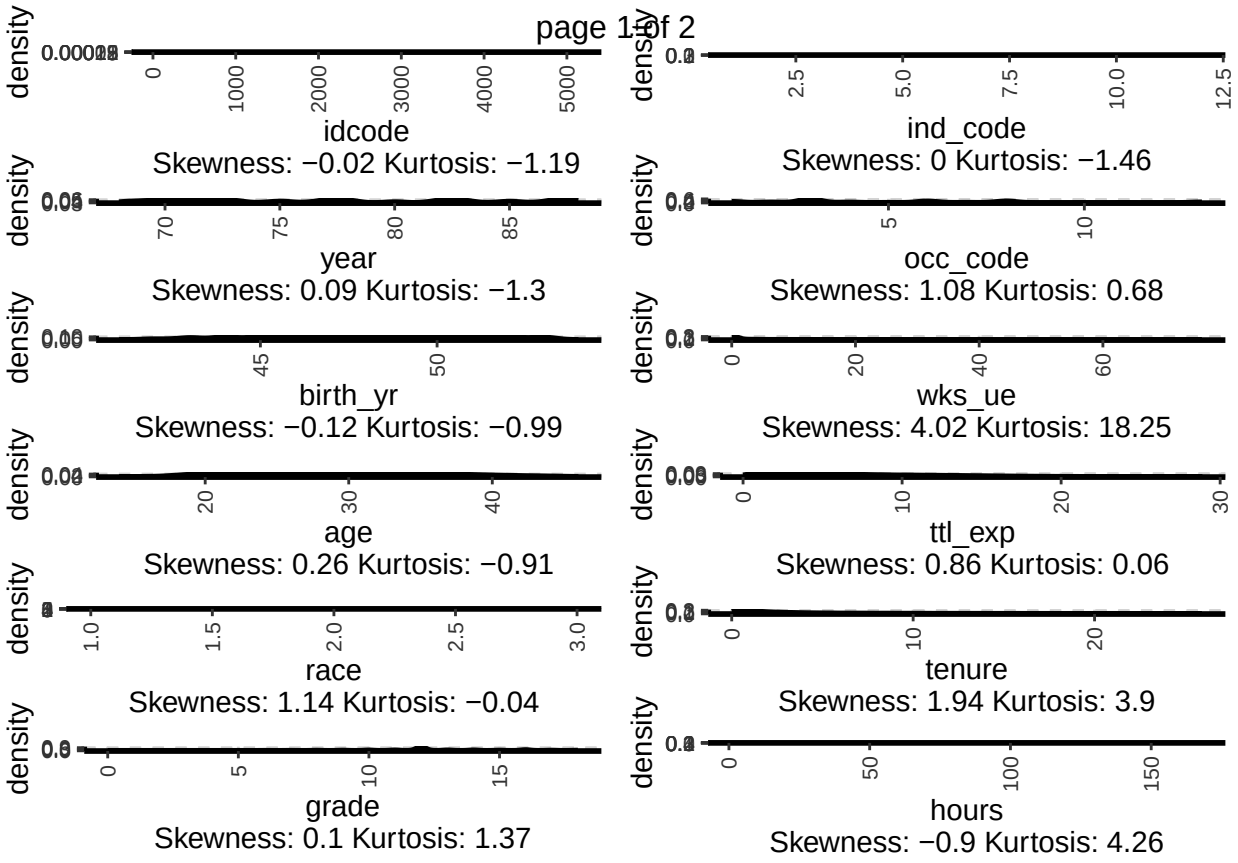

```
##
## [[7]]
```

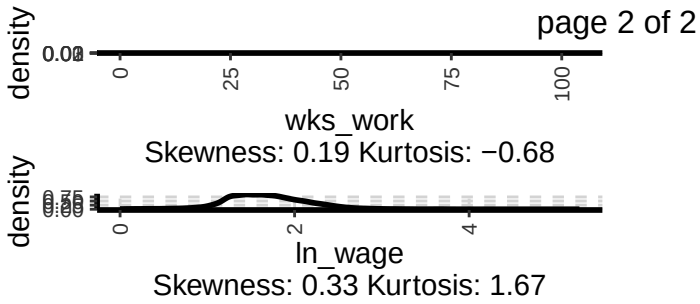



```
##
## [[8]]
```




```
## Warning in matrix(data = seq(1, pn), nrow = nr, ncol = nc): data length [14] is
## not a sub-multiple or multiple of the number of rows [6]

## $`0`
```

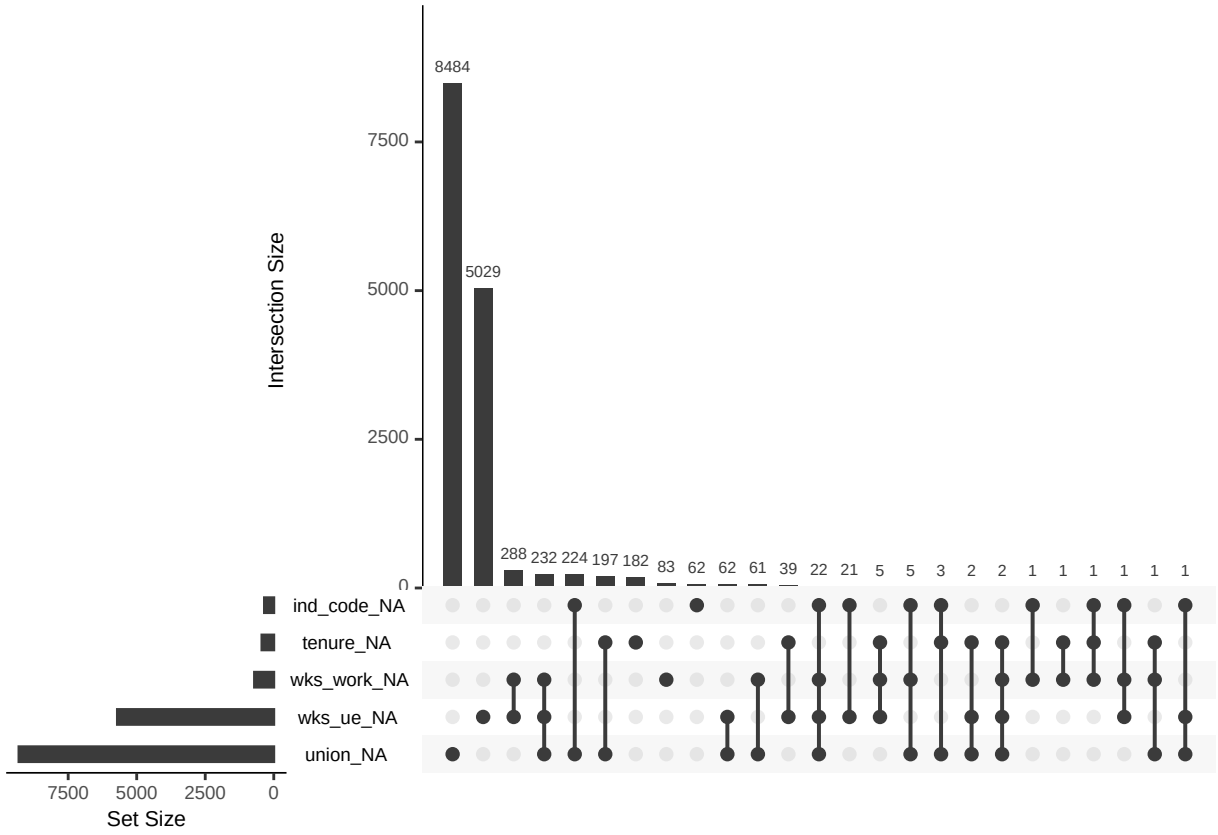

density
idcode
Skewness: −0.02 Kurtosis: −1.19
ind_code
Skewness: 0 Kurtosis: −1.46
year
Skewness: 0.09 Kurtosis: −1.3
occ_code
Skewness: 1.08 Kurtosis: 0.68
birth_yr
Skewness: −0.12 Kurtosis: −0.99
wks_ue
Skewness: 4.02 Kurtosis: 18.25
age
Skewness: 0.26 Kurtosis: −0.91
ttl_exp
Skewness: 0.86 Kurtosis: 0.06
race
Skewness: 1.14 Kurtosis: −0.04
tenure
Skewness: 1.94 Kurtosis: 3.9
grade
Skewness: 0.1 Kurtosis: 1.37
hours
Skewness: −0.9 Kurtosis: 4.26



MISSING VALUES

```
vis_dat(nlswork)
```


```
# vis_miss(nlswork) # ALTERNATIVE

  gg_miss_upset(nlswork)
```



Add a dataframe

Export output

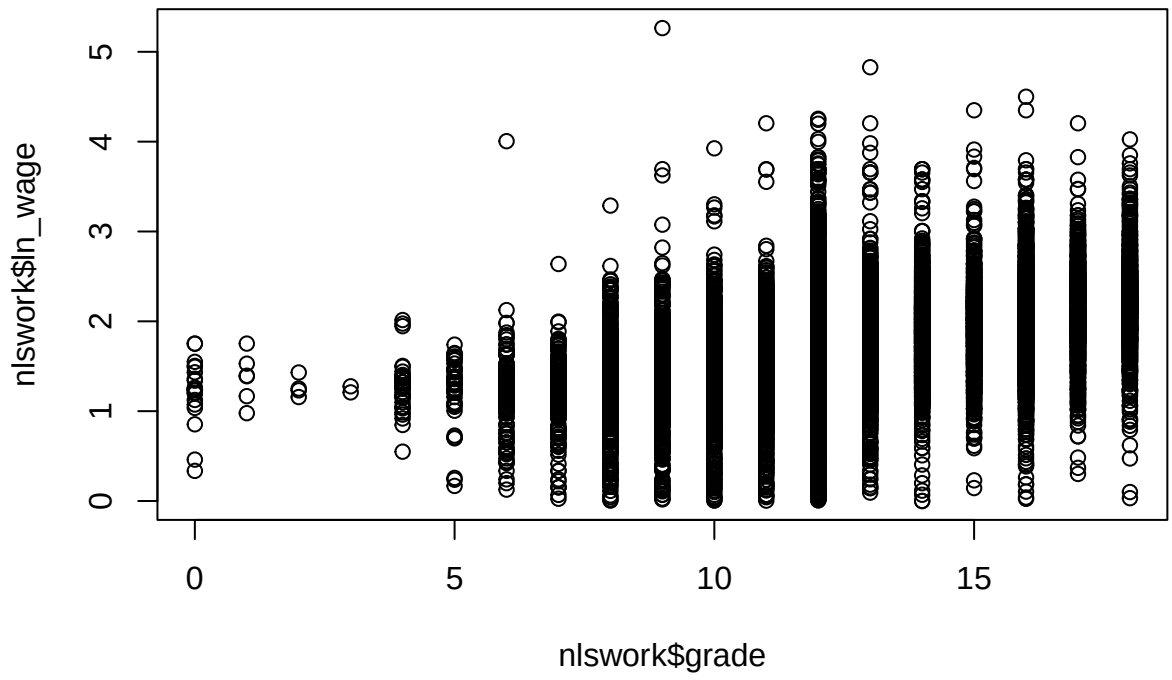
```
stargazer(nls,
          title = "Summary statistics",
          label = "tb:statistcis",
          table.placement = "ht",
          header=FALSE,type="text")
```

```
##
## 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
## ------------------------------------------------------------------------
```

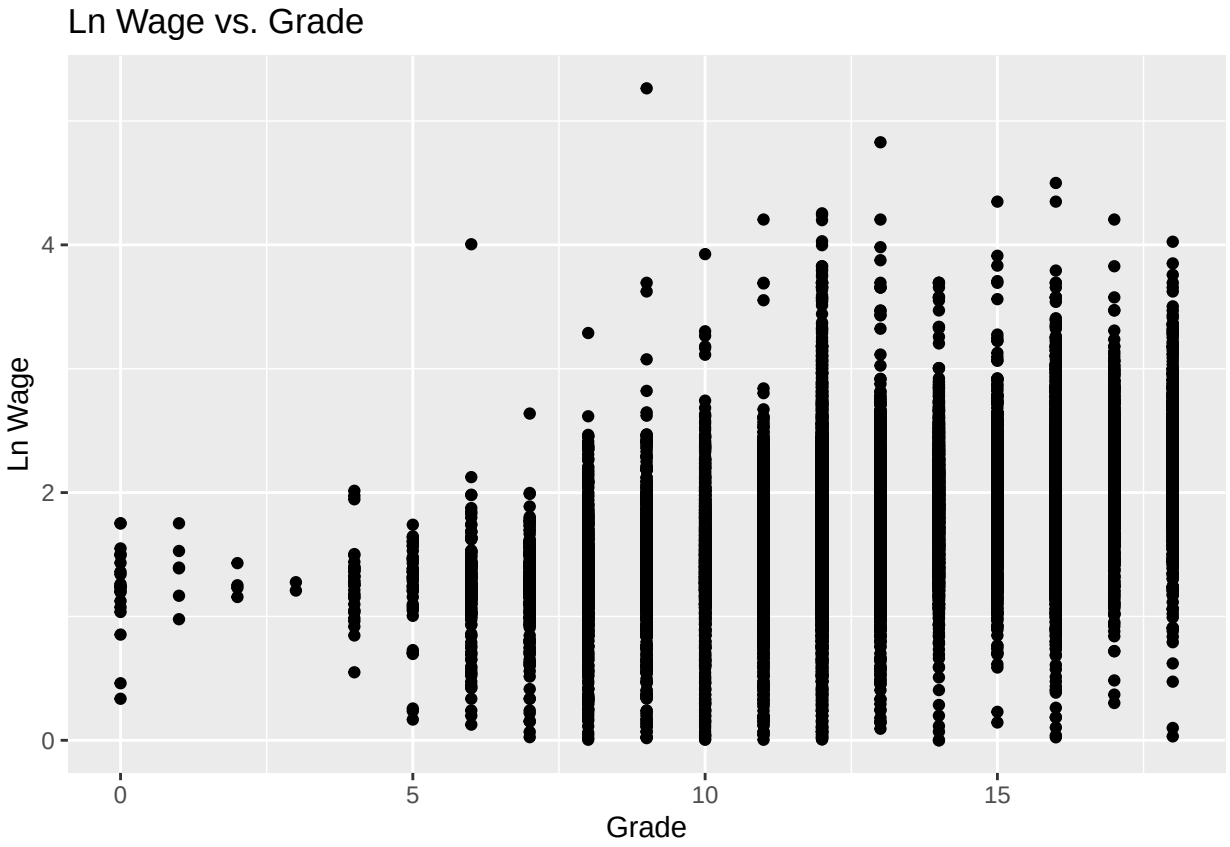
Produce a graph

```
plot(nlswork$grade,nlswork$ln_wage)
```



Save the graph

```
## Warning: Removed 2 rows containing missing values (geom_point).
```




```
## Saving 6.5 x 4.5 in image
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```

Tabulations and further statistics

```
##  nlswork$race     n    percent
##             1 20180 0.70722647
##             2  8051 0.28215462
##             3   303 0.01061891
```

```
## Frequencies
## nlswork$year
## Label: interview year
## Type: Numeric
##
##                Freq   % Valid   % Valid Cum.   % Total   % Total Cum.
## ----------- ------- --------- -------------- --------- --------------
##          88    2272      7.96           7.96      7.96           7.96
##          77    2171      7.61          15.57      7.61          15.57
##          87    2164      7.58          23.15      7.58          23.15
##          75    2141      7.50          30.66      7.50          30.66
##          82    2085      7.31          37.97      7.31          37.97
##          85    2085      7.31          45.27      7.31          45.27
```

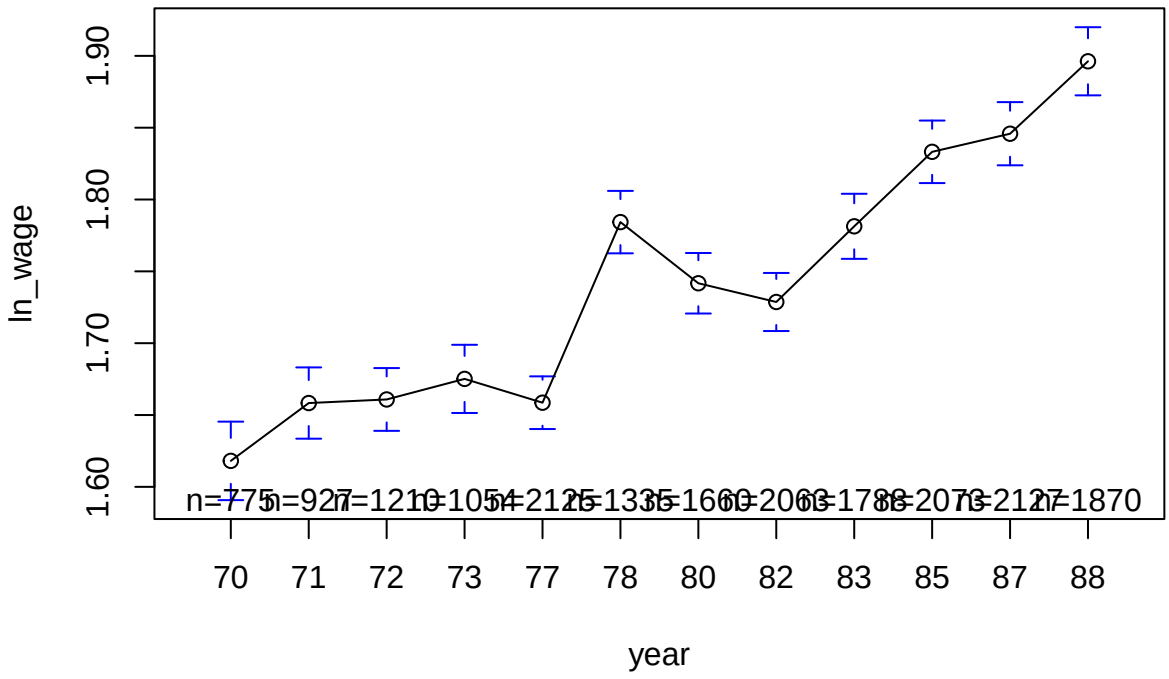
```
##          83    1987      6.96          52.24      6.96          52.24
##          73    1981      6.94          59.18      6.94          59.18
##          78    1964      6.88          66.06      6.88          66.06
##          71    1851      6.49          72.55      6.49          72.55
##          80    1847      6.47          79.02      6.47          79.02
##          72    1693      5.93          84.95      5.93          84.95
##          70    1686      5.91          90.86      5.91          90.86
##          68    1375      4.82          95.68      4.82          95.68
##          69    1232      4.32         100.00      4.32         100.00
##        <NA>       0                                0.00         100.00
##       Total   28534    100.00         100.00    100.00         100.00
```

```
## Frequencies
## nlswork$race
## Label: 1=white, 2=black, 3=other
## Type: Numeric
##
##                Freq   % Valid   % Valid Cum.   % Total   % Total Cum.
## ----------- ------- --------- -------------- --------- --------------
##           1   20180     70.72          70.72     70.72          70.72
##           2    8051     28.22          98.94     28.22          98.94
##           3     303      1.06         100.00      1.06         100.00
##        <NA>       0                                0.00         100.00
##       Total   28534    100.00         100.00    100.00         100.00
```

A new dataset: exclude onservations with missing information in a subset of variables

Add variable

Plot variables means



Regression analysis

- *Estimating a Mincerian Wage Equation*
- *POLS estimator with cluster-robust standard errors*

Q1

Pooled OLS model

Export regression output

```
##
## Regression analysis
## ============================================
```

```
##                          OLS             panel
##                                         linear
##                          OLS            Pooled
## ------------------------------------------------
## Union                  0.113***        0.113***
##                         (0.007)         (0.007)
## Collage Graduate       0.351***        0.351***
##                         (0.007)         (0.007)
## Age                    0.022***        0.022***
##                         (0.004)         (0.004)
## Age sqrd.             -0.0003***      -0.0003***
##                         (0.0001)        (0.0001)
## Tenure                 0.055***        0.055***
##                         (0.002)         (0.002)
## Tenure sqrd.          -0.002***       -0.002***
##                         (0.0001)        (0.0001)
## Not SMSA              -0.205***       -0.205***
##                         (0.007)         (0.007)
## South                 -0.141***       -0.141***
##                         (0.006)         (0.006)
## City                  -0.032***       -0.032***
##                         (0.007)         (0.007)
## N                       19,007          19,007
## R2                      0.319           0.319
## ================================================
## Notes:            Standard errors in parentheses.
```

- *SMSA*: Standard Metropolitan Statistical Area

```
# ftable(c_city) # 1 if central city
```

CLUSTERED Standard-errors

```
pols_robust <- coeftest(pols, function(x) vcovHC(x, type = 'sss'))

stargazer(pols,pols_robust,title = "Regression analysis",
          model.numbers = FALSE,
          column.labels = c("Pooled","Pooled (cluster)"),
          label = "regressions",
          table.placement = "!ht",
          notes.append = FALSE,
          notes.align="l",
          notes="Standard errors in parentheses.",
          header = FALSE,
          no.space = TRUE,
          covariate.labels = c("Union","Collage graduate","Age","Age sqrd.",
                               "Tenure","Tenure sqrd.","Not SMSA","South","City"),
          omit = c("Constant"),
          omit.stat = c("adj.rsq","f","ser"),
          digits = 6,
          digits.extra = 7,
```

```
            omit.yes.no = c("Constant",""),
            dep.var.caption="",
            dep.var.labels.include = FALSE,
            style = "qje",
            type="text")
```

```
##
## Regression analysis
## ================================================
##                        panel        coefficient
##                       linear            test
##                       Pooled      Pooled (cluster)
## ------------------------------------------------
## Union                0.112774***     0.112774***
##                      (0.006774)       (0.011731)
## Collage graduate     0.350946***     0.350946***
##                      (0.007149)       (0.014112)
## Age                  0.022481***     0.022481***
##                      (0.004249)       (0.005373)
## Age sqrd.           -0.000306***     -0.000306***
##                      (0.000068)       (0.000088)
## Tenure               0.054787***     0.054787***
##                      (0.001944)       (0.002743)
## Tenure sqrd.        -0.001540***     -0.001540***
##                      (0.000125)       (0.000180)
## Not SMSA            -0.205457***     -0.205457***
##                      (0.007120)       (0.013137)
## South               -0.140589***     -0.140589***
##                      (0.005850)       (0.010964)
## City                -0.031543***     -0.031543***
##                      (0.006683)       (0.011691)
## N                      19,007
## R2                    0.319459
## ================================================
## Notes:            Standard errors in parentheses.
```

Q2

Random effects estimator (RE)

- SEE THE DISCUSSION HERE for the comparison between R and Stata

https://stats.stackexchange.com/questions/421374/different-results-from-random-effects-plm-r-and-xtreg-stata

- R and Stata treat differently unbalanced panels

for a balanced panel we have

```r
nlswork_balanced <- read_dta("data/nlswork_balanced.dta")

re_balanced <- plm(data = nlswork_balanced, ln_wage ~ union +
                     collgrad +age +agesq +tenure +tensq +
                     not_smsa +south +c_city, model="random",
                   index=c("idcode", "year"))
    summary(re_balanced)
```

```
## Oneway (individual) effect Random Effect Model
##    (Swamy-Arora's transformation)
##
## Call:
## plm(formula = ln_wage ~ union + collgrad + age + agesq + tenure +
##     tensq + not_smsa + south + c_city, data = nlswork_balanced,
##     model = "random", index = c("idcode", "year"))
##
## Balanced Panel: n = 53, T = 12, N = 636
##
## Effects:
##                   var std.dev share
## idiosyncratic 0.03698 0.19230 0.319
## individual    0.07902 0.28110 0.681
## theta: 0.8063
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -0.904519 -0.104813  0.015673  0.114854  0.658580
##
## Coefficients:
##                Estimate  Std. Error z-value  Pr(>|z|)
## (Intercept)  1.05650211  0.20514289  5.1501 2.604e-07 ***
## union        0.06087668  0.02949229  2.0642 0.0390030 *
## collgrad     0.20128253  0.17651938  1.1403 0.2541673
## age          0.04592525  0.01334703  3.4409 0.0005799 ***
## agesq       -0.00051693  0.00020986 -2.4632 0.0137701 *
## tenure       0.00332254  0.00616575  0.5389 0.5899766
## tensq        0.00011290  0.00028483  0.3964 0.6918193
## not_smsa    -0.29590935  0.07567198 -3.9104 9.214e-05 ***
## south       -0.06346941  0.06258349 -1.0142 0.3105084
## c_city       0.00068168  0.03609511  0.0189 0.9849322
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    32.65
## Residual Sum of Squares: 23.689
## R-Squared:      0.27447
## Adj. R-Squared: 0.26404
## Chisq: 236.819 on 9 DF, p-value: < 2.22e-16
```

```r
re <- plm(data = nlswork_clean, ln_wage ~ union +
            collgrad +age +agesq +tenure +tensq +
            not_smsa +south +c_city, model="random",
          index=c("idcode", "year"))
```

```
summary(re)
```

```
## Oneway (individual) effect Random Effect Model
##    (Swamy-Arora's transformation)
##
## Call:
## plm(formula = ln_wage ~ union + collgrad + age + agesq + tenure +
##     tensq + not_smsa + south + c_city, data = nlswork_clean,
##     model = "random", index = c("idcode", "year"))
##
## Unbalanced Panel: n = 4134, T = 1-12, N = 19007
##
## Effects:
##                   var std.dev share
## idiosyncratic 0.06476 0.25448 0.444
## individual    0.08108 0.28475 0.556
## theta:
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.3336  0.5920  0.6572  0.6406  0.6987  0.7502
##
## Residuals:
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -1.77886 -0.13081  0.00854  0.00428  0.14314  3.03289
##
## Coefficients:
##                Estimate  Std. Error  z-value  Pr(>|z|)
## (Intercept)  1.1369e+00  5.0729e-02  22.4103 < 2.2e-16 ***
## union        1.0368e-01  6.4468e-03  16.0819 < 2.2e-16 ***
## collgrad     3.6931e-01  1.2344e-02  29.9171 < 2.2e-16 ***
## age          2.3031e-02  3.3174e-03   6.9424 3.856e-12 ***
## agesq       -2.4910e-04  5.3181e-05  -4.6839 2.814e-06 ***
## tenure       4.0771e-02  1.5826e-03  25.7618 < 2.2e-16 ***
## tensq       -1.2466e-03  1.0022e-04 -12.4393 < 2.2e-16 ***
## not_smsa    -1.5114e-01  9.3804e-03 -16.1119 < 2.2e-16 ***
## south       -1.1157e-01  8.4671e-03 -13.1766 < 2.2e-16 ***
## c_city       3.9713e-04  7.4923e-03   0.0530    0.9577
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    1942.3
## Residual Sum of Squares: 1268
## R-Squared:      0.34903
## Adj. R-Squared: 0.34872
## Chisq: 4820.91 on 9 DF, p-value: < 2.22e-16
```

```
re_robust <- coeftest(re, function(x) vcovHC(x, type = 'sss'))
```

```
stargazer(pols,pols_robust,re,re_robust,title = "Regression analysis",
          model.numbers = FALSE,
          column.labels = c("Pooled","Pooled (cluster)","RE","RE (cluster"),
          label = "regressions",
          table.placement = "!ht",
```

```
            notes.append = FALSE,
            notes.align="l",
            notes="Standard errors in parentheses.",
            header = FALSE,
            no.space = TRUE,
            covariate.labels = c("Union","College Graduate","Age","Age sqrd.",
                                 "Tenure","Tenure sqrd.","Not SMSA","South","City"),
            omit = c("Constant"),
            omit.stat = c("adj.rsq","f","ser"),
            digits = 3,
            digits.extra = 5,
            omit.yes.no = c("Constant",""),
            dep.var.caption="",
            dep.var.labels.include = FALSE,
            style = "qje",
            type="text")
```

```
##
## Regression analysis
## ============================================================================
##                     panel      coefficient      panel    coefficient
##                     linear         test         linear      test
##                     Pooled   Pooled (cluster)     RE     RE (cluster
## ----------------------------------------------------------------------------
## Union              0.113***      0.113***      0.104***   0.104***
##                    (0.007)       (0.012)       (0.006)     (0.009)
## College Graduate   0.351***      0.351***      0.369***   0.369***
##                    (0.007)       (0.014)       (0.012)     (0.013)
## Age                0.022***      0.022***      0.023***   0.023***
##                    (0.004)       (0.005)       (0.003)     (0.005)
## Age sqrd.         -0.0003***    -0.0003***    -0.0002*** -0.0002***
##                    (0.0001)      (0.0001)      (0.0001)   (0.0001)
## Tenure             0.055***      0.055***      0.041***   0.041***
##                    (0.002)       (0.003)       (0.002)     (0.002)
## Tenure sqrd.      -0.002***     -0.002***     -0.001***   -0.001***
##                    (0.0001)      (0.0002)      (0.0001)   (0.0001)
## Not SMSA          -0.205***     -0.205***     -0.151***   -0.151***
##                    (0.007)       (0.013)       (0.009)     (0.012)
## South             -0.141***     -0.141***     -0.112***   -0.112***
##                    (0.006)       (0.011)       (0.008)     (0.011)
## City              -0.032***     -0.032***      0.0004     0.0004
##                    (0.007)       (0.012)       (0.007)     (0.010)
## N                   19,007                      19,007
## R2                  0.319                       0.349
## ============================================================================
## Notes:            Standard errors in parentheses.
```

```
  stargazer(pols,pols_robust,re,re_robust,title = "Regression analysis",
            model.numbers = FALSE,
            column.labels = c("Pooled","Pooled (cluster)","RE","RE (cluster"),
            label = "regressions",
            table.placement = "!ht",
            notes.append = FALSE,
```

```
            notes.align="l",
            notes="Standard errors in parentheses.",
            header = FALSE,
            no.space = TRUE,
            covariate.labels = c("Union","College Graduate","Age","Age sqrd.",
                                 "Tenure","Tenure sqrd.","Not SMSA","South","City"),
            omit = c("Constant"),
            omit.stat = c("adj.rsq","f","ser"),
            digits = 3,
            digits.extra = 5,
            omit.yes.no = c("Constant",""),
            dep.var.caption="",
            dep.var.labels.include = FALSE,
            style = "qje",
            type="text")
```

```
##
## Regression analysis
## ============================================================================
##                     panel      coefficient      panel    coefficient
##                     linear         test         linear      test
##                     Pooled   Pooled (cluster)     RE     RE (cluster
## ----------------------------------------------------------------------------
## Union              0.113***      0.113***      0.104***   0.104***
##                    (0.007)       (0.012)       (0.006)     (0.009)
## College Graduate   0.351***      0.351***      0.369***   0.369***
##                    (0.007)       (0.014)       (0.012)     (0.013)
## Age                0.022***      0.022***      0.023***   0.023***
##                    (0.004)       (0.005)       (0.003)     (0.005)
## Age sqrd.         -0.0003***    -0.0003***    -0.0002*** -0.0002***
##                    (0.0001)      (0.0001)      (0.0001)   (0.0001)
## Tenure             0.055***      0.055***      0.041***   0.041***
##                    (0.002)       (0.003)       (0.002)     (0.002)
## Tenure sqrd.      -0.002***     -0.002***     -0.001***   -0.001***
##                    (0.0001)      (0.0002)      (0.0001)   (0.0001)
## Not SMSA          -0.205***     -0.205***     -0.151***   -0.151***
##                    (0.007)       (0.013)       (0.009)     (0.012)
## South             -0.141***     -0.141***     -0.112***   -0.112***
##                    (0.006)       (0.011)       (0.008)     (0.011)
## City              -0.032***     -0.032***       0.0004     0.0004
##                    (0.007)       (0.012)       (0.007)     (0.010)
## N                   19,007                      19,007
## R2                  0.319                       0.349
## ============================================================================
## Notes:            Standard errors in parentheses.
```

LM test for the presence of unobserved effects

```
plmtest(pols, type=c("bp"))
```

```
##
```

```
##  Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels
##
## data:  ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +  ...
## chisq = 14041, df = 1, p-value < 2.2e-16
## alternative hypothesis: significant effects
```

```
  kable(tidy(plmtest(pols, type=c("bp"))), format = "simple",caption=
          "LM test for the presence of unobserved effects")
```

Table 1: LM test for the presence of unobserved effects

statistic	p.value	parameter	method	alternative
14041.19	0	1	Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels	significant effects

Fixed effects estimator (FE)

```
# //Final slide 32
#
# *Q3*
#

  fe <- plm(data = nlswork_clean, ln_wage ~ union +
              collgrad +age +agesq +tenure +tensq +
              not_smsa +south +c_city, model="within", index=c("idcode", "year"))

      summary(fe)
```

```
## Oneway (individual) effect Within Model
##
## Call:
## plm(formula = ln_wage ~ union + collgrad + age + agesq + tenure +
##     tensq + not_smsa + south + c_city, data = nlswork_clean,
##     model = "within", index = c("idcode", "year"))
##
## Unbalanced Panel: n = 4134, T = 1-12, N = 19007
##
## Residuals:
##     Min.  1st Qu.   Median  3rd Qu.     Max.
## -1.88027 -0.10216  0.00000  0.10774  2.80710
##
## Coefficients:
##             Estimate  Std. Error  t-value  Pr(>|t|)
## union     9.3877e-02  6.9662e-03  13.4761 < 2.2e-16 ***
## age       2.4259e-02  3.4467e-03   7.0383 2.031e-12 ***
## agesq    -2.2618e-04  5.5316e-05  -4.0890 4.356e-05 ***
## tenure    3.2966e-02  1.6465e-03  20.0218 < 2.2e-16 ***
## tensq    -1.1002e-03  1.0291e-04 -10.6916 < 2.2e-16 ***
## not_smsa -9.3105e-02  1.2970e-02  -7.1787 7.372e-13 ***
## south    -6.3222e-02  1.3279e-02  -4.7611 1.944e-06 ***
## c_city    1.1409e-02  8.8964e-03   1.2824    0.1997
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    1119.5
## Residual Sum of Squares: 962.69
## R-Squared:      0.14005
## Adj. R-Squared: -0.099505
## F-statistic: 302.62 on 8 and 14865 DF, p-value: < 2.22e-16
```

```
stargazer(pols,re,fe,title = "Regression analysis",
          model.numbers = FALSE,
          column.labels = c("Pooled","RE","FE"),
          label = "regressions",
          table.placement = "!ht",
          notes.append = FALSE,
          notes.align="l",
          notes="Standard errors in parentheses.",
          header = FALSE,
          no.space = TRUE,
          covariate.labels = c("Union","College","Age","Age sqrd.","Tenure",
                               "Tenure sqrd.","Not SMSA","South","City"),
          omit = c("Constant"),
          omit.stat = c("adj.rsq","f","ser"),
          digits = 6,
          digits.extra = 7,
          omit.yes.no = c("Constant",""),
          dep.var.caption="",
          dep.var.labels.include = FALSE,
          style = "qje",
          type="text")
```

```
##
## Regression analysis
## ================================================
##                   Pooled         RE           FE
## Union          0.112774***  0.103677***  0.093877***
##                 (0.006774)   (0.006447)   (0.006966)
## College        0.350946***  0.369309***
##                 (0.007149)   (0.012344)
## Age            0.022481***  0.023031***  0.024259***
##                 (0.004249)   (0.003317)   (0.003447)
## Age sqrd.     -0.000306*** -0.000249*** -0.000226***
##                 (0.000068)   (0.000053)   (0.000055)
## Tenure         0.054787***  0.040771***  0.032966***
##                 (0.001944)   (0.001583)   (0.001646)
## Tenure sqrd. -0.001540*** -0.001247*** -0.001100***
##                 (0.000125)   (0.000100)   (0.000103)
## Not SMSA      -0.205457*** -0.151136*** -0.093105***
##                 (0.007120)   (0.009380)   (0.012970)
## South         -0.140589*** -0.111567*** -0.063222***
##                 (0.005850)   (0.008467)   (0.013279)
## City          -0.031543***   0.000397     0.011409
##                 (0.006683)   (0.007492)   (0.008896)
## N                 19,007       19,007       19,007
```

```
## R2              0.319459     0.349029     0.140054
## ================================================
## Notes:       Standard errors in parentheses.
```

```
# Testing for fixed effects, null: OLS better than fixed
# 'F test for individual effects' <<==>> 'F test that all u_i=0'

  ols_0 <- lm(data = nlswork_clean, ln_wage ~ union +
                age +agesq +tenure +tensq +
                not_smsa +south +c_city)
      summary(ols_0)
```

```
##
## Call:
## lm(formula = ln_wage ~ union + age + agesq + tenure + tensq +
##     not_smsa + south + c_city, data = nlswork_clean)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.7497 -0.2508 -0.0182  0.2379  3.4100
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.008e+00  6.821e-02  14.776  < 2e-16 ***
## union        1.294e-01  7.181e-03  18.026  < 2e-16 ***
## age          3.929e-02  4.495e-03   8.740  < 2e-16 ***
## agesq       -5.387e-04  7.175e-05  -7.509 6.24e-14 ***
## tenure       5.806e-02  2.062e-03  28.158  < 2e-16 ***
## tensq       -1.699e-03  1.331e-04 -12.765  < 2e-16 ***
## not_smsa    -2.311e-01  7.538e-03 -30.657  < 2e-16 ***
## south       -1.475e-01  6.208e-03 -23.762  < 2e-16 ***
## c_city      -3.451e-02  7.094e-03  -4.864 1.16e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4091 on 18998 degrees of freedom
## Multiple R-squared:  0.2331, Adjusted R-squared:  0.2328
## F-statistic: 721.9 on 8 and 18998 DF,  p-value: < 2.2e-16
```

```
  pFtest(fe, ols_0)
```

```
##
##  F test for individual effects
##
## data:  ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +  ...
## F = 8.2833, df1 = 4133, df2 = 14865, p-value < 2.2e-16
## alternative hypothesis: significant effects
```

```
# generate fixed-effects

# nlswork_clean$specific_effects <- fixef(fe)
```

```r
# *Q3.1*

  fe_robust <- coeftest(fe, function(x) vcovHC(x, type = 'sss'))

  stargazer(ols_0,fe,fe_robust,title = "Regression analysis",
            model.numbers = FALSE,
            column.labels = c("OLS","FE","FE (cluster)"),
            label = "regressions",
            table.placement = "!ht",
            notes.append = FALSE,
            notes.align="l",
            notes="Standard errors in parentheses.",
            header = FALSE,
            no.space = TRUE,
            covariate.labels = c("Union","Age","Age sqrd.","Tenure",
                                 "Tenure sqrd.","Not SMSA","South","City"),
            omit = c("Constant"),
            omit.stat = c("adj.rsq","f","ser"),
            digits = 6,
            digits.extra = 7,
            omit.yes.no = c("Constant",""),
            dep.var.caption="",
            dep.var.labels.include = FALSE,
            style = "qje",
            type="text")
```

```
##
## Regression analysis
## ================================================
##                   OLS         panel     coefficient
##                               linear        test
##                   OLS           FE      FE (cluster)
## ------------------------------------------------
## Union         0.129446***  0.093877***  0.093877***
##                (0.007181)   (0.006966)   (0.009565)
## Age           0.039289***  0.024259***  0.024259***
##                (0.004495)   (0.003447)   (0.005008)
## Age sqrd.    -0.000539*** -0.000226*** -0.000226***
##                (0.000072)   (0.000055)   (0.000081)
## Tenure        0.058063***  0.032966***  0.032966***
##                (0.002062)   (0.001646)   (0.002085)
## Tenure sqrd. -0.001699*** -0.001100*** -0.001100***
##                (0.000133)   (0.000103)   (0.000126)
## Not SMSA     -0.231095*** -0.093105*** -0.093105***
##                (0.007538)   (0.012970)   (0.019790)
## South        -0.147518*** -0.063222*** -0.063222***
##                (0.006208)   (0.013279)   (0.021653)
## City         -0.034506***   0.011409     0.011409
##                (0.007094)   (0.008896)   (0.012605)
## N               19,007       19,007
## R2              0.233124     0.140054
## ================================================
## Notes:       Standard errors in parentheses.
```

```r
# *Q3.2*

  linearHypothesis(ols,c("age=0","agesq=0"))
```

```
## Linear hypothesis test
##
## Hypothesis:
## age = 0
## agesq = 0
##
## Model 1: restricted model
## Model 2: ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +
##     south + c_city
##
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1  18999 2832.2
## 2  18997 2821.8  2    10.418 35.066 6.294e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
  linearHypothesis(ols,c("age=0","agesq=0"), white.adjust = "hc1")
```

```
## Linear hypothesis test
##
## Hypothesis:
## age = 0
## agesq = 0
##
## Model 1: restricted model
## Model 2: ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +
##     south + c_city
##
## Note: Coefficient covariance matrix supplied.
##
##   Res.Df Df      F    Pr(>F)
## 1  18999
## 2  18997  2 40.554 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
  Wald_test(fe, vcov = "CR1", cluster = nlswork_clean$idcode,
            constraints = constrain_zero(c("age","agesq")), test = "Naive-F")
```

```
##     test Fstat df_num df_denom  p_val sig
##  Naive-F  80.4      2     4133 <0.001 ***
```

LSDV estimator

```r
# *LSDV Estimator=FE estimator* <<==>> takes too long
# *using a smaller sample*

nlswork_balanced <- read_dta("data/nlswork_balanced_small.dta")

  LSDV <- lm(data = nlswork_balanced, ln_wage ~ union +
               age +agesq +tenure +tensq +
               not_smsa +south +c_city + factor(idcode))
  summary(LSDV)
```

```
##
## Call:
## lm(formula = ln_wage ~ union + age + agesq + tenure + tensq +
##     not_smsa + south + c_city + factor(idcode), data = nlswork_balanced)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.254362 -0.069457  0.004535  0.078344  0.239917
##
## Coefficients: (2 not defined because of singularities)
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        0.5332323  0.4915522   1.085   0.2833
## union              0.0895838  0.0548743   1.633   0.1090
## age                0.0758967  0.0334355   2.270   0.0276 *
## agesq             -0.0011959  0.0005405  -2.212   0.0316 *
## tenure             0.0125105  0.0162130   0.772   0.4440
## tensq              0.0006329  0.0007176   0.882   0.3821
## not_smsa                  NA         NA      NA       NA
## south                     NA         NA      NA       NA
## c_city             0.1164782  0.0875330   1.331   0.1895
## factor(idcode)20   0.3287869  0.1289784   2.549   0.0140 *
## factor(idcode)126 -0.0167263  0.0546551  -0.306   0.7609
## factor(idcode)128  0.0375653  0.0882907   0.425   0.6724
## factor(idcode)379 -0.1504303  0.1188913  -1.265   0.2118
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1149 on 49 degrees of freedom
## Multiple R-squared:  0.8021, Adjusted R-squared:  0.7617
## F-statistic: 19.86 on 10 and 49 DF,  p-value: 5.49e-14
```

```r
  fe_LSDV <- plm(data = nlswork_balanced, ln_wage ~ union +
              age +agesq +tenure +tensq +
              not_smsa +south +c_city, model="within", index=c("idcode", "year"))
  summary(fe_LSDV)
```

```
## Oneway (individual) effect Within Model
##
## Call:
## plm(formula = ln_wage ~ union + age + agesq + tenure + tensq +
##     not_smsa + south + c_city, data = nlswork_balanced, model = "within",
##     index = c("idcode", "year"))
```

```
##
## Balanced Panel: n = 5, T = 12, N = 60
##
## Residuals:
##       Min.    1st Qu.     Median    3rd Qu.       Max.
## -0.2543619 -0.0694565  0.0045351  0.0783435  0.2399171
##
## Coefficients:
##           Estimate  Std. Error t-value Pr(>|t|)
## union   0.08958377  0.05487432  1.6325  0.10898
## age     0.07589667  0.03343547  2.2699  0.02765 *
## agesq  -0.00119586  0.00054052 -2.2124  0.03163 *
## tenure  0.01251051  0.01621304  0.7716  0.44404
## tensq   0.00063295  0.00071759  0.8821  0.38206
## c_city  0.11647818  0.08753305  1.3307  0.18945
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    2.3839
## Residual Sum of Squares: 0.64685
## R-Squared:      0.72866
## Adj. R-Squared: 0.67329
## F-statistic: 21.9312 on 6 and 49 DF, p-value: 2.4403e-12
```

```
stargazer(LSDV,fe_LSDV,title = "Regression analysis",
          model.numbers = FALSE,
          column.labels = c("LSDV","FE"),
          label = "regressions",
          table.placement = "!ht",
          notes.append = FALSE,
          notes.align="l",
          notes="Standard errors in parentheses.",
          header = FALSE,
          no.space = TRUE,
          covariate.labels = c("Union","Age","Age sqrd.","Tenure",
                               "Tenure sqrd.","Not SMSA","South","City"),
          omit = c("Constant"),
          omit.stat = c("adj.rsq","f","ser"),
          digits = 6,
          digits.extra = 7,
          omit.yes.no = c("Constant",""),
          dep.var.caption="",
          dep.var.labels.include = FALSE,
          style = "qje",
          type="text")
```

```
##
## Regression analysis
## ================================================
##                          OLS             panel
##                                         linear
##                          LSDV              FE
## ------------------------------------------------
## Union                 0.089584        0.089584
```

```
##                       (0.054874)      (0.054874)
## Age                  0.075897**      0.075897**
##                       (0.033435)      (0.033435)
## Age sqrd.           -0.001196**     -0.001196**
##                       (0.000541)      (0.000541)
## Tenure                0.012511        0.012511
##                       (0.016213)      (0.016213)
## Tenure sqrd.          0.000633        0.000633
##                       (0.000718)      (0.000718)
## Not SMSA
##
## South
##
## City                  0.116478        0.116478
##                       (0.087533)      (0.087533)
## factor(idcode)20     0.328787**
##                       (0.128978)
## factor(idcode)126    -0.016726
##                       (0.054655)
## factor(idcode)128     0.037565
##                       (0.088291)
## factor(idcode)379    -0.150430
##                       (0.118891)
## N                         60              60
## R2                    0.802119        0.728663
## ================================================
## Notes:            Standard errors in parentheses.
```

Hausman test

```
# //Final slide 35
#
# *Q4*
  fe_0 <- plm(data = nlswork_clean, ln_wage ~ union +
                age +agesq +tenure +tensq +
                not_smsa +south +c_city, model="within", index=c("idcode", "year"))
  re_0 <- plm(data = nlswork_clean, ln_wage ~ union +
                age +agesq +tenure +tensq +
                not_smsa +south +c_city, model="random", index=c("idcode", "year"))

  phtest(fe_0, re_0)
```

```
##
##  Hausman Test
##
## data:  ln_wage ~ union + age + agesq + tenure + tensq + not_smsa + south +  ...
## chisq = 607.1, df = 8, p-value < 2.2e-16
## alternative hypothesis: one model is inconsistent
```

BE estimator

```
#   //Final slide 46
#
# *Q5*

  be <- plm(data = nlswork_clean, ln_wage ~ union +
              collgrad +age +agesq +tenure +tensq +
              not_smsa +south +c_city, model="between",
            index=c("idcode", "year"))

      summary(be)
```

```
## Oneway (individual) effect Between Model
##
## Call:
## plm(formula = ln_wage ~ union + collgrad + age + agesq + tenure +
##     tensq + not_smsa + south + c_city, data = nlswork_clean,
##     model = "between", index = c("idcode", "year"))
##
## Unbalanced Panel: n = 4134, T = 1-12, N = 19007
## Observations used in estimation: 4134
##
## Residuals:
##       Min.    1st Qu.     Median    3rd Qu.       Max.
## -1.5946586 -0.2004452 -0.0067495  0.1909616  1.8487578
##
## Coefficients:
##                Estimate  Std. Error  t-value  Pr(>|t|)
## (Intercept)  1.19446539  0.15356828   7.7781 9.240e-15 ***
## union        0.11135322  0.01636297   6.8052 1.154e-11 ***
## collgrad     0.34850931  0.01308193  26.6405 < 2.2e-16 ***
## age          0.02113165  0.01022918   2.0658   0.03891 *
## agesq       -0.00034316  0.00016368  -2.0965   0.03610 *
## tenure       0.09570307  0.00539210  17.7488 < 2.2e-16 ***
## tensq       -0.00343998  0.00036430  -9.4426 < 2.2e-16 ***
## not_smsa    -0.20536231  0.01440760 -14.2537 < 2.2e-16 ***
## south       -0.13058886  0.01145804 -11.3971 < 2.2e-16 ***
## c_city      -0.02215011  0.01385878  -1.5983   0.11006
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    773.5
## Residual Sum of Squares: 464.95
## R-Squared:      0.3989
## Adj. R-Squared: 0.39759
## F-statistic: 304.083 on 9 and 4124 DF, p-value: < 2.22e-16
```

FD estimator

```r
# //Final slide 53
#
# *Q6*
  fd <- plm(data = nlswork_clean, ln_wage ~ 0 + union +
              collgrad +age +agesq +tenure +tensq +
              not_smsa +south +c_city, model="fd",
            index=c("idcode", "year"))

    summary(fd)
```

```
## Oneway (individual) effect First-Difference Model
##
## Call:
## plm(formula = ln_wage ~ 0 + union + collgrad + age + agesq +
##     tenure + tensq + not_smsa + south + c_city, data = nlswork_clean,
##     model = "fd", index = c("idcode", "year"))
##
## Unbalanced Panel: n = 4134, T = 1-12, N = 19007
## Observations used in estimation: 14873
##
## Residuals:
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -2.9266 -0.0925  0.0073  0.0156  0.1279  3.3217
##
## Coefficients:
##             Estimate  Std. Error t-value  Pr(>|t|)
## union     6.9160e-02  6.6336e-03 10.4257 < 2.2e-16 ***
## age       2.2744e-02  5.5436e-03  4.1027 4.104e-05 ***
## agesq    -2.5853e-04  9.0084e-05 -2.8698  0.004113 **
## tenure    3.2078e-02  2.1241e-03 15.1024 < 2.2e-16 ***
## tensq    -1.2023e-03  1.7526e-04 -6.8600 7.160e-12 ***
## not_smsa -7.7277e-02  1.4369e-02 -5.3780 7.645e-08 ***
## south    -4.6889e-02  1.5675e-02 -2.9913  0.002782 **
## c_city    2.2987e-02  9.9149e-03  2.3185  0.020437 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    1441.5
## Residual Sum of Squares: 1404.4
## R-Squared:      0.02879
## Adj. R-Squared: 0.028332
## F-statistic: 85.5285 on 8 and 14865 DF, p-value: < 2.22e-16
```

Output Table

```r
  stargazer(pols,re,fe,be,title = "Regression analysis",
            model.numbers = FALSE,
            column.labels = c("OLS","RE","FE","BE"),
            label = "regressions",
            table.placement = "!ht",
            notes.append = FALSE,
```

```
            notes.align="l",
            notes="Standard errors in parentheses.",
            header = FALSE,
            no.space = TRUE,
            omit = c("Constant"),
            omit.stat = c("adj.rsq","f","ser"),
            digits = 6,
            digits.extra = 7,
            omit.yes.no = c("Constant",""),
            dep.var.caption="",
            dep.var.labels.include = FALSE,
            style = "qje",
            type="text")
```

```
##
## Regression analysis
## ============================================================
##              OLS           RE           FE           BE
## union    0.112774***  0.103677***  0.093877***  0.111353***
##           (0.006774)   (0.006447)   (0.006966)   (0.016363)
## collgrad 0.350946***  0.369309***                0.348509***
##           (0.007149)   (0.012344)                (0.013082)
## age      0.022481***  0.023031***  0.024259***   0.021132**
##           (0.004249)   (0.003317)   (0.003447)   (0.010229)
## agesq    -0.000306*** -0.000249*** -0.000226*** -0.000343**
##           (0.000068)   (0.000053)   (0.000055)   (0.000164)
## tenure   0.054787***  0.040771***  0.032966***  0.095703***
##           (0.001944)   (0.001583)   (0.001646)   (0.005392)
## tensq    -0.001540*** -0.001247*** -0.001100*** -0.003440***
##           (0.000125)   (0.000100)   (0.000103)   (0.000364)
## not_smsa -0.205457*** -0.151136*** -0.093105*** -0.205362***
##           (0.007120)   (0.009380)   (0.012970)   (0.014408)
## south    -0.140589*** -0.111567*** -0.063222*** -0.130589***
##           (0.005850)   (0.008467)   (0.013279)   (0.011458)
## c_city   -0.031543***   0.000397     0.011409    -0.022150
##           (0.006683)   (0.007492)   (0.008896)   (0.013859)
## N           19,007       19,007       19,007       4,134
## R2         0.319459     0.349029     0.140054     0.398899
## ============================================================
## Notes:   Standard errors in parentheses.
```

FURTHER SPECIFICATION TESTS FOR PANEL DATA

Test for heteroskedasticity within panel data

```
# H0) The null hypothesis for the Breusch-Pagan test is homoskedasticity

# takes too long to compute

# bptest(data = nlswork_clean, ln_wage ~ union +
```

```
#          collgrad +age +agesq +tenure +tensq +
#          not_smsa +south +c_city + factor(idcode), studentize=F)


  bptest(data = nlswork_balanced, ln_wage ~ union +
           collgrad +age +agesq +tenure +tensq +
           not_smsa +south +c_city + factor(idcode), studentize=F)
```

```
##
##  Breusch-Pagan test
##
## data:  ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +     south + c_city + fa
## BP = 5.2368, df = 10, p-value = 0.8748
```

Test of serial correlation within panel data

- Unobserved effects test «» Wooldridge's test for unobserved individual effects «»

```
  pwtest(data = nlswork_clean, ln_wage ~ union +
           collgrad +age +agesq +tenure +tensq +
           not_smsa +south +c_city)
```

Locally robust tests for serial correlation or random effects

- Baltagi and Li AR-RE joint test - balanced panel

```
  pbsytest(data = nlswork_balanced, ln_wage ~ union +
             collgrad +age +agesq +tenure +tensq +
             not_smsa +south +c_city, test="j")
```

```
##
##  Baltagi and Li AR-RE joint test - balanced panel
##
## data:  formula
## chisq = 50.736, df = 2, p-value = 9.612e-12
## alternative hypothesis: AR(1) errors or random effects
```

General serial correlation tests

- Breusch-Godfrey/Wooldridge test for serial correlation in panel models «»

```
pbgtest(fe, order = 2)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel models
##
## data:  ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +     south + c_city
## chisq = 181.23, df = 2, p-value < 2.2e-16
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Wooldridge's test for serial correlation in FE panels

```
  pwartest(data = nlswork_balanced, ln_wage ~ union +
             collgrad +age +agesq +tenure +tensq +
             not_smsa +south +c_city)
```

```
##
##  Wooldridge's test for serial correlation in FE panels
##
## data:  plm.model
## F = 12.205, df1 = 1, df2 = 53, p-value = 0.0009707
## alternative hypothesis: serial correlation
```

Wooldridge first-difference-based test

```
  pwfdtest(data = nlswork_balanced, ln_wage ~ union +
             collgrad +age +agesq +tenure +tensq +
             not_smsa +south +c_city)
```

```
##
##  Wooldridge's first-difference test for serial correlation in panels
##
## data:  plm.model
## F = 8.5778, df1 = 1, df2 = 48, p-value = 0.005192
## alternative hypothesis: serial correlation in differenced errors
```

```
  pwfdtest(data = nlswork_balanced, ln_wage ~ union +
             collgrad +age +agesq +tenure +tensq +
             not_smsa +south +c_city, h0="fe")
```

```
##
##  Wooldridge's first-difference test for serial correlation in panels
##
## data:  plm.model
## F = 2.9964, df1 = 1, df2 = 48, p-value = 0.08988
## alternative hypothesis: serial correlation in original errors
```

Tests for cross-sectional dependence

```
  pcdtest(data = nlswork_balanced, ln_wage ~ union +
            collgrad +age +agesq +tenure +tensq +
            not_smsa +south +c_city)
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ln_wage ~ union + collgrad + age + agesq + tenure + tensq + not_smsa +     south + c_city
## z = 1.8975, p-value = 0.05776
## alternative hypothesis: cross-sectional dependence
```

HIGH DIMENSIONAL FIXED-EFFECTS

```
## CHECK: 'lfe' and 'fixest'
### https://github.com/sgaure/lfe
### https://github.com/lrberge/fixest

# *including 1 fixed effect*

  HDFE1a <- feols(data = nlswork_clean, ln_wage ~ union +
                    age +agesq +tenure +tensq +
                    not_smsa +south +c_city | idcode)

      summary(HDFE1a)
```

```
## OLS estimation, Dep. Var.: ln_wage
## Observations: 19,007
## Fixed-effects: idcode: 4,134
## Standard-errors: Clustered (idcode)
##           Estimate Std. Error   t value  Pr(>|t|)
## union     0.093877   0.009566  9.814100 < 2.2e-16 ***
## age       0.024259   0.005008  4.843600  1.32e-06 ***
## agesq    -0.000226   0.000081 -2.778400  0.005488 **
## tenure    0.032966   0.002085 15.807000 < 2.2e-16 ***
## tensq    -0.001100   0.000126 -8.719200 < 2.2e-16 ***
## not_smsa -0.093105   0.019791 -4.704500  2.63e-06 ***
## south    -0.063222   0.021654 -2.919600  0.003524 **
## c_city    0.011409   0.012606  0.905058  0.365487
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.225053     Adj. R2: 0.703151
##                  Within R2: 0.140054
```

```
  HDFE1b <- felm(data = nlswork_clean, ln_wage ~ union +
                   age +agesq +tenure +tensq +
                   not_smsa +south +c_city | idcode, clustervar=c("idcode"))
```

```
## Warning: Argument(s) clustervar are deprecated and will be removed, use
## multipart formula instead
```

```
      summary(HDFE1b)
```

```
##
## Call:
##    felm(formula = ln_wage ~ union + age + agesq + tenure + tensq +      not_smsa + south + c_city | i
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8803 -0.1022  0.0000  0.1077  2.8071
##
## Coefficients:
##            Estimate Cluster s.e. t value Pr(>|t|)
```

```
## union     9.388e-02    9.565e-03   9.814  < 2e-16 ***
## age       2.426e-02    5.008e-03   4.844 1.32e-06 ***
## agesq    -2.262e-04    8.141e-05  -2.778  0.00549 **
## tenure    3.297e-02    2.086e-03  15.807  < 2e-16 ***
## tensq    -1.100e-03    1.262e-04  -8.719  < 2e-16 ***
## not_smsa -9.310e-02    1.979e-02  -4.705 2.63e-06 ***
## south    -6.322e-02    2.165e-02  -2.920  0.00352 **
## c_city    1.141e-02    1.261e-02   0.905  0.36549
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2545 on 14865 degrees of freedom
## Multiple R-squared(full model): 0.7678   Adjusted R-squared: 0.7032
## Multiple R-squared(proj model): 0.1401   Adjusted R-squared: -0.0995
## F-statistic(full model, *iid*):11.87 on 4141 and 14865 DF, p-value: < 2.2e-16
## F-statistic(proj model):   168 on 8 and 4133 DF, p-value: < 2.2e-16
```

```
# *including a 2nd fixed effect*

  HDFE2a <- feols(data = nlswork_clean, ln_wage ~ union +
                    age +agesq +tenure +tensq +
                    not_smsa +south +c_city | idcode + year)

      summary(HDFE2a)
```

```
## OLS estimation, Dep. Var.: ln_wage
## Observations: 19,007
## Fixed-effects: idcode: 4,134,  year: 12
## Standard-errors: Clustered (idcode)
##           Estimate Std. Error   t value  Pr(>|t|)
## union     0.095700   0.009523 10.049000 < 2.2e-16 ***
## age       0.073440   0.013588  5.404700  6.86e-08 ***
## agesq    -0.000720   0.000116 -6.218800  5.51e-10 ***
## tenure    0.032423   0.002104 15.408000 < 2.2e-16 ***
## tensq    -0.001090   0.000129 -8.443500 < 2.2e-16 ***
## not_smsa -0.090537   0.019619 -4.614600  4.06e-06 ***
## south    -0.064281   0.021622 -2.972900  0.002967 **
## c_city    0.010432   0.012668  0.823497  0.410273
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## RMSE: 0.223942     Adj. R2: 0.705857
##                  Within R2: 0.066421
```

```
  HDFE2b <- felm(data = nlswork_clean, ln_wage ~ union +
                   age +agesq +tenure +tensq +
                   not_smsa +south +c_city  | idcode + year, clustervar=c("idcode"))
```

```
## Warning: Argument(s) clustervar are deprecated and will be removed, use
## multipart formula instead
```

```
      summary(HDFE2b)
```

```
##
## Call:
##    felm(formula = ln_wage ~ union + age + agesq + tenure + tensq +      not_smsa + south + c_city | i
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.90155 -0.09933  0.00000  0.10738  2.78536
##
## Coefficients:
##            Estimate Cluster s.e. t value Pr(>|t|)
## union     0.0956999    0.0095207  10.052  < 2e-16 ***
## age       0.0734400    0.0135842   5.406 6.80e-08 ***
## agesq    -0.0007205    0.0001158  -6.221 5.44e-10 ***
## tenure    0.0324225    0.0021036  15.413  < 2e-16 ***
## tensq    -0.0010902    0.0001291  -8.446  < 2e-16 ***
## not_smsa -0.0905368    0.0196138  -4.616 4.03e-06 ***
## south    -0.0642811    0.0216158  -2.974  0.00296 **
## c_city    0.0104319    0.0126641   0.824  0.41014
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2533 on 14854 degrees of freedom
## Multiple R-squared(full model): 0.7701   Adjusted R-squared: 0.7059
## Multiple R-squared(proj model): 0.06642   Adjusted R-squared: -0.1945
## F-statistic(full model, *iid*):11.98 on 4152 and 14854 DF, p-value: < 2.2e-16
## F-statistic(proj model): 62.59 on 8 and 4133 DF, p-value: < 2.2e-16
```

Exercise with simulated data

See the Stata file 'stata_do_example.do' that produces the data in folder tmp_files.

```
simulated <- read_dta("data/data_simulation.dta")

# names(nlswork)
# head(nlswork)
# str(nlswork)
```

EDA: Exploratory Data Analysis

```
# eda_report(simulated,output_dir = "EDA/",output_file = "eda_simulated.pdf")

  ExpData(simulated,type=1)
```

```
##                                       Descriptions       Value
## 1                                Sample size (nrow)        4950
## 2                           No. of variables (ncol)          22
## 3                  No. of numeric/interger variables          22
## 4                            No. of factor variables           0
## 5                              No. of text variables           0
## 6                           No. of logical variables           0
```

```
## 7                          No. of identifier variables           2
## 8                                No. of date variables           0
## 9              No. of zero variance variables (uniform)          0
## 10                %. of variables having complete cases 95.45% (21)
## 11   %. of variables having >0% and <50% missing cases   4.55% (1)
## 12 %. of variables having >=50% and <90% missing cases      0% (0)
## 13          %. of variables having >=90% missing cases      0% (0)
```

```
ExpData(simulated,type=2)
```

```
##    Index Variable_Name Variable_Type Sample_n Missing_Count Per_of_Missing
## 1      1      workerid       numeric     4950             0             0.0
## 2      2          year       numeric     4950             0             0.0
## 3      3            ui       numeric     4950             0             0.0
## 4      4       quarter       numeric     4950             0             0.0
## 5      5            q1       numeric     4950             0             0.0
## 6      6          wage       numeric     4950             0             0.0
## 7      7          educ       numeric     4950             0             0.0
## 8      8         exper       numeric     4950             0             0.0
## 9      9         union       numeric     4950             0             0.0
## 10    10        exper2       numeric     4950             0             0.0
## 11    11        lnwage       numeric     4950             0             0.0
## 12    12           yy1       numeric     4950             0             0.0
## 13    13           yy2       numeric     4950             0             0.0
## 14    14           yy3       numeric     4950             0             0.0
## 15    15           yy4       numeric     4950             0             0.0
## 16    16           yy5       numeric     4950             0             0.0
## 17    17           yy6       numeric     4950             0             0.0
## 18    18           yy7       numeric     4950             0             0.0
## 19    19           yy8       numeric     4950             0             0.0
## 20    20           yy9       numeric     4950             0             0.0
## 21    21          yy10       numeric     4950             0             0.0
## 22    22    lag_lnwage       numeric     4455           495             0.1
##    No_of_distinct_values
## 1                    495
## 2                     10
## 3                    495
## 4                      4
## 5                      2
## 6                   4950
## 7                   2469
## 8                     29
## 9                      2
## 10                    29
## 11                  4950
## 12                     2
## 13                     2
## 14                     2
## 15                     2
## 16                     2
## 17                     2
## 18                     2
## 19                     2
## 20                     2
```

```
## 21                    2
## 22                 4454
```

```
summary(simulated)
```

```
##     workerid        year            ui               quarter
##  Min.   :  1   Min.   : 1.0   Min.   :0.0004503   Min.   :1.000
##  1st Qu.:124   1st Qu.: 3.0   1st Qu.:0.2438383   1st Qu.:2.000
##  Median :248   Median : 5.5   Median :0.4766747   Median :2.000
##  Mean   :248   Mean   : 5.5   Mean   :0.4879205   Mean   :2.517
##  3rd Qu.:372   3rd Qu.: 8.0   3rd Qu.:0.7447072   3rd Qu.:4.000
##  Max.   :495   Max.   :10.0   Max.   :0.9957856   Max.   :4.000
##
##        q1              wage             educ            exper
##  Min.   :0.0000   Min.   : 662.1   Min.   : 0.000   Min.   : 0.00
##  1st Qu.:0.0000   1st Qu.:1226.8   1st Qu.: 2.322   1st Qu.: 9.00
##  Median :0.0000   Median :1718.1   Median : 4.646   Median :15.00
##  Mean   :0.2404   Mean   :1998.8   Mean   : 5.226   Mean   :14.34
##  3rd Qu.:0.0000   3rd Qu.:2482.9   3rd Qu.: 7.635   3rd Qu.:19.00
##  Max.   :1.0000   Max.   :7170.2   Max.   :19.446   Max.   :28.00
##
##      union            exper2          lnwage           yy1           yy2
##  Min.   :0.0000   Min.   :  0.0   Min.   :6.495   Min.   :0.0   Min.   :0.0
##  1st Qu.:0.0000   1st Qu.: 81.0   1st Qu.:7.112   1st Qu.:0.0   1st Qu.:0.0
##  Median :0.0000   Median :225.0   Median :7.449   Median :0.0   Median :0.0
##  Mean   :0.4863   Mean   :247.3   Mean   :7.483   Mean   :0.1   Mean   :0.1
##  3rd Qu.:1.0000   3rd Qu.:361.0   3rd Qu.:7.817   3rd Qu.:0.0   3rd Qu.:0.0
##  Max.   :1.0000   Max.   :784.0   Max.   :8.878   Max.   :1.0   Max.   :1.0
##
##       yy3           yy4           yy5           yy6           yy7
##  Min.   :0.0   Min.   :0.0   Min.   :0.0   Min.   :0.0   Min.   :0.0
##  1st Qu.:0.0   1st Qu.:0.0   1st Qu.:0.0   1st Qu.:0.0   1st Qu.:0.0
##  Median :0.0   Median :0.0   Median :0.0   Median :0.0   Median :0.0
##  Mean   :0.1   Mean   :0.1   Mean   :0.1   Mean   :0.1   Mean   :0.1
##  3rd Qu.:0.0   3rd Qu.:0.0   3rd Qu.:0.0   3rd Qu.:0.0   3rd Qu.:0.0
##  Max.   :1.0   Max.   :1.0   Max.   :1.0   Max.   :1.0   Max.   :1.0
##
##       yy8           yy9           yy10       lag_lnwage
##  Min.   :0.0   Min.   :0.0   Min.   :0.0   Min.   :6.495
##  1st Qu.:0.0   1st Qu.:0.0   1st Qu.:0.0   1st Qu.:7.085
##  Median :0.0   Median :0.0   Median :0.0   Median :7.425
##  Mean   :0.1   Mean   :0.1   Mean   :0.1   Mean   :7.455
##  3rd Qu.:0.0   3rd Qu.:0.0   3rd Qu.:0.0   3rd Qu.:7.784
##  Max.   :1.0   Max.   :1.0   Max.   :1.0   Max.   :8.724
##                                            NA's   :495
```

```
ftable(simulated$year)
```

```
##    1   2   3   4   5   6   7   8   9  10
##
##  495 495 495 495 495 495 495 495 495 495
```

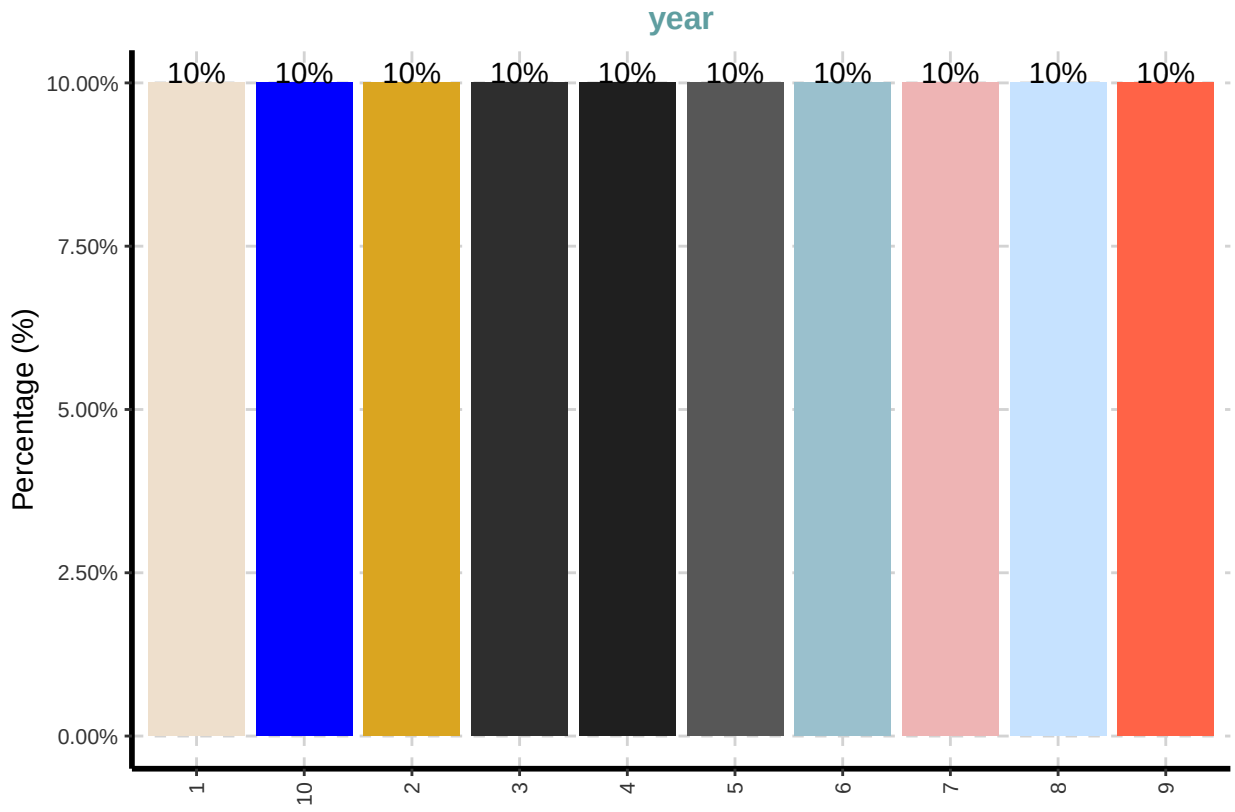
```
ExpCTable(simulated)
```

```
##    Variable Valid Frequency Percent CumPercent
## 1      year     1       495   10.00      10.00
## 2      year    10       495   10.00      20.00
## 3      year     2       495   10.00      30.00
## 4      year     3       495   10.00      40.00
## 5      year     4       495   10.00      50.00
## 6      year     5       495   10.00      60.00
## 7      year     6       495   10.00      70.00
## 8      year     7       495   10.00      80.00
## 9      year     8       495   10.00      90.00
## 10     year     9       495   10.00     100.00
## 11     year TOTAL      4950      NA         NA
## 12  quarter     1      1190   24.04      24.04
## 13  quarter     2      1350   27.27      51.31
## 14  quarter     3      1070   21.62      72.93
## 15  quarter     4      1340   27.07     100.00
## 16  quarter TOTAL      4950      NA         NA
## 17       q1     0      3760   75.96      75.96
## 18       q1     1      1190   24.04     100.00
## 19       q1 TOTAL      4950      NA         NA
## 20    union     0      2543   51.37      51.37
## 21    union     1      2407   48.63     100.00
## 22    union TOTAL      4950      NA         NA
## 23      yy1     0      4455   90.00      90.00
## 24      yy1     1       495   10.00     100.00
## 25      yy1 TOTAL      4950      NA         NA
## 26      yy2     0      4455   90.00      90.00
## 27      yy2     1       495   10.00     100.00
## 28      yy2 TOTAL      4950      NA         NA
## 29      yy3     0      4455   90.00      90.00
## 30      yy3     1       495   10.00     100.00
## 31      yy3 TOTAL      4950      NA         NA
## 32      yy4     0      4455   90.00      90.00
## 33      yy4     1       495   10.00     100.00
## 34      yy4 TOTAL      4950      NA         NA
## 35      yy5     0      4455   90.00      90.00
## 36      yy5     1       495   10.00     100.00
## 37      yy5 TOTAL      4950      NA         NA
## 38      yy6     0      4455   90.00      90.00
## 39      yy6     1       495   10.00     100.00
## 40      yy6 TOTAL      4950      NA         NA
## 41      yy7     0      4455   90.00      90.00
## 42      yy7     1       495   10.00     100.00
## 43      yy7 TOTAL      4950      NA         NA
## 44      yy8     0      4455   90.00      90.00
## 45      yy8     1       495   10.00     100.00
## 46      yy8 TOTAL      4950      NA         NA
## 47      yy9     0      4455   90.00      90.00
## 48      yy9     1       495   10.00     100.00
## 49      yy9 TOTAL      4950      NA         NA
## 50     yy10     0      4455   90.00      90.00
```

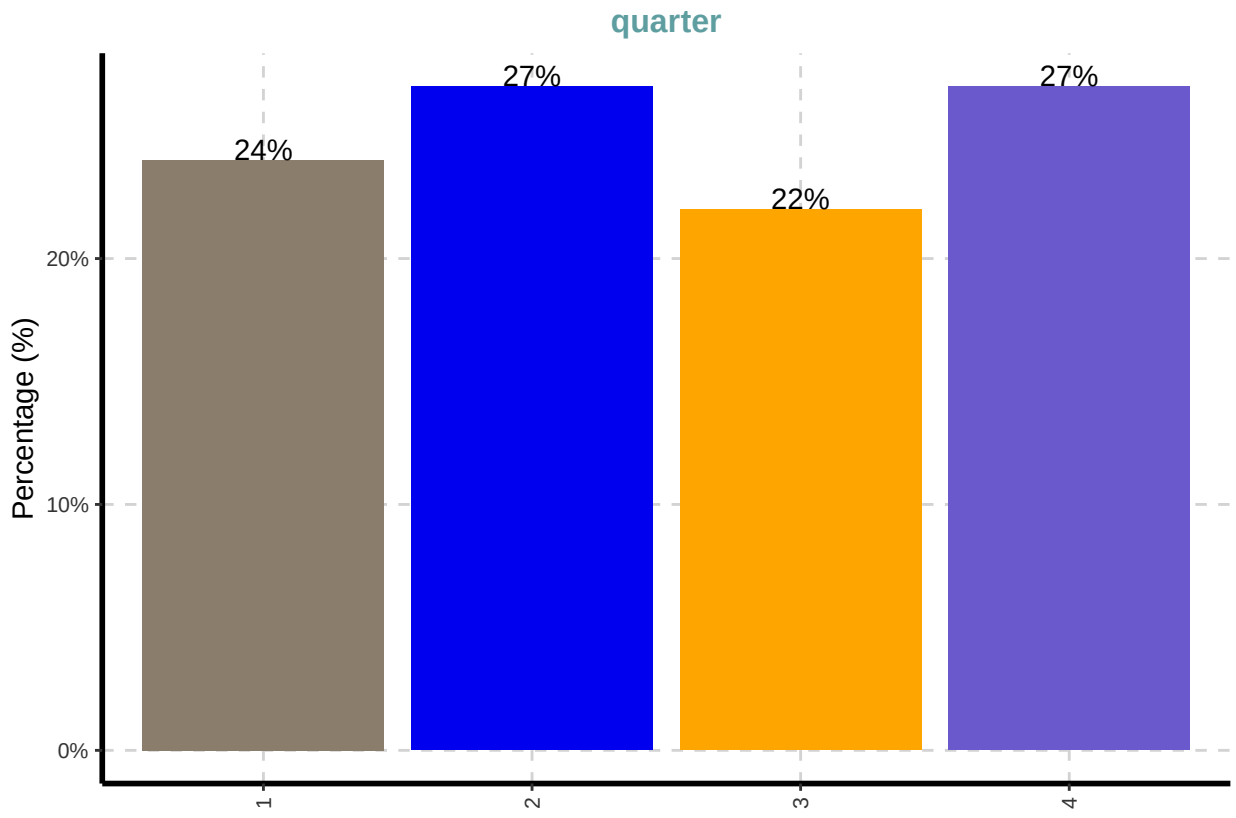
```
## 51      yy10     1       495   10.00      100.00
## 52      yy10 TOTAL      4950      NA          NA
```

```
  ExpCatViz(simulated)
```

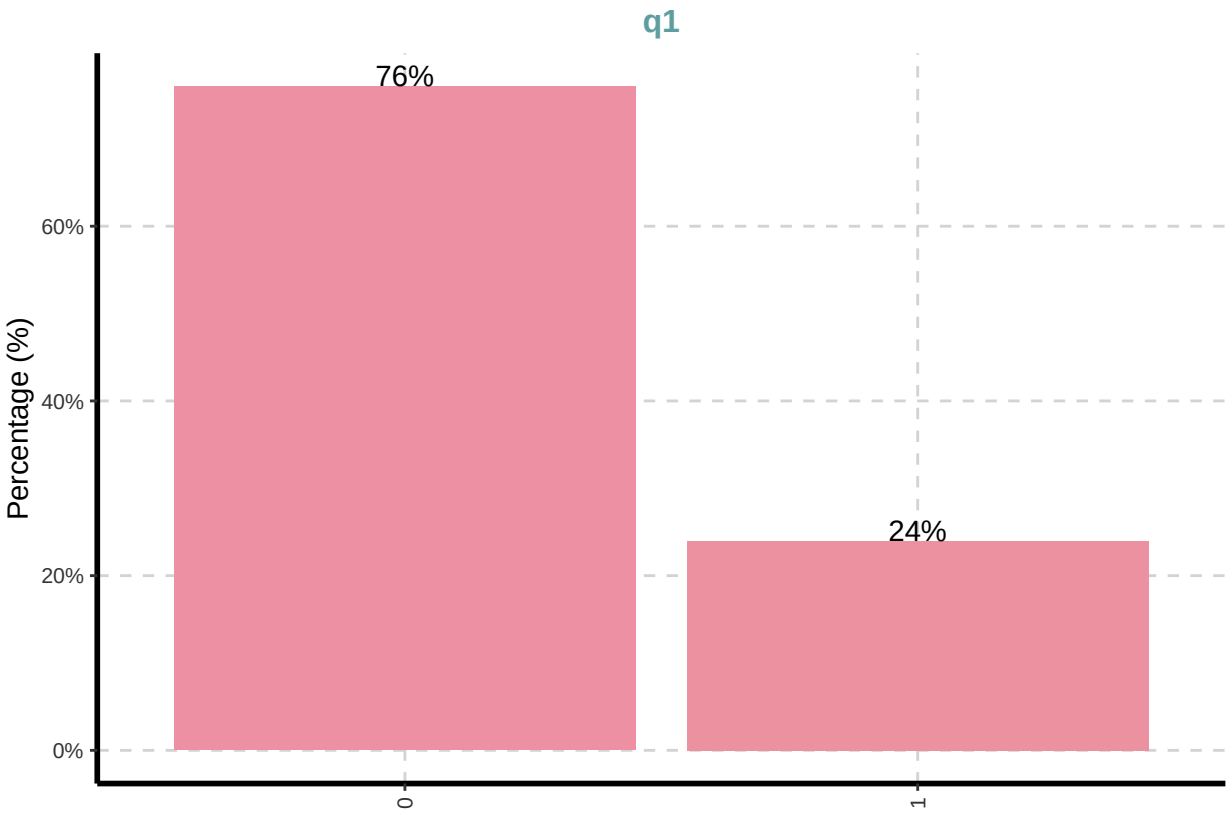
```
## [[1]]
```



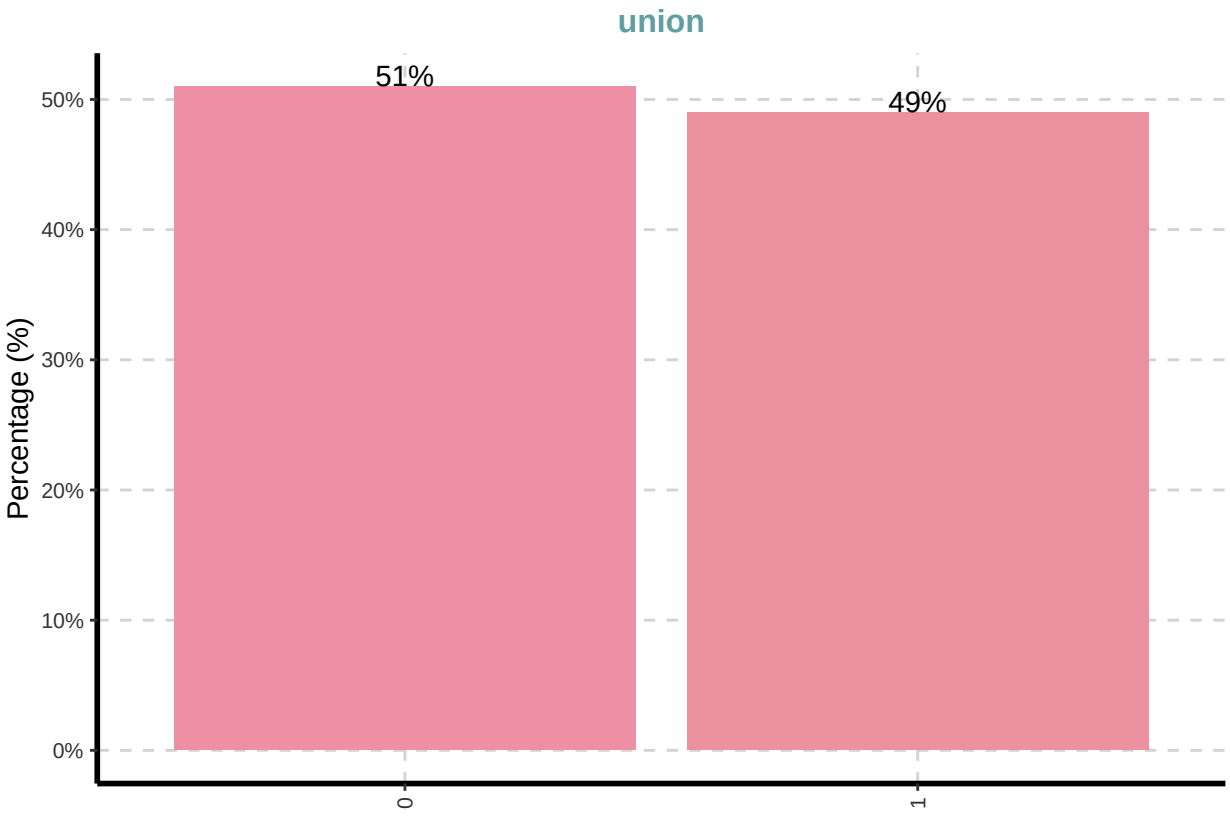

```
##
## [[2]]
```



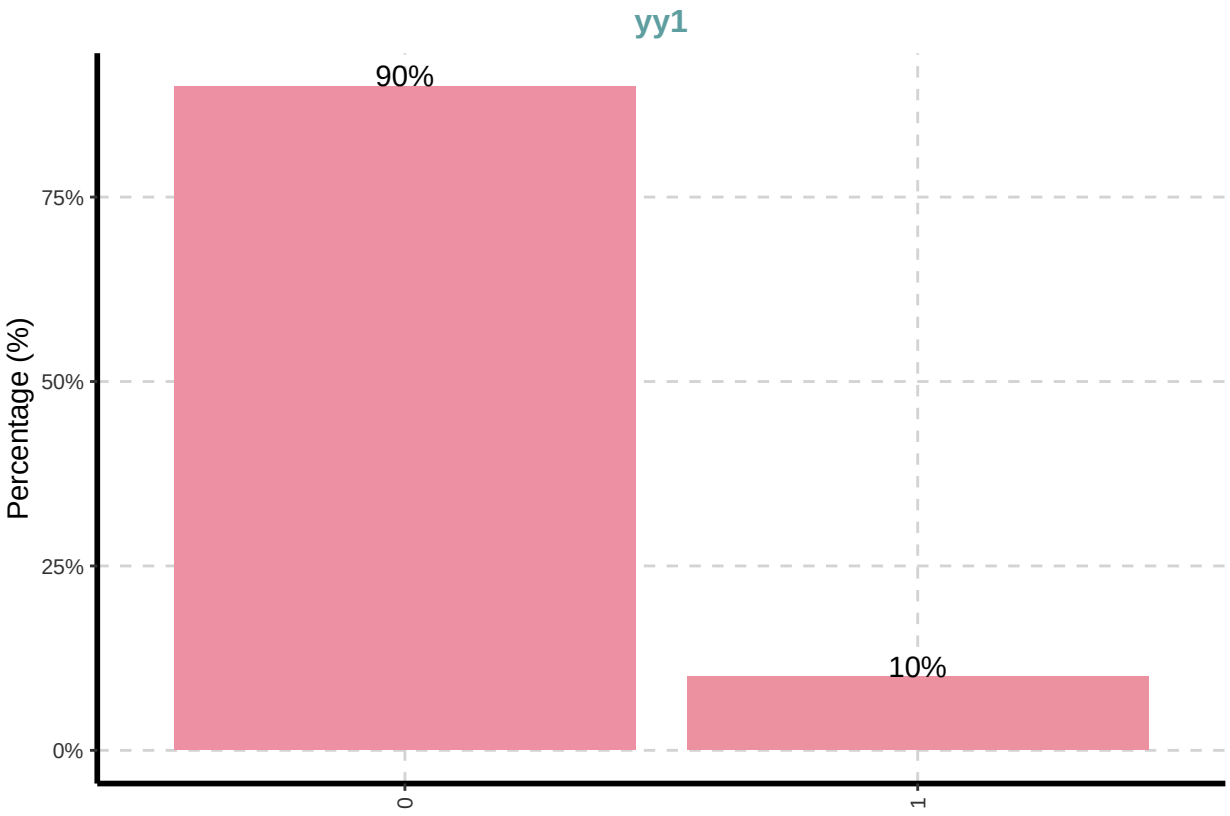

```
##
## [[3]]
```



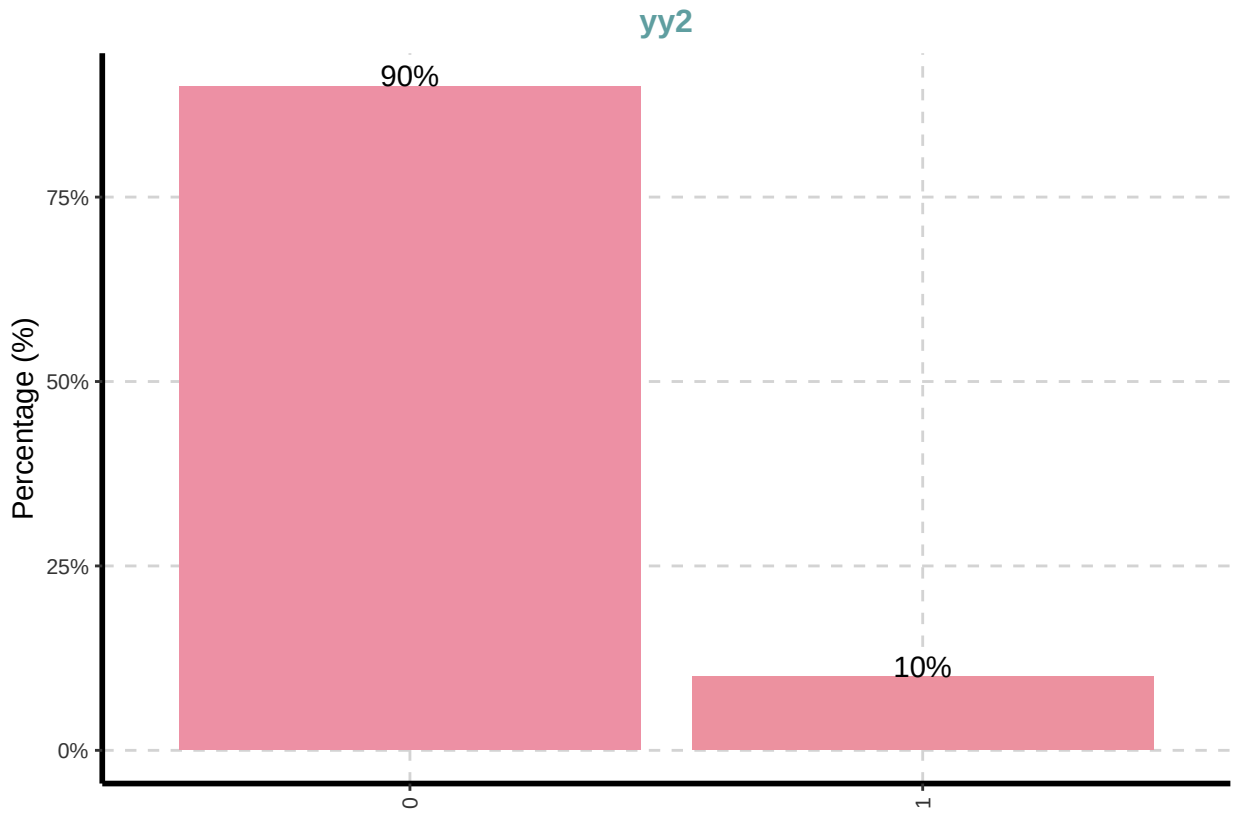

```
##
## [[4]]
```



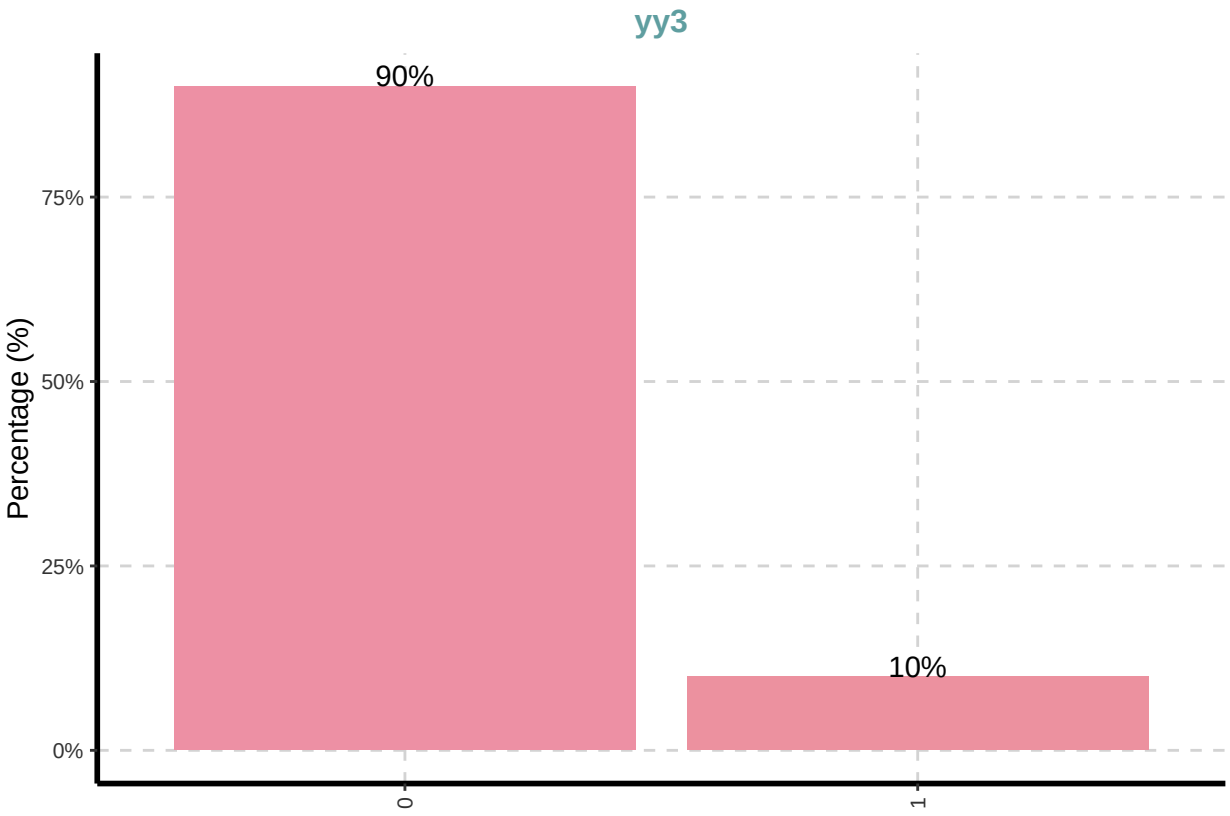

```
##
## [[5]]
```



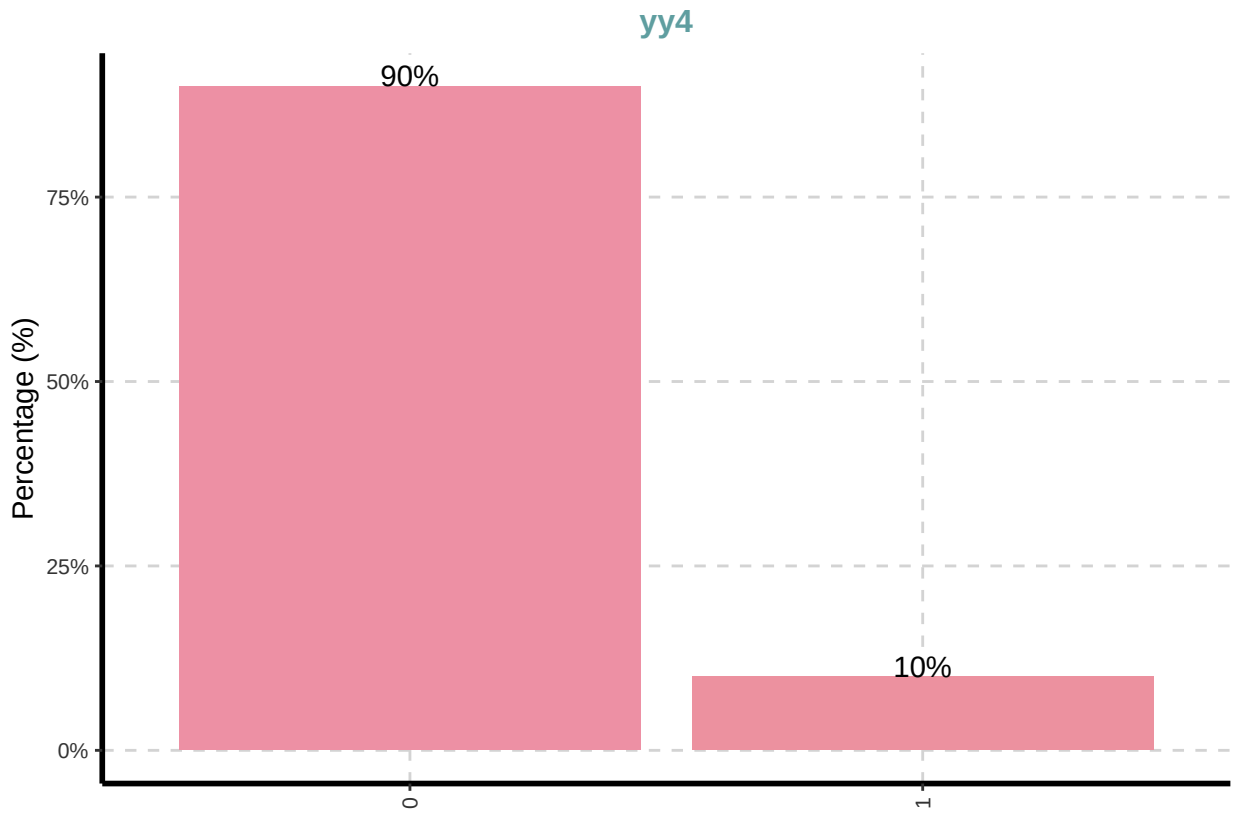

```
##
## [[6]]
```



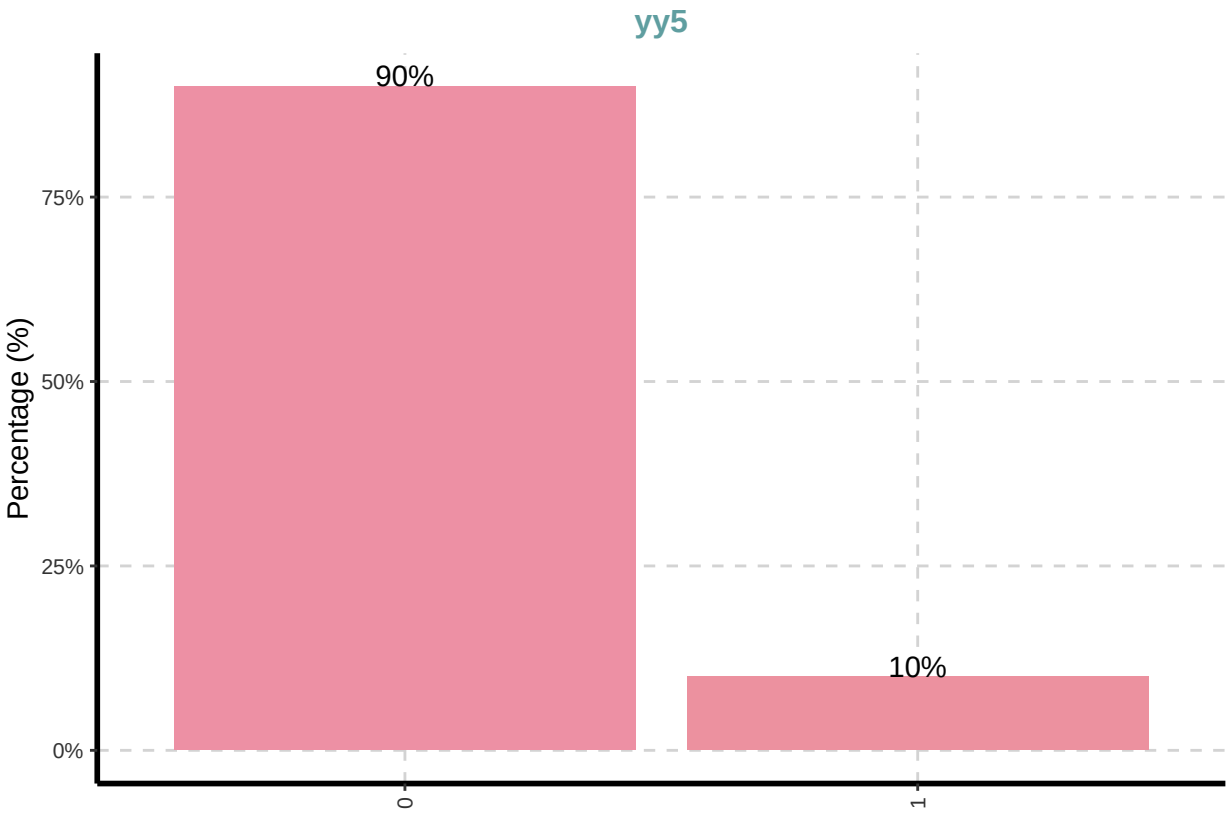

```
##
## [[7]]
```



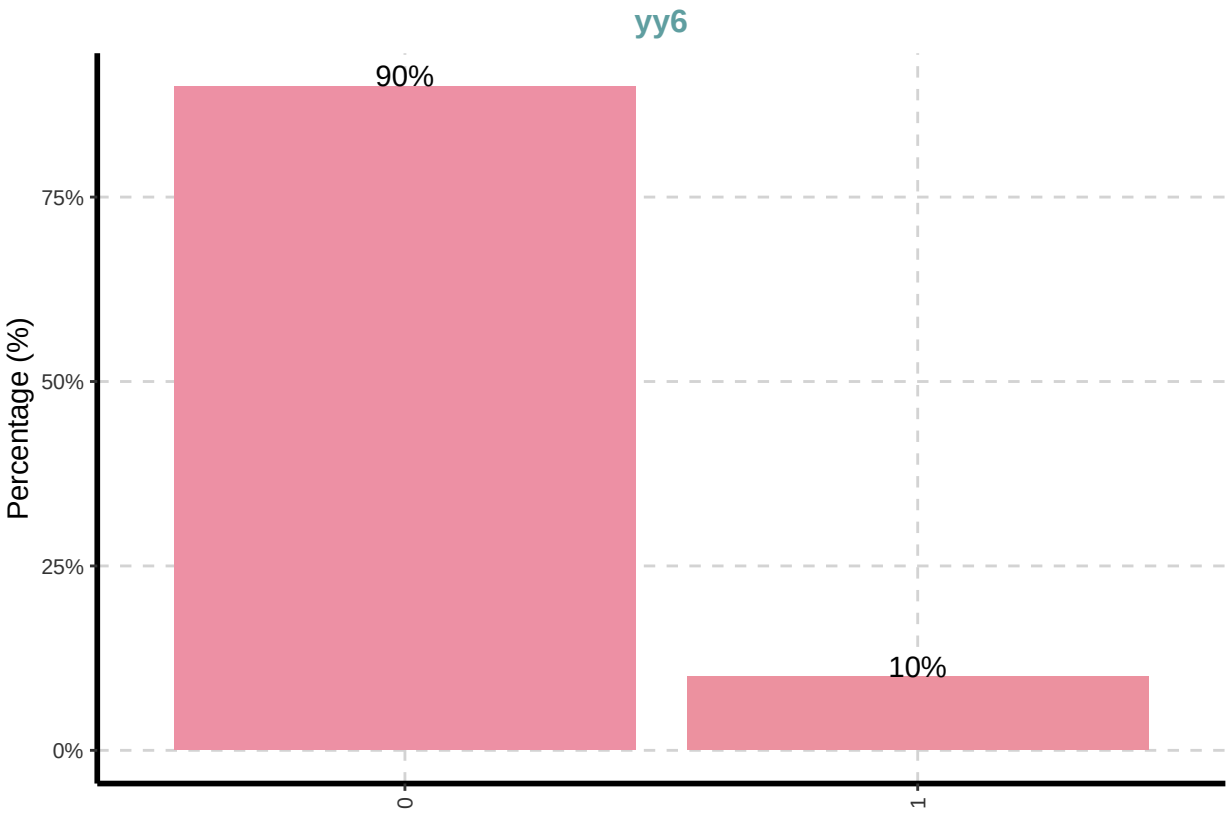

```
##
## [[8]]
```



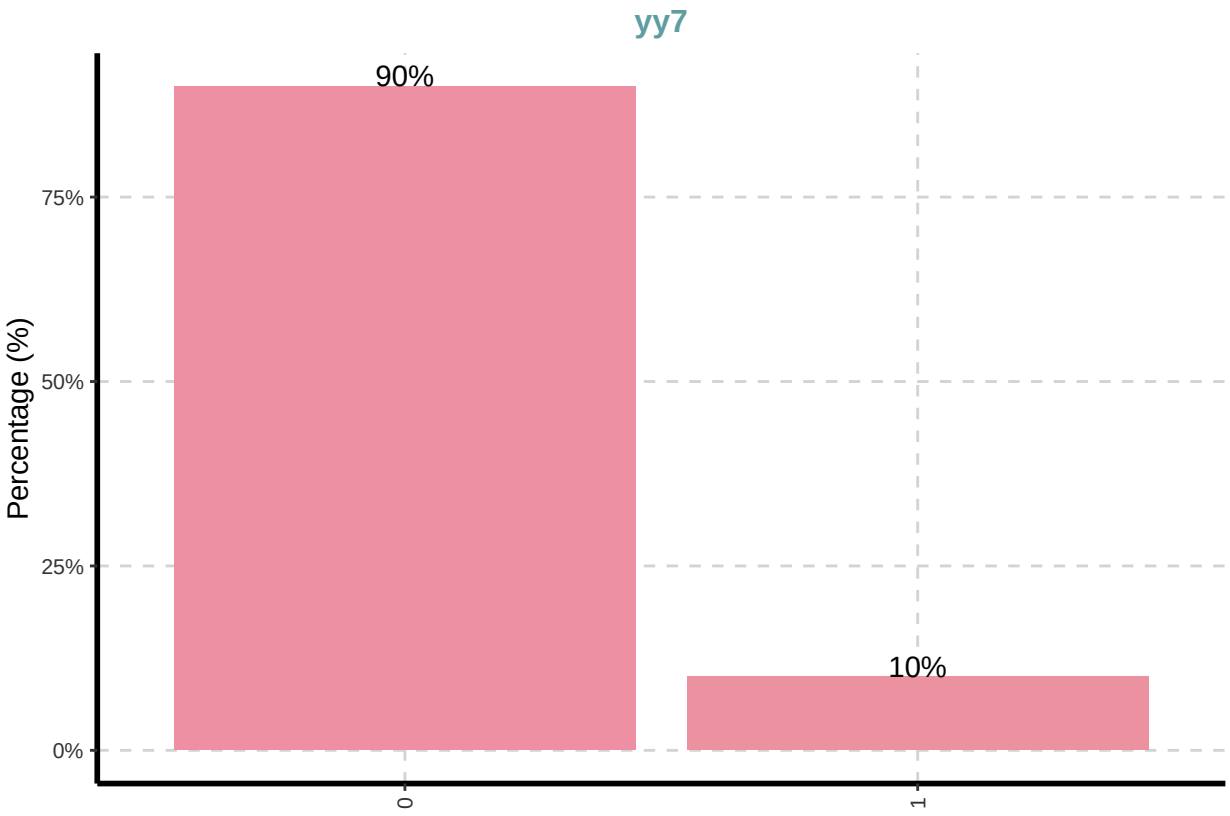

```
##
## [[9]]
```



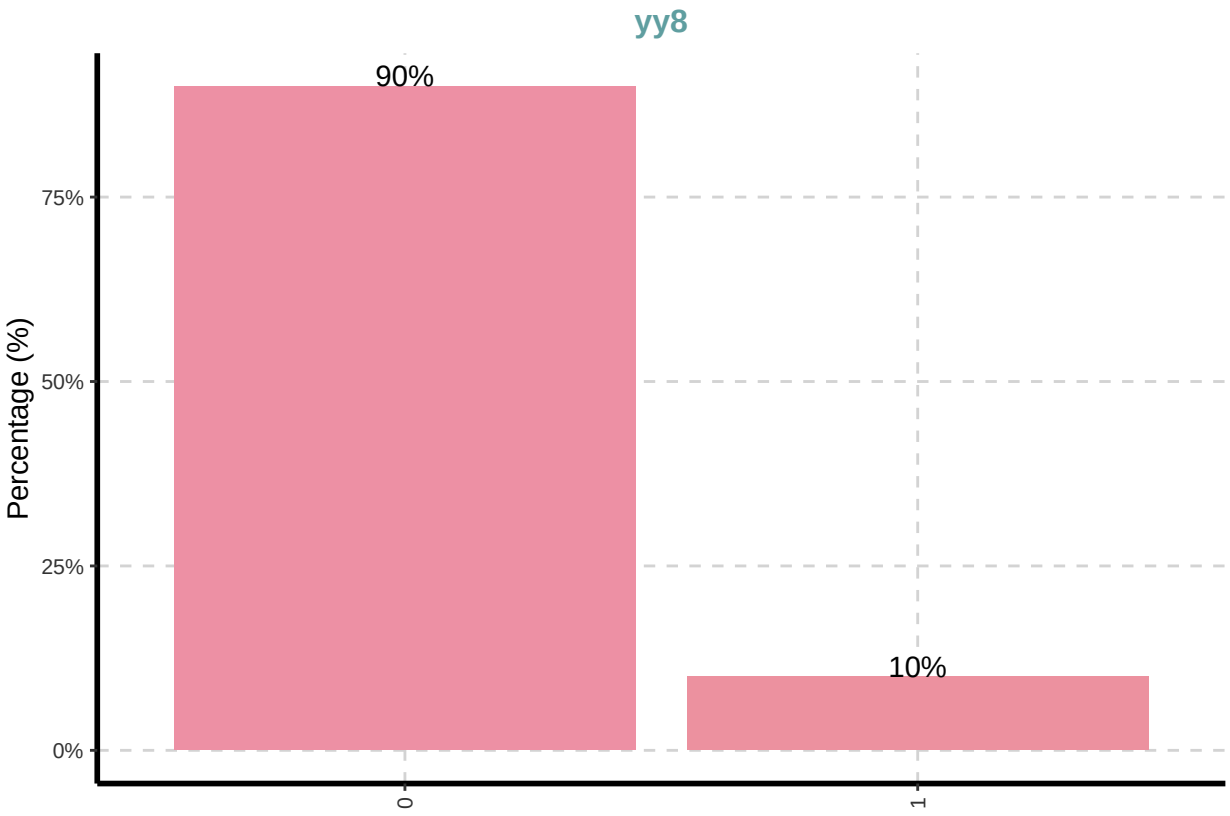

```
##
## [[10]]
```



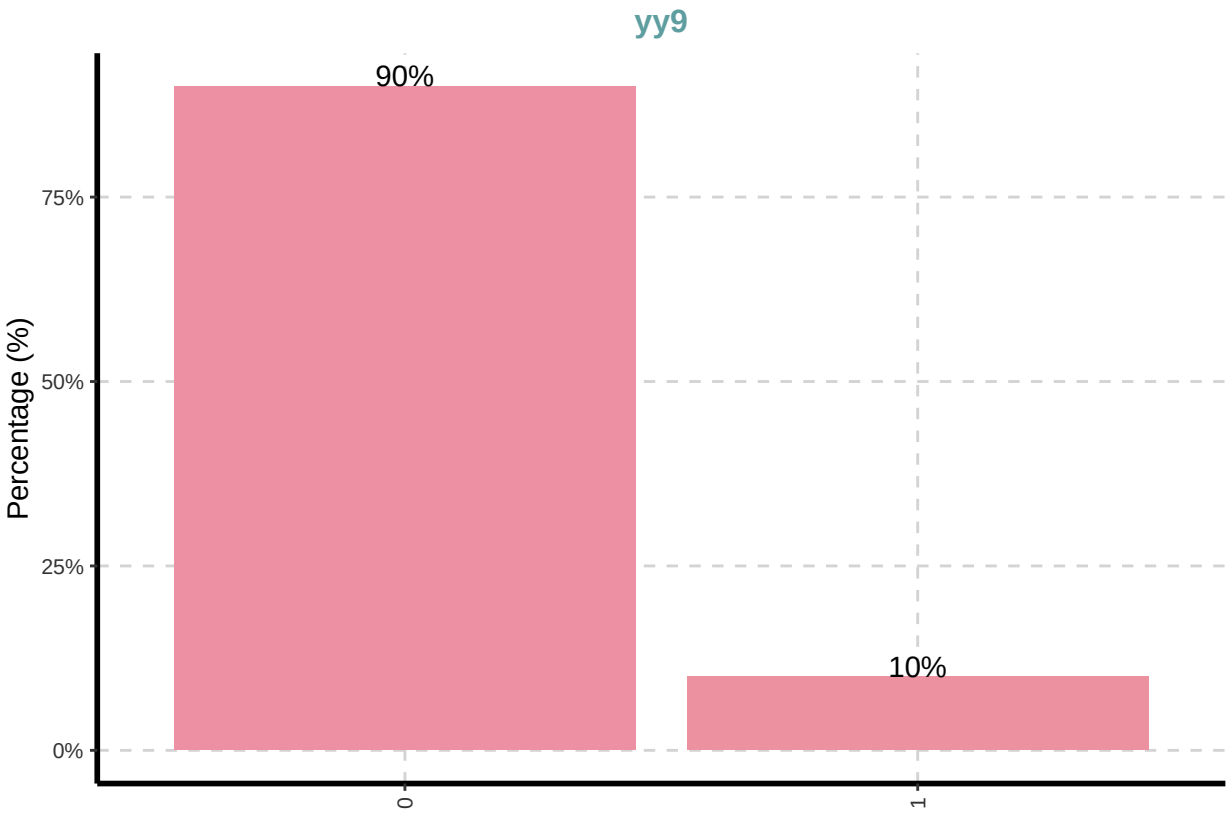

```
##
## [[11]]
```



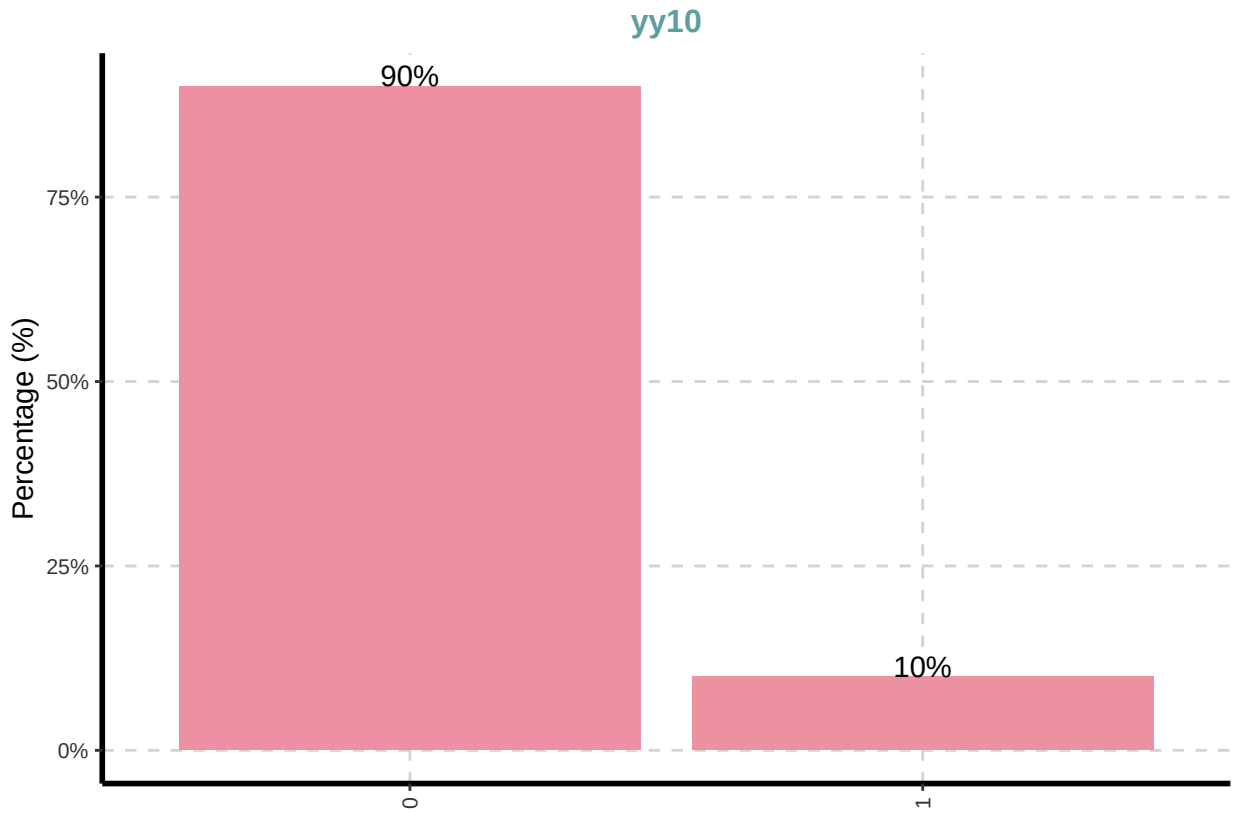

```
##
## [[12]]
```




```
##
## [[13]]
```




```
##
## [[14]]
```



TRY IN A 'JUPYTER NOTEBOOK': ExpNumViz(nlswork)

```
ExpNumStat(simulated,by="A",Outlier = TRUE,round=2,Qnt=c(0.1,0.25,0.50,0.99))
```

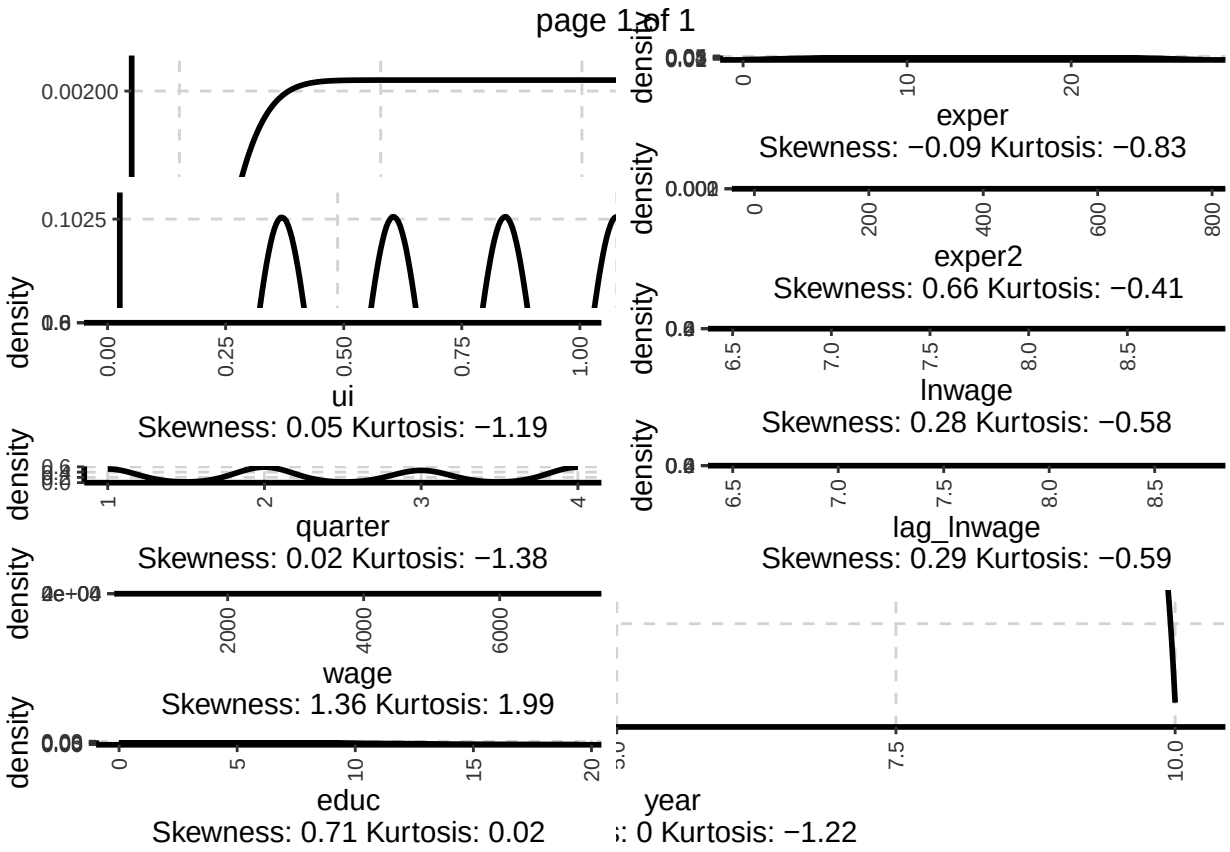
```
##        Vname Group   TN nNeg nZero nPos NegInf PosInf NA_Value Per_of_Missing
## 5       educ   All 4950    0   333 4617      0      0        0              0
## 6      exper   All 4950    0    24 4926      0      0        0              0
## 7     exper2   All 4950    0    24 4926      0      0        0              0
## 9 lag_lnwage   All 4950    0     0 4455      0      0      495             10
## 8     lnwage   All 4950    0     0 4950      0      0        0              0
## 3         ui   All 4950    0     0 4950      0      0        0              0
## 4       wage   All 4950    0     0 4950      0      0        0              0
## 1   workerid   All 4950    0     0 4950      0      0        0              0
## 2       year   All 4950    0     0 4950      0      0        0              0
##           sum    min     max    mean  median      SD   CV     IQR Skewness
## 5    25870.22   0.00   19.45    5.23    4.65    3.79 0.73    5.31     0.71
## 6    70965.00   0.00   28.00   14.34   15.00    6.46 0.45   10.00    -0.09
## 7  1223895.00   0.00  784.00  247.25  225.00  187.13 0.76  280.00     0.66
## 9    33211.94   6.50    8.72    7.45    7.43    0.47 0.06    0.70     0.29
## 8    37041.95   6.50    8.88    7.48    7.45    0.48 0.06    0.71     0.28
## 3     2415.21   0.00    1.00    0.49    0.48    0.29 0.59    0.50     0.05
## 4 9893953.84 662.08 7170.24 1998.78 1718.12 1032.19 0.52 1256.13     1.36
## 1 1227600.00   1.00  495.00  248.00  248.00  142.91 0.58  248.00     0.00
```

```
## 2   27225.00   1.00   10.00    5.50    5.50    2.87 0.52    5.00     0.00
##   Kurtosis    10%    25%    50%    99%  LB.25%  UB.75% nOutliers
## 5     0.02   0.52   2.32   4.65  15.46   -5.65   15.61        46
## 6    -0.83   5.00   9.00  15.00  27.00   -6.00   34.00         0
## 7    -0.41  25.00  81.00 225.00 729.00 -339.00  781.00        19
## 9    -0.59   6.86   7.08   7.43   8.55    6.04    8.83         0
## 8    -0.58   6.88   7.11   7.45   8.61    6.05    8.87         1
## 3    -1.19   0.08   0.24   0.48   0.99   -0.51    1.50         0
## 4     1.99 969.90 1226.81 1718.12 5468.17 -657.39 4367.13       186
## 1    -1.20  50.00  124.00  248.00  490.51 -248.00  744.00         0
## 2    -1.22   1.90    3.00    5.50   10.00   -4.50   15.50         0
```

```
  ExpNumViz(simulated,Page=c(6,2))
```

```
## Warning in matrix(data = seq(1, pn), nrow = nr, ncol = nc): data length [10] is
## not a sub-multiple or multiple of the number of rows [6]
```

```
## $`0`
```



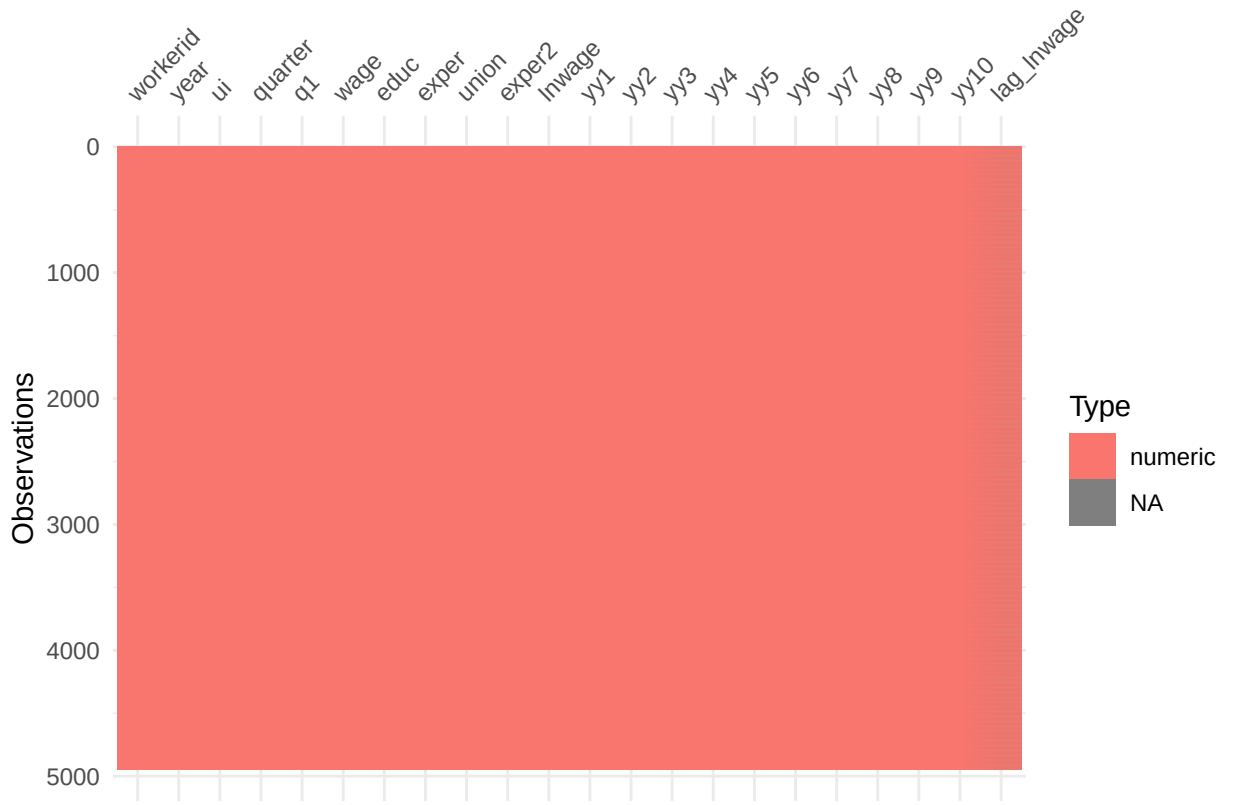

```
  ExpOutliers(simulated,varlist=c("lnwage"))
```

```
## $outlier_summary
##              Category           lnwage
## 1    Lower cap : 0.05 6.75808242272123
```

```
## 2    Upper cap : 0.95 8.32169651894011
## 3         Lower bound             6.05
## 4         Upper bound             8.87
## 5     Num of outliers                1
## 6  Lower outlier case
## 7  Upper outlier case              210
## 8         Mean before             7.48
## 9          Mean after             7.48
## 10      Median before 7.44898780138622
## 11       Median after 7.44896911785069
##
## $outlier_data
##       workerid year        ui quarter q1     wage      educ exper union exper2
##    1:        1    1 0.5734584       2  0 1913.481 6.3080420    17     1    289
##    2:        1    2 0.5734584       2  0 2065.687 6.3080420    18     1    324
##    3:        1    3 0.5734584       2  0 2015.642 7.3080420    19     1    361
##    4:        1    4 0.5734584       2  0 2274.630 8.3080425    20     1    400
##    5:        1    5 0.5734584       2  0 2576.639 9.3080425    21     1    441
##   ---
## 4946:      495    6 0.3515452       1  1 1257.155 0.0000000    17     1    289
## 4947:      495    7 0.3515452       1  1 1170.614 0.3515451    18     1    324
## 4948:      495    8 0.3515452       1  1 1211.788 0.3515451    19     1    361
## 4949:      495    9 0.3515452       1  1 1346.442 0.3515451    20     1    400
## 4950:      495   10 0.3515452       1  1 1279.959 0.3515451    21     0    441
##         lnwage yy1 yy2 yy3 yy4 yy5 yy6 yy7 yy8 yy9 yy10 lag_lnwage
##    1: 7.556680   1   0   0   0   0   0   0   0   0    0         NA
##    2: 7.633218   0   1   0   0   0   0   0   0   0    0   7.556680
##    3: 7.608693   0   0   1   0   0   0   0   0   0    0   7.633218
##    4: 7.729573   0   0   0   1   0   0   0   0   0    0   7.608693
##    5: 7.854241   0   0   0   0   1   0   0   0   0    0   7.729573
##   ---
## 4946: 7.136607   0   0   0   0   0   1   0   0   0    0   6.973784
## 4947: 7.065284   0   0   0   0   0   0   1   0   0    0   7.136607
## 4948: 7.099852   0   0   0   0   0   0   0   1   0    0   7.065284
## 4949: 7.205221   0   0   0   0   0   0   0   0   1    0   7.099852
## 4950: 7.154584   0   0   0   0   0   0   0   0   0    1   7.205221
##       out_cap_lnwage
##    1:       7.556680
##    2:       7.633218
##    3:       7.608693
##    4:       7.729573
##    5:       7.854241
##   ---
## 4946:       7.136607
## 4947:       7.065284
## 4948:       7.099852
## 4949:       7.205221
## 4950:       7.154584
##
## $outlier_index
## $outlier_index$upper_out_index
## $outlier_index$upper_out_index[[1]]
## [1] 210
##
```

```
##
## $outlier_index$lower_out_index
## $outlier_index$lower_out_index[[1]]
## numeric(0)
```

```
  vis_dat(simulated)
```




```
# gg_miss_upset(simulated)

  stargazer(simulated,
            title = "Summary statistics",
            label = "tb:statistcis",
            table.placement = "ht",
            header=FALSE,type="text")
```

```
##
## Summary statistics
## ===============================================================================
## Statistic     N      Mean     St. Dev.     Min    Pctl(25)  Pctl(75)      Max
## -------------------------------------------------------------------------------
## workerid   4,950  248.000    142.908      1         124       372        495
## year       4,950   5.500      2.873       1         3         8          10
## ui         4,950   0.488      0.289     0.0005    0.244     0.745      0.996
## quarter    4,950   2.517      1.128       1         2         4          4
## q1         4,950   0.240      0.427       0         0         0          1
```

```
## wage       4,950 1,998.779 1,032.194 662.083 1,226.806 2,482.937 7,170.242
## educ       4,950   5.226     3.795    0.000    2.322     7.635    19.446
## exper      4,950  14.336     6.460      0        9        19        28
## union      4,950   0.486     0.500      0        0         1         1
## exper2     4,950  247.252   187.126     0       81        361       784
## lnwage     4,950   7.483     0.476    6.495    7.112     7.817     8.878
## yy1        4,950   0.100     0.300      0        0         0         1
## yy2        4,950   0.100     0.300      0        0         0         1
## yy3        4,950   0.100     0.300      0        0         0         1
## yy4        4,950   0.100     0.300      0        0         0         1
## yy5        4,950   0.100     0.300      0        0         0         1
## yy6        4,950   0.100     0.300      0        0         0         1
## yy7        4,950   0.100     0.300      0        0         0         1
## yy8        4,950   0.100     0.300      0        0         0         1
## yy9        4,950   0.100     0.300      0        0         0         1
## yy10       4,950   0.100     0.300      0        0         0         1
## lag_lnwage 4,455   7.455     0.470    6.495    7.085     7.784     8.724
## ----------------------------------------------------------------------------
```

```
## DASHBOARD

  ####### ExPanD()
```

Regressions

OBSERVE THE MISTAKE FOLLOWING THE INTRODUCTION OF TIME DUMMIES AND EXPERIENCE IN THE FIXED-EFFECTS MODEL

```
  pols <- plm(data = simulated, lnwage ~ educ + exper +
              exper2 + factor(year),
            model="pooling", index=c("workerid", "year"))

  re <- plm(data = simulated, lnwage ~ educ + exper +
            exper2 + factor(year),
          model="random", index=c("workerid", "year"))

  plmtest(pols, type=c("bp"))
```

```
##
##  Lagrange Multiplier Test - (Breusch-Pagan) for balanced panels
##
## data:  lnwage ~ educ + exper + exper2 + factor(year)
## chisq = 19885, df = 1, p-value < 2.2e-16
## alternative hypothesis: significant effects
```

```
  fe <- plm(data = simulated, lnwage ~ educ + exper +
              exper2 + factor(year),
            model="within", index=c("workerid", "year"))

  pFtest(fe, pols)
```

```
##
```

```
##  F test for individual effects
##
## data:  lnwage ~ educ + exper + exper2 + factor(year)
## F = 270.97, df1 = 493, df2 = 4444, p-value < 2.2e-16
## alternative hypothesis: significant effects
```

```
  phtest(fe, re)
```

```
##
##  Hausman Test
##
## data:  lnwage ~ educ + exper + exper2 + factor(year)
## chisq = 309.92, df = 11, p-value < 2.2e-16
## alternative hypothesis: one model is inconsistent
```

```
  pols_robust <- coeftest(pols, function(x) vcovHC(x, type = 'sss'))
  re_robust <- coeftest(re, function(x) vcovHC(x, type = 'sss'))
  fe_robust <- coeftest(fe, function(x) vcovHC(x, type = 'sss'))

  stargazer(pols_robust,re_robust, fe_robust,title = "Regression analysis",
            model.numbers = FALSE,
            column.labels = c("Pooled (cluster)","RE (cluster)","FE (cluster"),
            label = "regressions",
            table.placement = "!ht",
            notes.append = FALSE,
            notes.align="l",
            notes="Standard errors in parentheses.",
            header = FALSE,
            no.space = TRUE,
            omit = c("Constant"),
            omit.stat = c("adj.rsq","f","ser"),
            digits = 3,
            digits.extra = 5,
            omit.yes.no = c("Constant",""),
            dep.var.caption="",
            dep.var.labels.include = FALSE,
            style = "qje",
            type="text")
```

```
##
## Regression analysis
## ============================================================
##                 Pooled (cluster) RE (cluster) FE (cluster
## educ                0.107***       0.067***    0.062***
##                     (0.002)        (0.001)      (0.001)
## exper               0.013***       0.005**     0.025***
##                     (0.005)        (0.002)      (0.001)
## exper2              -0.0003*       0.000004    0.000004
##                     (0.0002)      (0.00002)    (0.00002)
## factor(year)2        -0.001        0.019***     0.0002
##                     (0.004)        (0.004)      (0.003)
## factor(year)3        -0.002        0.038***      0.001
##                     (0.005)        (0.005)      (0.003)
```

```
## factor(year)4       -0.008        0.052***     -0.004*
##                    (0.007)        (0.007)      (0.003)
## factor(year)5       -0.004        0.075***     -0.0002
##                    (0.009)        (0.009)      (0.002)
## factor(year)6       -0.005        0.095***      0.001
##                    (0.010)        (0.011)      (0.003)
## factor(year)7       -0.009        0.112***     -0.001
##                    (0.012)        (0.013)      (0.003)
## factor(year)8       -0.011        0.131***     0.00004
##                    (0.014)        (0.015)      (0.003)
## factor(year)9       -0.013        0.148***     -0.002
##                    (0.016)        (0.017)      (0.003)
## factor(year)10      -0.011        0.169***
##                    (0.018)        (0.019)
## ============================================================
## Notes:         Standard errors in parentheses.
```

Close the log file

```
end_time <- Sys.time()

end_time - start_time
```

```
## Time difference of 53.42488 secs
```

```
  # sprintf(end_time - start_time,fmt = '%#.1f')
```

```
#
```