Statistics/Data analysis

```
      name:  <unnamed>
       log:  A:\_maestria_unibo_(operacional)\4_econometrics_1\4_problem_sets\1_ps1\2_
> log\log.smcl
  log type:  smcl
 opened on:  14 Oct 2021, 20:31:07

1 .
2 . *##############################################################################
3 . * 1. Question 1.
4 . *##############################################################################
5 . *==============================================================================
6 . * 1.1. Generate sample from the random variables and its population parameters.
7 . *==============================================================================
8 . set obs 100 // Set the number of  observations for the random sample.
  Number of observations (_N) was 0, now 100.

9 . set seed 1015 // Set the seed for the pseudo-random number generator.

10.
11. matrix means = (10,15,15,10) //Vector of means for the drawnorm().

12. matrix varcov = (1,0.6,0,0.2\0.6,1,0,0.3\0,0,1,0\0.2,0.3,0,1) //Matrix of var-cov fo
  > r the drawnorm().

13. matrix list means // Displays a matrix.

  means[1,4]
      c1  c2  c3  c4
  r1  10  15  15  10

14. matrix list varcov

  symmetric varcov[4,4]
      c1  c2  c3  c4
  r1   1
  r2  .6   1
  r3   0   0   1
  r4  .2  .3   0   1

15.
16. drawnorm y x1 x2 x3, cov(varcov) means(means) //Generates a sample of the random var
  > iables with the specified parameters.

17. list y in 1/10

       +----------+
       |        y |
       |----------|
    1. | 9.703876 |
    2. | 9.624805 |
    3. | 8.257296 |
    4. | 7.851505 |
    5. | 9.348859 |
       |----------|
    6. | 9.059323 |
    7. | 10.47427 |
    8. | 10.64235 |
    9. | 8.040435 |
   10. | 10.34571 |
       +----------+
```

```
18. summarize // Calculate mean and sd for the data.

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
           y |        100     9.83153     .990959   7.156042   12.93186
          x1 |        100    14.77765    .9627169   12.82143   17.81787
          x2 |        100    15.01672    .9772178   12.76052   17.20855
          x3 |        100    9.938679    1.097261   7.359324   12.43131

19.
20. gen constant = 1

21.
22. mata
------------------------------------------------- mata (type end to exit) ----------
:
: //---------------------------------------------------------------------------------
: // 1.1.a. Generate population values of the coefficients of X.
: //---------------------------------------------------------------------------------
: //----- Calculate the vector of coeficcients for X.
:
: means = (10,15,15,10)' //Vector of means for the drawnorm().

: varcov = (1,0.6,0,0.2\0.6,1,0,0.3\0,0,1,0\0.2,0.3,0,1) //Matrix of var-cov for the d
> rawnorm().

: means
        1
    +------+
  1 |  10  |
  2 |  15  |
  3 |  15  |
  4 |  10  |
    +------+

: varcov
[symmetric]
        1    2    3    4
    +---------------------+
  1 |   1                 |
  2 |  .6    1            |
  3 |   0    0    1       |
  4 |  .2   .3    0    1  |
    +---------------------+

:
: varcov_x = varcov[2..4,2..4]

: varcov_x
[symmetric]
        1    2    3
    +----------------+
  1 |   1            |
  2 |   0    1       |
  3 |  .3    0    1  |
    +----------------+

:
: cov_y = (varcov[1,2],varcov[1,3],varcov[1,4])'

: cov_y
        1
    +------+
  1 |  .6  |
  2 |   0  |
  3 |  .2  |
    +------+

:
: beta = invsym(varcov_x) * (cov_y)
```

```
: beta
                 1
    +--------------+
  1 |  .5934065934 |
  2 |            0 |
  3 |   .021978022 |
    +--------------+

:
: //----- Calculate B0.
:
: mean_x = (15,15,10)'

: mean_x
        1
    +------+
  1 |  15  |
  2 |  15  |
  3 |  10  |
    +------+

:
: beta_0 = 10 - (mean_x'*beta)

: beta_0
  .8791208791

:
: //------------------------------------------------------------------------------
: // 1.1.c. OLS Estimator.
: //------------------------------------------------------------------------------
:
: st_view(y=.,.,"y")

: st_view(x=.,.,("x1","x2","x3","constant"))

:
: beta_hat=invsym(x'x)*(x'y)

: beta_hat
                  1
    +---------------+
  1 |   .6141202149 |
  2 |   .0337280483 |
  3 |   .1213489504 |
  4 |  -.9562587499 |
    +---------------+

:
: //------------------------------------------------------------------------------
: // 1.1.d. SST, SSE, SSR.
: //------------------------------------------------------------------------------
:
: st_view(y=.,.,"y")

: st_view(x=.,.,("x1","x2","x3","constant"))

:
: mean_vector_y = J(rows(y),1,mean(y))

: //mean_vector_y
: sst = (y-mean_vector_y)'(y-mean_vector_y)

: sst
  97.21797076

:
: vector_y_hat = x * beta_hat

: //vector_y_hat
: sse = (vector_y_hat - mean_vector_y)'(vector_y_hat - mean_vector_y)
```

```
: sse
  44.52903988

:
: vector_u_hat = y - vector_y_hat

: //vector_u_hat
: ssr = (vector_u_hat)'(vector_u_hat)

: ssr
  52.68893088

:
: sst
  97.21797076

: sse + ssr
  97.21797076

:
: //----------------------------------------------------------------------------
: // 1.1.e. r2 and adjusted r2.
: //----------------------------------------------------------------------------
:
: r_squared = sse/sst

: r_squared
  .4580330111

:
: adjusted_r_squared = 1 - ((ssr / (rows(x) - cols(x))) / (sst / (rows(x) - 1)))

: adjusted_r_squared
  .4410965427

:
: //----------------------------------------------------------------------------
: // 1.1.f. OLS residuals and fitted values of y.
: //----------------------------------------------------------------------------
:
: //vector_y_hat
:
: //vector_u_hat
:
: //----------------------------------------------------------------------------
: // 1.1.g. Sample average of the OLS residuals and sample covariance between
: /// regressors and the residuals.
> //----------------------------------------------------------------------------
:
: mean_vector_u_hat = mean(vector_u_hat)

: mean_vector_u_hat
  -3.88471e-13

:
: cov_xu_hat = (1 / cols(y)) * (x'vector_u_hat) - (mean(x)'mean_vector_u_hat)

: cov_xu_hat
                 1
    +---------------+
  1 |  -5.86484e-10 |
  2 |  -5.85111e-10 |
  3 |  -3.78675e-10 |
  4 |  -3.84587e-11 |
    +---------------+
```

```
:
:
: // Comment: The mean of the residuals and the covariance between the residuals and t
> he
: // regressors is virtually zero.
:
: //------------------------------------------------------------------------------
: // 1.1.h. Comparison betweenthe average fitted value of y and the average value
: /// of y.
> //------------------------------------------------------------------------------
:
: mean_y = mean(y)

:
: mean_vector_y_hat = mean(vector_y_hat)

:
: mean_vector_y_hat - mean_y
  3.89022e-13

:
: // A summary of the key values to compare with the OLS regression output.
:
: beta_hat
                  1
    +----------------+
  1 |   .6141202149  |
  2 |   .0337280483  |
  3 |   .1213489504  |
  4 |  -.9562587499  |
    +----------------+

: sst
  97.21797076

: sse
  44.52903988

: ssr
  52.68893088

: r_squared
  .4580330111

: adjusted_r_squared
  .4410965427

:
: end
-------------------------------------------------------------------------------------

23.
24. *==============================================================================
25. * 1.2. OLS regression in STATA and comparison with results from MATA.
26. *==============================================================================
27.
28. reg y x*
```

Source	SS	df	MS			
				Number of obs	=	100
				F(3, 96)	=	27.04
Model	44.5290399	3	14.8430133	Prob > F	=	0.0000
Residual	52.6889309	96	.54884303	R-squared	=	0.4580
				Adj R-squared	=	0.4411
Total	97.2179708	99	.981999705	Root MSE	=	.74084

y	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
x1	.6141202	.0893371	6.87	0.000	.4367875	.7914529
x2	.033728	.0763631	0.44	0.660	-.1178514	.1853075
x3	.121349	.0782833	1.55	0.124	-.0340421	.27674
_cons	-.9562587	1.572035	-0.61	0.544	-4.076724	2.164206

```
29. corr y x*
  (obs=100)
```

	y	x1	x2	x3
y	1.0000			
x1	0.6658	1.0000		
x2	0.0782	0.0658	1.0000	
x3	0.4332	0.4985	0.0424	1.0000

```
30. // The results are exactly the same.
31.
32. *================================================================================
33. * 1.3. 1000 random samples from the joint distribution above.
34. *================================================================================
35.
36. capture program drop random_sample

37.
38. program define random_sample, rclass // Define the name of the program.
  1.           drop _all
  2.           scalar drop _all
  3.           matrix drop _all
  4.           set more off
  5.           set obs 100 // Set the number of observations in the sample.
  6.           matrix varcov = (1,0.6,0,0.2\0.6,1,0,0.3\0,0,1,0\0.2,0.3,0,1) //
  7.           matrix  means = (10,15,15,10)'    //Vector of means for the drawnorm().
  8.           drawnorm y x1 x2 x3, cov(varcov) means(means)
  9.
39.        reg y x1 x2 x3
 10.           // Store regression coefficients in r() in order to return them in the si
  > mulation
40.        return scalar beta_0 = _b[_cons]  //_b[namevariable]
 11.           return scalar beta_1 = _b[x1]
 12.       return scalar beta_2 = _b[x2]
 13.           return scalar beta_3 = _b[x3]
 14.           // End of program
41. end

42.
43. *--------------------------------------------------------------------------------
44. * 1.3.a. Estimation of parameters from 1000 replications.
45. *--------------------------------------------------------------------------------
46.
47. simulate ///
  > beta_0_hat = r(beta_0) ///
  > beta_1_hat = r(beta_1)  ///
  > beta_2_hat = r(beta_2) ///
  > beta_3_hat = r(beta_3), reps(1000)  ///
  > saving(0_data\coefficient_estimators, replace) seed(1015): random_sample

        Command: random_sample
     beta_0_hat: r(beta_0)
     beta_1_hat: r(beta_1)
     beta_2_hat: r(beta_2)
     beta_3_hat: r(beta_3)
```

```
Simulations (1,000)
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
..................................................   100
..................................................   150
..................................................   200
..................................................   250
..................................................   300
..................................................   350
..................................................   400
..................................................   450
..................................................   500
..................................................   550
..................................................   600
..................................................   650
..................................................   700
..................................................   750
..................................................   800
..................................................   850
..................................................   900
..................................................   950
.................................................. 1,000

*------------------------------------------------------------------------------
* 1.3.b. Unbiasness of the estimators of beta (against parameter beta).
*------------------------------------------------------------------------------

egen mean_beta_0_hat = mean(beta_0_hat)

egen mean_beta_1_hat = mean(beta_1_hat)

egen mean_beta_2_hat = mean(beta_2_hat)

egen mean_beta_3_hat = mean(beta_3_hat)


gen diff_b_0 = beta_0_hat - mean_beta_0_hat

gen diff_b_1 = beta_1_hat - mean_beta_1_hat

gen diff_b_2 = beta_2_hat - mean_beta_2_hat

gen diff_b_3 = beta_3_hat - mean_beta_3_hat


foreach var in beta_0_hat beta_1_hat beta_2_hat beta_3_hat{
2. summarize `var'
3. }
```

Variable	Obs	Mean	Std. dev.	Min	Max
beta_0_hat	**1,000**	**.8302528**	**1.838884**	**-4.651379**	**5.667601**

Variable	Obs	Mean	Std. dev.	Min	Max
beta_1_hat	**1,000**	**.5962717**	**.0876936**	**.1954905**	**.9266147**

Variable	Obs	Mean	Std. dev.	Min	Max
beta_2_hat	**1,000**	**.0033474**	**.0819166**	**-.2419794**	**.2505844**

Variable	Obs	Mean	Std. dev.	Min	Max
beta_3_hat	**1,000**	**.0176864**	**.0868876**	**-.2672546**	**.3348112**

```
64.
65. foreach var in diff_b_0 diff_b_1 diff_b_2 diff_b_3{
   2. summarize `var'
   3. }

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
    diff_b_0 |      1,000   -1.31e-08    1.838884  -5.481631   4.837348

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
    diff_b_1 |      1,000    3.81e-09    .0876936  -.4007812    .330343

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
    diff_b_2 |      1,000   -7.69e-10    .0819166  -.2453268    .247237

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
    diff_b_3 |      1,000   -1.45e-09    .0868876   -.284941   .3171248

66.
67. *-------------------------------------------------------------------------------
68. * 1.3.c. beta_hat distribution plots
69. *-------------------------------------------------------------------------------
70.
71. foreach var  of varlist beta_0_hat beta_1_hat beta_2_hat beta_3_hat{
   2.         histogram `var', normal name(`var', replace)
   3.         local graphnames `graphnames' `var'
   4. }
  (bin=29, start=-4.6513786, width=.35582689)
  (bin=29, start=.19549048, width=.02521118)
  (bin=29, start=-.24197945, width=.01698496)
  (bin=29, start=-.26725462, width=.02076089)

72.
73. graph combine `graphnames'

74. graph save 3_graphs\betas.gph, replace
  file 3_graphs\betas.gph saved

75.
76. //Comment: They look pretty normal, no pun intended.
77.
78. *###############################################################################
79. * 2. Question 2.
80. *###############################################################################
81. *===============================================================================
82. * 2.1. Load dataset in STATA and MATA and calculate the regression model in MATA.
83. *===============================================================================
84. clear all

85. use 0_data\ps1_group15

86.
87. summarize

    Variable |        Obs        Mean    Std. dev.       Min        Max
-------------+---------------------------------------------------------
     workedm |    322,542    .5656597    .4956708          0          1
     weeksm1 |    322,542    20.84158    22.28615          0         52
     hourswm |    322,542    18.80672    18.91383          0         99
     incomem |    322,542    7168.956    10839.99          0     260308
    kidcount |    322,542    2.553159    .8104265          2         12
-------------+---------------------------------------------------------
twin_birth_2 |    322,542    .0094747    .0968762          0          1
    same_sex |    322,542    .5053233    .4999724          0          1
    morekids |    322,542    .4022949    .4903616          0          1
      blackm |    322,542    .1191783    .3239987          0          1
       hispm |    322,542    .0302472    .1712671          0          1
-------------+---------------------------------------------------------
    othracem |    322,542    .0288366    .1673472          0          1
```

```
       educm |    322,542    12.12603    2.402849          0         20
       agem1 |    322,542    30.12355    3.506812         21         35
     agefstm |    322,542    20.13954    2.950454         15         33

88.
89. gen constant = 1

90. mata
------------------------------------------------- mata (type end to exit) ------------
:
: st_view(y = .,.,"hourswm")

: st_view(x = .,.,("morekids","educm","agefstm","blackm","hispm","othracem","agem1","c
> onstant"))

:
: beta = invsym(x'x) * (x'y)

: beta
                  1
    +----------------+
  1 |  -6.374661875  |
  2 |   .7717738957  |
  3 |   -1.60535276  |
  4 |   5.431590302  |
  5 |   2.491738478  |
  6 |   4.365351396  |
  7 |   .8708522197  |
  8 |   17.26199847  |
    +----------------+

:
: // I cannot compute the partitioned regression in mata because of the inability
: // to create an identity matrix of dimension = n (Insuficiente memory).
:
: end
--------------------------------------------------------------------------------------

91.
92. *===============================================================================
93. * 2.2. Calculate the regression model in STATA and compare it with the one
94. * obtained in MATA.
95. *===============================================================================
96.
97. reg hourswm morekids educm agem1 agefstm blackm hispm othracem

      Source |       SS           df       MS      Number of obs   =   322,542
-------------+----------------------------------   F(7, 322534)    =   3626.21
       Model |   8418182.8         7  1202597.54   Prob > F        =    0.0000
    Residual |   106965359   322,534  331.640568   R-squared       =    0.0730
-------------+----------------------------------   Adj R-squared   =    0.0729
       Total |   115383542   322,541  357.732945   Root MSE        =    18.211

------------------------------------------------------------------------------
     hourswm | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
    morekids |  -6.374662   .0684161   -93.17   0.000    -6.508756   -6.240568
       educm |   .7717739   .0150779    51.19   0.000     .7422216    .8013262
       agem1 |   .8708522   .0102514    84.95   0.000     .8507597    .8909447
     agefstm |  -1.605353   .0133654  -120.11   0.000    -1.631548   -1.579157
      blackm |    5.43159    .101549    53.49   0.000     5.232557    5.630623
       hispm |   2.491738   .1917857    12.99   0.000     2.115844    2.867633
    othracem |   4.365351   .1924748    22.68   0.000     3.988106    4.742597
       _cons |     17.262   .3179841    54.29   0.000     16.63876    17.88524
------------------------------------------------------------------------------
```

```

// The results are the same.

*===============================================================================
* 2.3.a.
*===============================================================================

cls

//----- Remove the effect of educm from hourswm.
reg hourswm educm

      Source |       SS           df       MS      Number of obs   =   322,542
-------------+----------------------------------   F(1, 322540)    =    578.93
       Model |   206732.46         1   206732.46   Prob > F        =    0.0000
    Residual |   115176809   322,540  357.093102   R-squared       =    0.0018
-------------+----------------------------------   Adj R-squared   =    0.0018
       Total |   115383542   322,541  357.732945   Root MSE        =    18.897

------------------------------------------------------------------------------
     hourswm | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       educm |   .3331849   .0138475    24.06   0.000     .3060442    .3603256
       _cons |   14.76651   .1711802    86.26   0.000       14.431    15.10202
------------------------------------------------------------------------------

predict e2_tilda, residuals


//----- Remove the effect of educm from morekids
reg morekids educm

      Source |       SS           df       MS      Number of obs   =   322,542
-------------+----------------------------------   F(1, 322540)    =   7822.27
       Model |  1836.36986         1  1836.36986   Prob > F        =    0.0000
    Residual |  75720.0515   322,540  .234761739   R-squared       =    0.0237
-------------+----------------------------------   Adj R-squared   =    0.0237
       Total |  77556.4213   322,541  .240454458   Root MSE        =    .48452

------------------------------------------------------------------------------
    morekids | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       educm |  -.0314023   .0003551   -88.44   0.000    -.0320982   -.0307064
       _cons |   .7830797   .0043891   178.41   0.000     .7744772    .7916822
------------------------------------------------------------------------------

predict x1_tilda, residuals


//----- Regress filtered-out y onto filetred out x, filter being educm.
reg e2_tilda x1_tilda

      Source |       SS           df       MS      Number of obs   =   322,542
-------------+----------------------------------   F(1, 322540)    =   3425.60
       Model |  1210401.47         1  1210401.47   Prob > F        =    0.0000
    Residual |   113966408   322,540  353.340385   R-squared       =    0.0105
-------------+----------------------------------   Adj R-squared   =    0.0105
       Total |   115176809   322,541  357.091995   Root MSE        =    18.797

------------------------------------------------------------------------------
    e2_tilda | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
    x1_tilda |  -3.998152   .0683111   -58.53   0.000    -4.132039   -3.864264
       _cons |   2.96e-07   .0330981     0.00   1.000    -.0648711    .0648717
------------------------------------------------------------------------------
```

```
reg hourswm morekids educm
```

Source	SS	df	MS
Model	1417133.91	2	708566.954
Residual	113966408	322,539	353.341481
Total	115383542	322,541	357.732945

Number of obs	=	322,542
F(2, 322539)	=	2005.33
Prob > F	=	0.0000
R-squared	=	0.0123
Adj R-squared	=	0.0123
Root MSE	=	18.797

hourswm	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
morekids	-3.998152	.0683112	-58.53	0.000	-4.13204	-3.864264
educm	.2076339	.0139406	14.89	0.000	.1803107	.2349571
_cons	17.89738	.1784834	100.27	0.000	17.54756	18.2472

```

//----- Remove the effect of morekids from hourswm.

reg hourswm morekids
```

Source	SS	df	MS
Model	1338749.89	1	1338749.89
Residual	114044792	322,540	353.583406
Total	115383542	322,541	357.732945

Number of obs	=	322,542
F(1, 322540)	=	3786.24
Prob > F	=	0.0000
R-squared	=	0.0116
Adj R-squared	=	0.0116
Root MSE	=	18.804

hourswm	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
morekids	-4.154711	.0675207	-61.53	0.000	-4.28705	-4.022373
_cons	20.47814	.0428262	478.17	0.000	20.3942	20.56208

```
predict e1_tilda, residuals

//----- Remove the effect of morekids from educm.
reg educm morekids
```

Source	SS	df	MS
Model	44094.0925	1	44094.0925
Residual	1818156.04	322,540	5.63699397
Total	1862250.13	322,541	5.77368498

Number of obs	=	322,542
F(1, 322540)	=	7822.27
Prob > F	=	0.0000
R-squared	=	0.0237
Adj R-squared	=	0.0237
Root MSE	=	2.3742

educm	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
morekids	-.7540173	.0085254	-88.44	0.000	-.7707269	-.7373078
_cons	12.42936	.0054074	2298.59	0.000	12.41877	12.43996

```
predict x2_tilda, residuals

//----- Remove the effect of educm from morekids.
```

```
reg e1_tilda x2_tilda

      Source |       SS           df       MS      Number of obs   =   322,542
-------------+----------------------------------   F(1, 322540)    =    221.84
       Model |   78384.007         1   78384.007   Prob > F        =    0.0000
    Residual |   113966407   322,540  353.340383   R-squared       =    0.0007
-------------+----------------------------------   Adj R-squared   =    0.0007
       Total |   114044791   322,541  353.582308   Root MSE        =    18.797

------------------------------------------------------------------------------
    e1_tilda | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
    x2_tilda |   .2076338   .0139406    14.89   0.000     .1803107     .234957
       _cons |   5.33e-07   .0330981     0.00   1.000    -.0648709    .0648719
------------------------------------------------------------------------------

reg hourswm morekids educm

      Source |       SS           df       MS      Number of obs   =   322,542
-------------+----------------------------------   F(2, 322539)    =   2005.33
       Model |  1417133.91         2  708566.954   Prob > F        =    0.0000
    Residual |   113966408   322,539  353.341481   R-squared       =    0.0123
-------------+----------------------------------   Adj R-squared   =    0.0123
       Total |   115383542   322,541  357.732945   Root MSE        =    18.797

------------------------------------------------------------------------------
     hourswm | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
    morekids |  -3.998152   .0683112   -58.53   0.000     -4.13204   -3.864264
       educm |   .2076339   .0139406    14.89   0.000     .1803107    .2349571
       _cons |   17.89738   .1784834   100.27   0.000     17.54756     18.2472
------------------------------------------------------------------------------


*################################################################################
* n. Close log.
*################################################################################

log close
      name:  <unnamed>
       log:  A:\_maestria_unibo_(operacional)\4_econometrics_1\4_problem_sets\1_ps1\2_
> log\log.smcl
  log type:  smcl
 closed on:  14 Oct 2021, 20:31:20
-------------------------------------------------------------------------------------
```