Problem Set 5 (SOLUTIONS)

This problem set will revise some of the material covered in Handout 5 on panel data models. This will require you to familiarize yourself with Stata's panel-data commands.

```
help xtset
help xttab
help xtreg
```

You will be using a dataset that comes with Stata: psidextract.dta. The data is a correct version of the PSID sample in Cornwell and Rupert (1988), found in Baltagi and Khanti-Akom (1990). It includes a sample of 595 individuals observed for the years 1976-82.

Preamble

```
<IPython.core.display.HTML object>
```

Create a do-file for this problem set and include a preamble that sets the directory and opens the data. For example,

```
clear
//or, to remove all stored values (including macros, matrices, scalars, etc.)
*clear all

* Replace $rootdir with the relevant path to on your local harddrive.
cd "$rootdir/problem-sets/ps-5"

cap log close
log using problem-set-5-log.txt, replace

use problem-set-5-data.dta, clear
```

```
C:\Users\neil_\OneDrive - University of Warwick\Documents\EC910\website\warwick
> -ec910\problem-sets\ps-5
-------------------------------------------------------------------------------
      name:  <unnamed>
       log:  C:\Users\neil_\OneDrive - University of Warwick\Documents\EC910\we
> bsite\warwick-ec910\problem-sets\ps-5\problem-set-5-log.txt
  log type:  smcl
 opened on:  11 Nov 2024, 14:07:07
(PSID wage data 1976-82 from Baltagi and Khanti-Akom (1990))
```

Questions

1. Set the unit identifier and time variable using `xtset`. Note, you can also use `tsset` for this task. This will allow you to use `xt` package commands.

```
xtset id t
```

```
Panel variable: id (strongly balanced)
 Time variable: t, 1 to 7
         Delta: 1 unit
```

2. Describe and summarise the variables in the dataset using the normal `describe` and `summarize` commands.

```
des
sum id t lwage ed exper weeks south
```

```
Contains data from problem-set-5-data.dta
 Observations:         4,165                  PSID wage data 1976-82 from
                                                Baltagi and Khanti-Akom (1990)
    Variables:            14                  11 Nov 2024 11:19
                                              (_dta has notes)
------------------------------------------------------------------------------
Variable      Storage   Display    Value
    name         type    format    label      Variable label
------------------------------------------------------------------------------
exper           float   %9.0g                 years of full-time work
                                                experience
weeks           float   %9.0g                 weeks worked
occup           float   %9.0g                 occupation; occ==1 if in a
                                                blue-collar occupation
industry        float   %9.0g                 industry; ind==1 if working in a
                                                manufacturing industry
south           float   %9.0g                 residence; south==1 if in the
                                                South area
smsa            float   %9.0g                 smsa==1 if in the Standard
                                                metropolitan statistical area
ms              float   %9.0g                 marital status
female          float   %9.0g                 female or male
```

```
union           float   %9.0g                 if wage set be a union contract
educ            float   %9.0g                 years of education
black           float   %9.0g                 black
lwage           float   %9.0g                 log wage
id              float   %9.0g
t               float   %9.0g
------------------------------------------------------------------------------
Sorted by: id  t
```

Variable	Obs	Mean	Std. dev.	Min	Max
id	4,165	298	171.7821	1	595
t	4,165	4	2.00024	1	7
lwage	4,165	6.676346	.4615122	4.60517	8.537
educ	4,165	12.84538	2.787995	4	17
exper	4,165	19.85378	10.96637	1	51
weeks	4,165	46.81152	5.129098	5	52
south	4,165	.2902761	.4539442	0	1

3. Describe and summarise the variables in the dataset using the panel commands: `xtdescribe` and `xtsummarize`. Comment on the information provided.

```
xtdescribe
xtsum id t lwage ed exper weeks south
```

```
      id:  1, 2, ..., 595                                 n =        595
       t:  1, 2, ..., 7                                   T =          7
           Delta(t) = 1 unit
           Span(t)  = 7 periods
           (id*t uniquely identifies each observation)

Distribution of T_i:   min      5%     25%       50%       75%     95%     max
                         7       7       7         7         7       7       7

     Freq.  Percent    Cum. |  Pattern
 ---------------------------+---------
     595    100.00  100.00 |  1111111
 ---------------------------+---------
     595    100.00         |  XXXXXXX
```

```
Variable         |      Mean   Std. dev.       Min        Max |    Observations
-----------------+--------------------------------------------+----------------
id       overall |       298   171.7821          1        595 |     N =    4165
         between |             171.906          1        595 |     n =     595
         within  |                   0        298        298 |     T =       7
                 |                                            |
t        overall |         4    2.00024          1          7 |     N =    4165
         between |                   0          4          4 |     n =     595
         within  |              2.00024          1          7 |     T =       7
                 |                                            |
lwage    overall |  6.676346   .4615122    4.60517      8.537 |     N =    4165
         between |             .3942387     5.3364   7.813596 |     n =     595
         within  |             .2404023   4.781808   8.621092 |     T =       7
                 |                                            |
educ     overall |  12.84538   2.787995          4         17 |     N =    4165
         between |             2.790006          4         17 |     n =     595
         within  |                   0   12.84538   12.84538 |     T =       7
                 |                                            |
exper    overall |  19.85378   10.96637          1         51 |     N =    4165
         between |             10.79018          4         48 |     n =     595
         within  |              2.00024   16.85378   22.85378 |     T =       7
                 |                                            |
weeks    overall |  46.81152   5.129098          5         52 |     N =    4165
         between |             3.284016   31.57143   51.57143 |     n =     595
         within  |             3.941881    12.2401   63.66867 |     T =       7
                 |                                            |
south    overall |  .2902761   .4539442          0          1 |     N =    4165
         between |             .4489462          0          1 |     n =     595
         within  |             .0693042  -.5668667   1.147419 |     T =       7
```

4. Use the command `xttab` and `xtrans, freq` to describe transitions over time in the variable `south`.

```
xttab south
xttrans south, freq
```

```
                Overall            Between            Within
    south |    Freq.  Percent      Freq.  Percent        Percent
----------+-----------------------------------------------------
        0 |    2956     70.97       428     71.93          98.66
        1 |    1209     29.03       182     30.59          94.90
```

```
----------+--------------------------------------------------------
    Total |    4165    100.00       610    102.52          97.54
                              (n = 595)
```

```
residence; |
  south==1 |  residence; south==1
 if in the | if in the South area
South area |         0          1 |     Total
-----------+----------------------+----------
         0 |     2,527          8 |     2,535
           |     99.68       0.32 |    100.00
-----------+----------------------+----------
         1 |         8      1,027 |     1,035
           |      0.77      99.23 |    100.00
-----------+----------------------+----------
     Total |     2,535      1,035 |     3,570
           |     71.01      28.99 |    100.00
```

5. Create the variable: `expsq=exper^2/1000`. Why would you scale the variable in this way?

```
gen expsq=exp*exp/1000
```

6. Estimate the following model using pooled OLS, between-group, feasible GLS, within-group, LSDV, and first-difference. For the first-difference estimator, you can define a first-difference in Stata using the time-series operator: `D.variable`.

$$\ln(Wage_{it}) = \beta_1 + \beta_2 Exper_{it} + \beta_3 Exper_{it}^2 + \beta_4 Weeks_{it} + \beta_5 Eduyrs_{it} + \varepsilon_{it}$$

With each model, store the results using `estimates store`. For example,

```
* clear existing stored estimates
est clear

* Pooled OLS
regress lwage exper expsq weeks ed
est store OlS

* alternatively,
eststo OLS: regress lwage exper expsq weeks ed
```

```
est clear
* Pooled-OLS
eststo OLS: regress lwage exper expsq weeks ed

* Between-group
eststo BG: xtreg lwage exper expsq weeks ed, be

* Feasible-GLS
eststo FGLS: xtreg lwage exper expsq weeks ed, re theta

* Within-group
eststo WG: xtreg lwage exper expsq weeks ed, fe

* LSDV
eststo LSDV: areg lwage exper expsq weeks ed, absorb(id)

* First-differnce
eststo FD: reg D.(lwage exper expsq weeks), noconst
```

```
      Source |       SS           df       MS      Number of obs   =     4,165
-------------+----------------------------------   F(4, 4160)      =    411.62
       Model |  251.491445         4  62.8728612   Prob > F        =    0.0000
    Residual |  635.413457     4,160  .152743619   R-squared       =    0.2836
-------------+----------------------------------   Adj R-squared   =    0.2829
       Total |  886.904902     4,164  .212993492   Root MSE        =    .39082

------------------------------------------------------------------------------
       lwage | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |    .044675   .0023929    18.67   0.000     .0399838    .0493663
       expsq |   -.715631   .0527938   -13.56   0.000    -.8191351   -.6121268
       weeks |    .005827   .0011827     4.93   0.000     .0035084    .0081456
        educ |   .0760407   .0022266    34.15   0.000     .0716754     .080406
       _cons |   4.907961   .0673297    72.89   0.000     4.775959    5.039963
------------------------------------------------------------------------------

Between regression (regression on group means)  Number of obs     =      4,165
Group variable: id                              Number of groups  =        595

R-squared:                                      Obs per group:
     Within  = 0.1357                                         min =          7
```

```
     Between = 0.3264                                        avg =        7.0
     Overall = 0.2723                                        max =          7

                                                 F(4,590)          =      71.48
sd(u_i + avg(e_i.)) = .324656                    Prob > F          =     0.0000

------------------------------------------------------------------------------
       lwage | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |    .038153   .0056967     6.70   0.000     .0269647    .0493412
       expsq |   -.631272   .1256812    -5.02   0.000    -.8781089    -.384435
       weeks |   .0130903   .0040659     3.22   0.001     .0051048    .0210757
        educ |   .0737838   .0048985    15.06   0.000     .0641632    .0834044
       _cons |   4.683039   .2100989    22.29   0.000     4.270407    5.095672
------------------------------------------------------------------------------

Random-effects GLS regression                    Number of obs     =      4,165
Group variable: id                               Number of groups  =        595

R-squared:                                       Obs per group:
     Within  = 0.6340                                         min =          7
     Between = 0.1716                                         avg =        7.0
     Overall = 0.1830                                         max =          7

                                                 Wald chi2(4)      =    3012.45
corr(u_i, X) = 0 (assumed)                       Prob > chi2       =     0.0000
theta        = .82280511

------------------------------------------------------------------------------
       lwage | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |   .0888609   .0028178    31.54   0.000     .0833382    .0943837
       expsq |   -.772565   .0622619   -12.41   0.000     -.894596   -.6505339
       weeks |   .0009658   .0007433     1.30   0.194     -.000491    .0024226
        educ |   .1117099   .0060572    18.44   0.000     .0998381    .1235818
       _cons |   3.829366   .0936336    40.90   0.000     3.645848    4.012885
-------------+----------------------------------------------------------------
     sigma_u |  .31951859
     sigma_e |  .15220316
         rho |  .81505521   (fraction of variance due to u_i)
------------------------------------------------------------------------------
note: educ omitted because of collinearity.
```

```
Fixed-effects (within) regression               Number of obs     =      4,165
Group variable: id                              Number of groups  =        595

R-squared:                                      Obs per group:
     Within  = 0.6566                                         min =          7
     Between = 0.0276                                         avg =        7.0
     Overall = 0.0476                                         max =          7

                                                F(3, 3567)        =    2273.74
corr(u_i, Xb) = -0.9107                         Prob > F          =     0.0000

------------------------------------------------------------------------------
       lwage | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |   .1137879   .0024689    46.09   0.000     .1089473    .1186284
       expsq |  -.4243693   .0546316    -7.77   0.000    -.5314816    -.317257
       weeks |   .0008359   .0005997     1.39   0.163    -.0003399    .0020116
        educ |           0  (omitted)
       _cons |   4.596396   .0389061   118.14   0.000     4.520116    4.672677
-------------+----------------------------------------------------------------
     sigma_u |  1.0362039
     sigma_e |  .15220316
         rho |  .97888036   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(594, 3567) = 53.12                 Prob > F = 0.0000
note: educ omitted because of collinearity.

Linear regression, absorbing indicators           Number of obs     =   4,165
Absorbed variable: id                             No. of categories =     595
                                                  F(3, 3567)        = 2273.74
                                                  Prob > F          =  0.0000
                                                  R-squared         =  0.9068
                                                  Adj R-squared     =  0.8912
                                                  Root MSE          =  0.1522

------------------------------------------------------------------------------
       lwage | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |   .1137879   .0024689    46.09   0.000     .1089473    .1186284
       expsq |  -.4243693   .0546316    -7.77   0.000    -.5314816    -.317257
       weeks |   .0008359   .0005997     1.39   0.163    -.0003399    .0020116
        educ |           0  (omitted)
       _cons |   4.596396   .0389061   118.14   0.000     4.520116    4.672677
```

```
------------------------------------------------------------------------------
F test of absorbed indicators: F(594, 3567) = 53.118          Prob > F = 0.000

      Source |       SS           df       MS      Number of obs   =     3,570
-------------+----------------------------------   F(3, 3567)      =    337.12
       Model |  33.3371458         3  11.1123819   Prob > F        =    0.0000
    Residual |   117.57812     3,567  .032962747   R-squared       =    0.2209
-------------+----------------------------------   Adj R-squared   =    0.2202
       Total |  150.915266     3,570  .042273184   Root MSE        =    .18156

------------------------------------------------------------------------------
     D.lwage | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |
         D1. |   .1170654   .0063106    18.55   0.000     .1046927    .1294381
             |
       expsq |
         D1. |  -.5321208   .1392741    -3.82   0.000    -.8051857    -.259056
             |
       weeks |
         D1. |  -.0002683   .0005648    -0.47   0.635    -.0013757    .0008392
------------------------------------------------------------------------------
```

7. Using the formula from Handout 5, replicate the value of θ reported above by the FGLS estimator. Note, you will need to use the stored values of σ^2_ε and σ^2_α.

```
qui xtreg lwage exper expsq weeks ed, re theta
display "theta = "  1 - sqrt(e(sigma_e)^2 / (7*e(sigma_u)^2+e(sigma_e)^2))
```

```
theta = .82280511
```

8. Make a table of the computed estimates. You can either use `estimates table` or `esttab`. The latter is part of the `estout` package, which you may need to install: `ssc install estout`.

```
esttab OLS BG FGLS, se scalar(N r2 r2_o r2_b r2_w sigma_u sigma_e rho) mtitle("OLS" "BG" "FGL
esttab WG LSDV FD, se scalar(N r2 r2_o r2_b r2_w sigma_u sigma_e rho) rename(D.exper exper D
```

```
------------------------------------------------------------
                    (1)             (2)             (3)
```

	OLS	BG	FGLS
exper	0.0447***	0.0382***	0.0889***
	(0.00239)	(0.00570)	(0.00282)
expsq	-0.716***	-0.631***	-0.773***
	(0.0528)	(0.126)	(0.0623)
weeks	0.00583***	0.0131**	0.000966
	(0.00118)	(0.00407)	(0.000743)
educ	0.0760***	0.0738***	0.112***
	(0.00223)	(0.00490)	(0.00606)
_cons	4.908***	4.683***	3.829***
	(0.0673)	(0.210)	(0.0936)
N	4165	4165	4165
r2	0.284	0.326	
r2_o		0.272	0.183
r2_b		0.326	0.172
r2_w		0.136	0.634
sigma_u			0.320
sigma_e			0.152
rho			0.815

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

	(1)	(2)	(3)
	WG	LSDV	FD
exper	0.114***	0.114***	0.117***
	(0.00247)	(0.00247)	(0.00631)
expsq	-0.424***	-0.424***	-0.532***
	(0.0546)	(0.0546)	(0.139)
weeks	0.000836	0.000836	-0.000268
	(0.000600)	(0.000600)	(0.000565)
educ	0	0	

```
                     (.)             (.)

_cons                4.596***        4.596***
                   (0.0389)        (0.0389)
------------------------------------------------------------
N                     4165            4165            3570
r2                   0.657           0.907           0.221
r2_o                0.0476
r2_b                0.0276
r2_w                 0.657
sigma_u              1.036
sigma_e              0.152
rho                  0.979
------------------------------------------------------------
Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001
```

9. Perform a Hausman test comparing the results of the FLGS and WG estimators. You should use the `hausman` command, with the option `sigmamore`. Be sure to get the order of the estimates correct. What do you learn from the test?

```
hausman WG FGLS, sigmamore
```

```
                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       WG          FGLS        Difference       Std. err.
-------------+----------------------------------------------------------------
       exper |    .1137879     .0888609        .0249269        .0012778
       expsq |   -.4243693     -.772565        .3481957        .0284727
       weeks |    .0008359     .0009658       -.0001299        .0001108
------------------------------------------------------------------------------
                           b = Consistent under H0 and Ha; obtained from xtreg.
            B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            = 1513.02
Prob > chi2 =  0.0000
```

10. Estimate FGLS for the model below:

$$\ln(Wage_{it}) = \beta_1 + \beta_2 Exper_{it} + \beta_3 Exper_{it}^2 + \beta_4 Weeks_{it} + \beta_5 Eduyrs_{it} + \gamma_2 \overline{Exper}_i + \gamma_3 \overline{Exper^2}_i + \gamma_4 \overline{Weeks}_i + \varepsilon_{it}$$

You will need to manually create the variables: $\{\overline{Exper}_i, \overline{Exper^2}_i, \overline{Weeks}_i\}$ - the individual-level averages of each variable. This is referred to as the Mundlack correction. Once you have estimated the model, repeat the Hausman test comparing these results with those of the WG estimator. What is the significance of the Mundlack correction?

```
foreach var in exper expsq weeks{
    bys id: egen av`var' = mean(`var')
}

eststo MUN: xtreg lwage exper expsq weeks ed avexper avexpsq avweeks, re theta

esttab WG LSDV FD MUN, se scalar(N r2 r2_o r2_b r2_w sigma_u sigma_e rho) rename(D.exper expe

hausman MUN FGLS, sigmamore
```

```
Random-effects GLS regression                   Number of obs     =      4,165
Group variable: id                              Number of groups  =        595

R-squared:                                      Obs per group:
     Within  = 0.6566                                         min =          7
     Between = 0.3264                                         avg =        7.0
     Overall = 0.4160                                         max =          7

                                                Wald chi2(7)      =    7107.12
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
theta        = .82280511

------------------------------------------------------------------------------
       lwage | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
       exper |   .1137879   .0024689    46.09   0.000     .1089489    .1186268
       expsq |  -.4243693   .0546316    -7.77   0.000    -.5314452   -.3172934
       weeks |   .0008359   .0005997     1.39   0.163    -.0003395    .0020112
        educ |   .0737838   .0048985    15.06   0.000     .0641829    .0833846
     avexper |  -.0756349   .0062087   -12.18   0.000    -.0878036   -.0634662
     avexpsq |  -.2069027   .1370415    -1.51   0.131    -.4754991    .0616937
     avweeks |   .0122544   .0041099     2.98   0.003     .0041991    .0203097
```

```
       _cons |   4.683039   .2100989    22.29   0.000     4.271253    5.094826
-------------+----------------------------------------------------------------
     sigma_u |  .31951859
     sigma_e |  .15220316
         rho |  .81505521   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

	(1) WG	(2) LSDV	(3) FD	(4) Mundlack
exper	0.114***	0.114***	0.117***	0.114***
	(0.00247)	(0.00247)	(0.00631)	(0.00247)
expsq	-0.424***	-0.424***	-0.532***	-0.424***
	(0.0546)	(0.0546)	(0.139)	(0.0546)
weeks	0.000836	0.000836	-0.000268	0.000836
	(0.000600)	(0.000600)	(0.000565)	(0.000600)
educ	0	0		0.0738***
	(.)	(.)		(0.00490)
avexper				-0.0756***
				(0.00621)
avexpsq				-0.207
				(0.137)
avweeks				0.0123**
				(0.00411)
_cons	4.596***	4.596***		4.683***
	(0.0389)	(0.0389)		(0.210)
N	4165	4165	3570	4165
r2	0.657	0.907	0.221	
r2_o	0.0476			0.416
r2_b	0.0276			0.326
r2_w	0.657			0.657
sigma_u	1.036			0.320
sigma_e	0.152			0.152
rho	0.979			0.815

```
------------------------------------------------------------------------------
Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Note: the rank of the differenced variance matrix (3) does not equal the number
        of coefficients being tested (4); be sure this is what you expect, or
        there may be problems computing the test.  Examine the output of your
        estimators for anything unexpected and possibly consider scaling your
        variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       MUN          FGLS        Difference       Std. err.
-------------+----------------------------------------------------------------
       exper |    .1137879     .0888609        .0249269        .0012778
       expsq |   -.4243693     -.772565        .3481957        .0284727
       weeks |    .0008359     .0009658       -.0001299        .0001108
        educ |    .0737838     .1117099       -.0379262        .0009972
------------------------------------------------------------------------------
                           b = Consistent under H0 and Ha; obtained from xtreg.
            B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            = 1513.02
Prob > chi2 =  0.0000
(V_b-V_B is not positive definite)
```

11. Export the results as a single CSV/Excel file. You can use `esttab` for .csv or `outreg2` for .xlsx.

```
esttab using "problem-set-5-results.csv", replace se scalar(N r2 r2_o r2_b r2_w sigma_u sigma
```

```
(output written to problem-set-5-results.csv)
```

Postamble

```
log close
```

```
      name:  <unnamed>
       log:  C:\Users\neil_\OneDrive - University of Warwick\Documents\EC910\we
> bsite\warwick-ec910\problem-sets\ps-5\problem-set-5-log.txt
  log type:  smcl
 closed on:  11 Nov 2024, 14:07:10
-------------------------------------------------------------------------------
```