Homework assignment #6
Panel Data Analysis

MPP-C6: Statistics 2

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Disclaimer: This document sketches some brief responses to the questions of the homework assignment. It serves to provide students with some guidance. The document may include som flaws - those should be reported to me as students go through the responses.

Project Description

The Environmental Kuznets Curve is at the heart of a long-standing discourse on the relationship between economic development and environmental quality. It hypothesizes an inverted U-shape relationship between indicators of environmental degradation and per capita income. While some have used the EKC to argue that growth policies are also superior for dealing with environmental problems, others have questioned the existence of EKCs for different indicators or stressed very high turning points. We aim to reproduce the results of Stern and Common (2001) which sought to investigate the presence of an environmental Kuznets curve (EKC) for sulfur emissions [1].

Dataset

The dataset stern2.dat contains country data from 1960-1990. The dataset contains the following variables

- *year*: the year in which the country was observed
- *country*: numerical code that uniquely identifies each country (see table 1)
- *gdpppp*: GDP per capita (purchasing power parity) in real 1990 international dollars
- *pop*: population in 1000 residents

- *so*: SO_2 emissions in tonnes
- *sopc*: SO_2 emissions in tonnes per capita
- *oe*: dummy variable describing oecd membership where 1000 represents membership and 2000 represents non-membership

Questions

1. **Read the paper by Stern and Common. Explain the EKC hypothesis in your own words. What is the difference between sulfur and carbon emissions in the empirical discussion and why? What is the authors' perceived contribution to the discussion? What is the role of panel data therein? [conceptual question]**

2. **Start by examining your data. Try out some descriptive statistics of the xt command family and report relevant ones. What sort of distribution do our variables of interest display? What transformations could we apply to the data? If necessary, create new variables that are appropriately transformed.**

   Interactive Stata Example

3. **Plot GDP per capita against sulfur emissions per capita (transformed if necessary). Describe the relationship you can see.**

   Interactive Stata Example

4. **Write the equation for a model that could estimate an EKC for sulfur emissions. Create any extra variables that would be necessary to run this.**

$$\ln SO_i = \beta_0 + \beta_1 lsopc + \beta_2 lsopc^2$$

5. **Carry out a pooled regression using the equation described in question 3. Interpret the coefficients. Run fixed-effects and random-effects models and interpret the results.**

   Interactive Stata Example

```
. *regress using pooled ols
. reg lsopc lgdp lgdpsq

      Source |       SS           df       MS      Number of obs   =     2,294
-------------+----------------------------------   F(2, 2291)      =    679.91
       Model |  3019.46587         2  1509.73294   Prob > F        =    0.0000
    Residual |  5087.10815     2,291  2.22047497   R-squared       =    0.3725
-------------+----------------------------------   Adj R-squared   =    0.3719
       Total |  8106.57402     2,293  3.53535718   Root MSE        =    1.4901
```

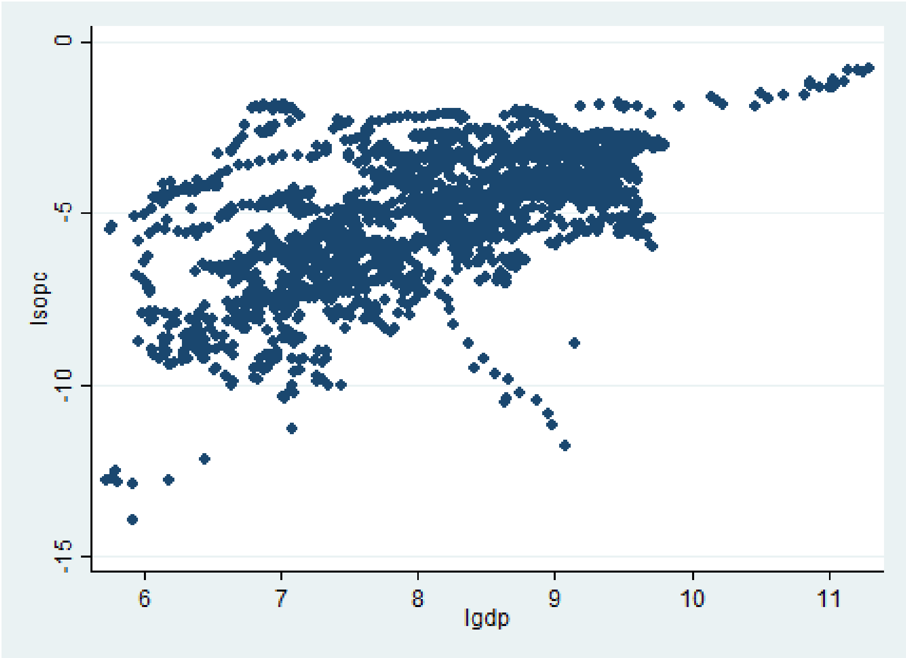

Figure 1: log GDP per capita against log sulfur emissions per capita

```
------------------------------------------------------------------------------
       lsopc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |    1.82093   .4380234     4.16   0.000     .9619664    2.679894
      lgdpsq |  -.0417549   .0271007    -1.54   0.124    -.0948993    .0113895
       _cons |  -17.02817   1.752482    -9.72   0.000    -20.46478   -13.59155
------------------------------------------------------------------------------

. est store pooled

.
. *random effects regression
. xtreg lsopc lgdp lgdpsq, re

Random-effects GLS regression                   Number of obs     =      2,294
Group variable: country                         Number of groups  =         74

R-sq:                                           Obs per group:
     within  = 0.1481                                         min =         31
     between = 0.3912                                         avg =       31.0
     overall = 0.3618                                         max =         31

                                                Wald chi2(2)      =     427.81
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
       lsopc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |   3.266315   .3497687     9.34   0.000     2.580781    3.951849
      lgdpsq |  -.1520899    .021113    -7.20   0.000    -.1934705   -.1107092
       _cons |  -21.37886   1.453844   -14.71   0.000    -24.22834   -18.52938
-------------+----------------------------------------------------------------
     sigma_u |  1.3905606
     sigma_e |  .58383059
         rho |  .85014041   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. est store ran

.
. *fixed effects regression
. xtreg lsopc lgdp lgdpsq, fe
```

```
Fixed-effects (within) regression               Number of obs     =      2,294
Group variable: country                         Number of groups  =         74

R-sq:                                           Obs per group:
     within  = 0.1481                                         min =         31
     between = 0.3903                                         avg =       31.0
     overall = 0.3611                                         max =         31

                                                F(2,2218)         =     192.87
corr(u_i, Xb)  = 0.2231                         Prob > F          =     0.0000

------------------------------------------------------------------------------
       lsopc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |   3.252834   .3533359     9.21   0.000      2.55993    3.945737
      lgdpsq |  -.1525319   .0212964    -7.16   0.000    -.1942948   -.1107689
       _cons |  -21.23976   1.462225   -14.53   0.000    -24.10723   -18.37228
-------------+----------------------------------------------------------------
     sigma_u |  1.4342211
     sigma_e |  .58383059
         rho |  .85784832   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(73, 2218) = 174.06                  Prob > F = 0.0000

. est store fix

.
.
```

6. Test which of the three models is preferable. Perform other relevant diagnostics for the model of choice. Is it appropriate to include time-fixed effects in the model?

Interactive Stata Example

```
. *conduct a Breusch-Pagan test for heteroscedasticity
. quietly reg lsopc lgdp lgdpsq

. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lsopc

         chi2(1)      =   303.50
         Prob > chi2  =   0.0000

.
. *conduct a hausman test
. hausman fix ran

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fix          ran         Difference          S.E.
-------------+----------------------------------------------------------------
        lgdp |    3.252834     3.266315       -.0134814         .050081
      lgdpsq |   -.1525319    -.1520899        -.000442         .002789
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        6.27
                Prob>chi2 =      0.0435

.
.
```

7. What is heterogeneity bias and is it relevant according to your results? [conceptual question]

8. A high Hausman statistic implies that there is correlation between country effects and income variables. What could be the most likely cause of this problem?

[conceptual question]

9. Compute the relevant turning points of the estimated curves for the world, OECD and non-OECD regressions. Summarize your results in a table.

Interactive Stata Example

```
.
. xtreg lsopc lgdp lgdpsq, re

Random-effects GLS regression                   Number of obs     =      2,294
Group variable: country                         Number of groups  =         74

R-sq:                                           Obs per group:
     within  = 0.1481                                         min =         31
     between = 0.3912                                         avg =       31.0
     overall = 0.3618                                         max =         31

                                                Wald chi2(2)      =     427.81
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
       lsopc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |   3.266315   .3497687     9.34   0.000     2.580781    3.951849
      lgdpsq |  -.1520899    .021113    -7.20   0.000    -.1934705   -.1107092
       _cons |  -21.37886   1.453844   -14.71   0.000    -24.22834   -18.52938
-------------+----------------------------------------------------------------
     sigma_u |  1.3905606
     sigma_e |  .58383059
         rho |  .85014041   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. est store ran_world

. mat w = _b[lgdp]\_b[lgdpsq]\_b[lgdp]/ ///
>          (-2*_b[lgdpsq])\exp(-_b[lgdp]/(2*_b[lgdpsq]))

.
. xtreg lsopc lgdp lgdpsq if oe==1000, re

Random-effects GLS regression                   Number of obs     =        713
Group variable: country                         Number of groups  =         23

R-sq:                                           Obs per group:
     within  = 0.3470                                         min =         31
     between = 0.1076                                         avg =       31.0
     overall = 0.1479                                         max =         31

                                                Wald chi2(2)      =     368.63
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
       lsopc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |   12.21955   .7285045    16.77   0.000     10.79171     13.6474
      lgdpsq |  -.6697365   .0411332   -16.28   0.000    -.7503561   -.5891168
       _cons |  -59.59001   3.226829   -18.47   0.000    -65.91448   -53.26554
-------------+----------------------------------------------------------------
     sigma_u |  .68765819
     sigma_e |  .25802593
         rho |  .87658312   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. est store ran_oecd

. mat o = _b[lgdp]\_b[lgdpsq]\_b[lgdp]/ ///
>          (-2*_b[lgdpsq])\exp(-_b[lgdp]/(2*_b[lgdpsq]))

.
. xtreg lsopc lgdp lgdpsq if oe==2000, re

Random-effects GLS regression                   Number of obs     =      1,581
Group variable: country                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.1490                                         min =         31
     between = 0.3072                                         avg =       31.0
     overall = 0.2847                                         max =         31

                                                Wald chi2(2)      =     287.25
```

```
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
       lsopc |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |   2.399114   .4360389     5.50   0.000     1.544494    3.253735
      lgdpsq |  -.0950999   .0268871    -3.54   0.000    -.1477977    -.042402
       _cons |  -18.26462   1.779192   -10.27   0.000    -21.75177   -14.77747
-------------+----------------------------------------------------------------
     sigma_u |  1.6195348
     sigma_e |   .6747042
         rho |   .8521091   (fraction of variance due to u_i)
------------------------------------------------------------------------------

. est store ran_nonoecd

. mat no = _b[lgdp]\_b[lgdpsq]\_b[lgdp]/ ///
>         (-2*_b[lgdpsq])\exp(-_b[lgdp]/(2*_b[lgdpsq]))

.
. mat all = w,o,no

. matrix colnames all = world oecd nonoecd

. matrix rownames all = lgdp lgdpsq tp e_tp

.
. frmttable, statmat(all)

                  -------------------------------------------
                              world       oecd      nonoecd
                  -------------------------------------------
                   lgdp        3.27       12.22        2.40
                   lgdpsq     -0.15       -0.67       -0.10
                   tp         10.74        9.12       12.61
                   e_tp     46,078.82   9,160.52   300,636.60
                  -------------------------------------------


.
.
```

10. Discuss why first-differencing may be a more appropriate method for the data.
11. Estimate the model for the “world” using first-differences and interpret the results.

Interactive Stata Example

```
. *First difference
. reg D.lsopc D.lgdp D.lgdpsq, noconstant

      Source |       SS           df       MS      Number of obs   =     2,220
-------------+----------------------------------   F(2, 2218)      =     23.67
       Model |  3.52188216         2  1.76094108   Prob > F        =    0.0000
    Residual |  165.031008     2,218  .074405324   R-squared       =    0.0209
-------------+----------------------------------   Adj R-squared   =    0.0200
       Total |   168.55289     2,220  .075924725   Root MSE        =    .27277

------------------------------------------------------------------------------
     D.lsopc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lgdp |
         D1. |   2.081773   .7397481     2.81   0.005      .631102    3.532445
             |
      lgdpsq |
         D1. |  -.0917739   .0461154    -1.99   0.047    -.1822078     -.00134
------------------------------------------------------------------------------

. est store FD

.
.
```

12. Comment on any differences between the models you have run.
13. Discuss whether we can observe an EKC for sulfur emissions with reference to your results.

Table 1: Country Codes

1	ALGERIA	95	JAPAN
14	EGYPT	97	KOREA,
18	GHANA	98	KUWAIT
22	KENYA	100	MALAYSIA
25	MADAGASCAR	102	MYANMAR
30	MOROCCO	106	PHILIPPINES
31	MOZAMBIQUE	108	SAUDI ARABIA
32	NAMIBIA	109	SINGAPORE
34	NIGERIA	110	SRI LANKA
41	SAFRICA	111	SYRIA
44	TANZANIA	112	TAIWAN
46	TUNISIA	113	THAILAND
48	ZAIRE	116	AUSTRIA
49	ZAMBIA	117	BELGIUM
50	ZIMBABWE	119	CYPRUS
52	BARBADOS	120	CZECHOSLOVAKIA
54	CANADA	121	DENMARK
60	GUATEMALA	122	FINLAND
62	HONDURAS	123	FRANCE
64	MEXICO	125	WGERMANY
65	NICARAGUA	126	GREECE
71	TRINIDAD&TOBAGO	129	IRELAND
72	U.S.A.	130	ITALY
73	ARGENTINA	131	LUXEMBOURG
74	BOLIVIA	133	NETHERLANDS
75	BRAZIL	134	NORWAY
76	CHILE	136	PORTUGAL
77	COLOMBIA	137	ROMANIA
81	PERU	138	SPAIN
83	URUGUAY	139	SWEDEN
84	VENEZUELA	140	SWITZERLAND
88	CHINA	141	TURKEY
89	HONG KONG	142	U.K.
90	INDIA	143	USSR
91	INDONESIA	144	YUGOSLAVIA
92	IRAN	145	AUSTRALIA
94	ISRAEL	147	NZ

References

[1] David I Stern and Michael S Common. Is there an environmental kuznets curve for sulfur? *Journal of Environmental Economics and Management*, 41(2):162–178, 2001.