Democratisation, Environmental and Income Inequality

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ONLINE APPENDIX

This appendix is introduced in support of section 4, and explains the reasons for selecting the econometric model represented by equation (13).

As was stressed in the text, section 4 does not pretend to be a formal test of the results implied by the theoretical model, but just a mere description of the main raw evidence that data show. However, a formal motivation for the choice of the simple econometric model used in section 4 is due.

First of all, I checked stationarity of the main variables used (per capita GDP and CO2 emissions). Tests of unit root of per capita GDP and CO2 emissions using the Levin, Lin and Chu (LLC) test, the Im, Pesaran and Shin (IPS) test, and finally the ADF and PP-Fisher tests show that the two variables are intergrated of order one. In the absence of cointegration, therefore, a regression of a I(1) variable over another I(1) variable would produce inconsistent estimates of the coefficients (see table III for results of the unit root tests).

Table I: Summary statistics of the primary variables used for descriptive statistics

Variable	Description	Obs	mean	Std.Dev.	min	max
$CO2$	Kg of carbon per-capita (1950-2002)	2255	563.663	834.6266	0	4470
$PM10$	Concentrations of particulate matters, micrograms per cubic meter (1990-2002)	611	72.10575	48.19759	11.9218	274.45
GDP	Percapita GDP, 1990$	2452	2778.26	2677.37	289.15	16572.83
Dem	Dummy for Democracy (Przeworski)	2234	.3531782	.4780645	0	1
$Ineq$	Household's income inequality (UTIP)	1129	42.00001	6.666231	19.81	62.32
$Year$	Year (from 1950 to 2002)	2491	1976	15.30013	1950	2002
N		2491				

In the Engle-Granger approach, cointegration is tested by verifying that the residual series generated by the regression of one I(1) variable over another I(1) variable is stationary. To verify whether per capita CO2 emissions and per capita GDP are cointegrated, I use the approach suggested by Kao (1999). The global ADF statistic for the Kao residual cointegration test with the null of no cointegration shows a t-stat of 3.499820 with a p-value of 0.0002, so this test strongly suggests that those two series are cointegrated.

Table II: Regime changes (years)

	Przeworski (1950-2002)		
Country	No.	Switch to dem.	Switch to dict.
Albania	1	1992	-
Bangladesh	1	1991	-
Bolivia	3	1979, 1982	1980
Brazil	2	1979	1964
Bulgaria	1	1990	-
Burundi	2	1993	1996
Central Afr. Rep.	1	1993	-
Chile	2	1990	1973
Colombia	1	1958	-
Congo (Brazzaville)	2	1992	1997
Cote d'Ivoire	1	2000	-
Czechoslovakia*	1	1990	-
Ecuador	3	1979	1963, 2000
El Salvador	1	1984	-
Ghana	5	1969, 1979, 1993	1972, 1981
Greece*	2	1974	1967
Guinea-Bissau	1	2000	-
Haiti	1	1994	-
Hungary	1	1990	-
Indonesia	1	1999	-
Kenya	1	1998	-
Korea Rep.*	3	1960, 1988	1961
Laos	1	-	1959
Lesotho	1	1993	-
Madagascar	1	1993	-
Malawi	1	1994	-
Mali	1	1992	-
Mexico	1	2000	-
Moldova	1	1996	-
Nepal	2	1991	2002
Nicaragua	1	1984	-
Niger	3	1993, 2000	1996
Nigeria	4	1979, 1999	1966, 1983
Pakistan	5	1972, 1988	1956, 1977, 1999
Panama	3	1852, 1989	1968
Peru	7	1956, 1963, 1980, 2001	1962, 1968, 1990
Philippines	2	1986	1965
Poland	1	1989	-
Portugal*	1	1976	-
Romania	1	1990	-
Senegal	1	2000	-
Sierra Leone	4	1996, 1998	1967, 1997
South Africa	1	1994	-
Spain*	1	1977	-
Sri Lanka	2	1989	1977
Venezuela	1	1959	-
Zambia	1	1991	-

The Maddala and Wu (1999) combined tests from individual cross-sections (trace and maximum eigenvalue tests) reject the hypothesis of absence of cointegration at 1% level, and, as expected, accept the hypothesis that there exists one cointegrating relation.

So, despite the regression of per capita GDP over per capita CO2 emissions produces "superconsistent" estimates and models like VAR and VECM can be implemented, I prefer to regress those variables in differences because they give qualitatively similar results to the cointegration model (results not shown) and also because the coefficient attached to the dummy variable Dem_{it} (which denotes periods of democracy) can be directly associated to figure 4 (main manuscript) since it represents the "average kink" of the panel, i.e., how the variation of CO2 emissions decreases as a consequence of democracy, given the growth of income.

In equation (13), I regress GDP over CO2 emissions using a panel fixed-effect model, which allows us to control for time-invariant differences among countries. Due to the fact that differenced variables are stationary (results of panel unit root tests on the differenced variables not shown), results of this estimation are consistent.

Environmental issues became important after the 1970s (Zürn, 1998), and considering that the period covered by my dataset for CO2 emissions begins in 1950 and ends in 2002, one may think of a possible structural break. However, environmental problems were raised mainly by developed and rich economies, and considering that the sample I am using is composed mainly of developing and underdeveloped countries, with few exceptions, I think that the structural break problems can be overlooked without affecting the main result of the estimation. Indeed, underdeveloped and developing countries did not participate until recently (often after the end of my observational period) in international agreements for pollution abatement because they claim(ed) a right to grow like the rich and developed countries did in the past without any external imposition. Moreover, they also raised the problem of "environmental justice", according to which the burden of emission reduction should be borne by rich countries because they are responsible for the main global pollution problems like greenhouse gases, and actually, they keep polluting not to satisfy their needs for survival, but their luxurious lifestyles

(United Nations Framework Convention on Climate Change).

This fact is confirmed by the regression over the period 1970-2002 of equation (13). Results indeed do not vary significantly from the original estimation for the whole period, being the effect of democracy still statistically significant and close to -17, and the effect of GDP significant as well and close to 0.10.

I also check whether the inclusion of potentially important variables in the regression (i.e. income inequality) would have affected (or nullified) the effect of democracy. Including in the regression variations in income inequality,[1] not only do the sign of the coefficients attached to democracy and GDP not vary, but variations in income inequality do not appear to be statistically significant, although negative. This is probably due to the fact that inequality takes more time to have an effect on pollution abatement.

Considering the sample I am using - mainly composed of underdeveloped and developing countries - data on possibly important variables that may bias the estimates because they are not included in the regression are not always available. Education is, for instance, one of these variables. It is reasonable however to believe that - similar to what happens for income inequality - its effect can be seen more in the long term than in the short, and that the inclusion of such a variable would produce a coefficient that is statistically not significant once introduced in difference in equation (13).

Moreover, I check whether the results are robust with respect to different subsets of countries. I find that results are less stable for countries that experience more than one regime switch. Bolivia, Brazil, Chile, Burundi, Congo, Ecuador, Ghana, Greece, South Korea, Laos, Nepal, Niger, Nigeria, Pakistan, Panama, Peru, Philippines, Sierra Leone and Sri Lanka are the countries which, during the period 1950 through 2002, had at least two regime changes, with Peru having 7 regime switches, Pakistan and Ghana 5, Sierra Leone and Nigeria 4, etc. High political instability is then a cause for the implementation of less stringent environmental policies. Results of the estimate for those "highly unstable" countries show indeed that emissions depend exclusively on production

[1] Data for inequality are from the EHII dataset of the University of Texas Inequality Project (UTIP), available at http://utip.gov.utexas.edu/data.html

because the coefficient attached to democracy becomes statistically not significant.

Table III: Panel Unit Root Test Summary

Exogenous variables: individual effect and individual trend **Lags included: 1**				
Series : CO2				
Method	Stat.	Prob**	Cross Section	Obs
Null: Common unit root process				
Levin, Lin & Chu	1.58923	0.9440	46	2164
Null: Individual unit root process				
Im, Pesaran and Shin W-Stat	3.77347	0.9999	46	2164
ADF-Fisher Chi-Square	55.8579	0.9989	46	2164
PP-Fisher Chi-Square	106.053	0.1501	46	2210
Series : GDP				
Method	Stat.	Prob**	Cross Section	Obs
Null: Common unit root process				
Levin, Lin & Chu	-0.20043	0.4206	47	2357
Null: Individual unit root process				
Im, Pesaran and Shin W-Stat	3.46602	0.9997	47	2357
ADF-Fisher Chi-Square	66.3949	0.9862	47	2357
PP-Fisher Chi-Square	58.8221	0.9983	47	2404
***Probabilities for Fisher tests are computed using an asymptotic Chi-Square distribution. All other tests assume asymptotic normality*				

References

Kao, C. (1999), 'Spurious regression and residual-based tests for cointegration in panel data', *Journal of Econometrics* **90**(1): 1-44.

Maddala, G.S. and S. Wu (1999), 'A comparative study of unit root test with panel data and a new simple test', *Oxford Bulletin of Economics and Statistics* **61**(Supplement 1): 631-652.

Zürn, M. (1998), 'The rise of international environmental politics: a review of current research', *World Politics* **50**(4): 617-649.