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Long-run Determinants of Pollution: A Robustness Analysis

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Outline

- Introduction and Motivation
- Variables
- Methodology
- Results
- Conclusion

Introduction and Motivation

- Enormous range of variables proposed to affect pollution
- Shift of attention from mainly economic to political and demographic variables

Introduction and Motivation

- Problem: Model uncertainty
- Extreme Bounds Analysis (Leamer, 1983)
- Gassebner et al. (2006) Panel Study employing Extreme Bounds Analysis (EBA), 23 Variables, 3 pollution proxies and up to 208 countries, 1960-2001
- New approach: Bayesian averaging of classical estimates (BACE) Sala-i-Martin et al. (2004)

Introduction and Motivation

Set-up : Cross Section Study

- 3 pollution proxies (water and air pollution)
- 38 explanatory variables
- Up to 135 Countries
- Long-term averages (1980-2000)
- Bayesian Averaging of Classical Estimates (BACE),
Sala-i-Martin et al. (2004)

Variables and Hypothesis

- Economic Determinants
 - Environmental Kuznets Curve (Grossman and Krueger, 1995)
 - Effects of trade and globalization (Antweiler et al., 2001)
 - Technology, Economic structure (Neumeier, 2003)
- Political variables
 - Democracy (Congleton, 1992)
 - Political System (Bernauer and Koubi, 2004)
- Demographic variables
 - Education (Torras and Boyce, 1998)
 - Urbanization (Cole et al., 2004)

Variables

Variable	Sign	Description	Source
LCO ₂ PC		Log of CO ₂ Emissions in metric tons per capita	WDI (2003)
LBODPC		Log of BOD in gramms per day per capita	WDI (2003)
LSO ₂ PC		Log of SO ₂ Emissions in metric tons per capita	Stern (2005)
ABSLATIT	+	Absolute latitude	Barro (1999)
AREA	?	Land Area	WDI (2003)
CORRUPT	+	Corruption in government	Knack et al. (1999)
CRISIS	-	Any rapidly developing situation that threatens to bring the downfall of the present regime, excluding situations of revolt aimed at such overthrow	Banks (2005)
DICT	?	Dummy variable for dictatorship (executive index of electoral competitiveness < 3)	Beck et al. (1999)
DURABLE	?	Time the political system is in power	
ECFREE	-	Fraser Economic Freedom Index	Gwartney et al. (2003)
ENERGYGDP	+	Commercial energy use times 1,000,000 (kt of oil equivalent)/GDP	WDI (2003)
EUROPE	?	Dummy variable European Country	
EXECL	?	Dummy variable for the party of the chief executive being left-wing	Beck et al. (1999)
FDINET	?	Net inflows of foreign direct investment (% of GDP)	WDI (2003)
FRAC	?	The probability that two deputies picked at random from the legislature will be of different parties	Beck et al.(2001)
GDPGR	?	GDP growth rate	WDI (2003)
GLOBAL	?	KOF Index of Globalization	Dreher (2006)
GOVSTAB	?	An assessment of the governments ability to carry out its declared programs and its ability to stay in office	ICRG
INDSHEMP	+	Employment in industry (% of total employment)	WDI (2003)
INDSHGDP	+	Manufacturing value added (% of GDP)	WDI (2003)
INEQUAL	+	Industrial pay-inequality measure	UTIP (2001)
LANDLOCKED	?	Dummy variable Landlocked Country	
LFERT	+	Log of fertilizer use in 100g per ha of arable land	WDI (2003)
LGDPPC	?	Log of real GDP per capita (in constant 1995 US \$)	WDI (2003)
LGDPPC ²	?	Squared log of real GDP per capita	WDI (2003)
LPOPDENS	+	Log of population per hectare	WDI (2003)
OIL	?	Dummy variable Oil producing country	
OILENERGY	+	Electricity production from oil sources (% of total)	WDI (2003)
POLFREE	-	Equally weighted sum of the Freedom House Indices	FHI (1999)
POPGR	-	Population Growth	WDI (2003)
PRIMEDU	-	Gross primary school enrollment (in %)	WDI (2003)
PRTYIN	?	Number of years that the party of the chief executive has been in office	Beck et al.(2001)
REGICHANGE	?	Dummy variable, 1 if the variable "durable" is 0 in the polity IV dataset, which means that a new regime has started or that the state is in anarchy, 0 otherwise	Jagger and Gurr
SOCIALIST	+	Dummy for countries under Socialist rule for considerable time	Gallup et al. (2001).
TRADE	?	Trade intensity ((import + export)/GDP)	WDI (2003)
URBREL	?	Urban population (% of total)	WDI (2003)
YRSOFFC	+	Number of years chief executive in office	Beck et al. (1999)

Political Variables

Corruption, Crisis, Dictatorship, Political Freedom, Government stability, Years in Office, Party in Power, Fractionalization of the Government, Left wing executive, Regime Change

Methodology

- Bayes' rule describes a probability update due to additional information
- Conditional on the estimation results based on the data, ex-ante beliefs about the true model or the significance of a variable are updated
- If the variable is supported by the data

$$P(\beta_i \neq 0|y) > P(\beta_i \neq 0)$$

Methodology

- Prior Inclusion Probability

$$P(\beta_i \neq 0) = \frac{\bar{k}}{K}$$

- Prior Model Probability

$$P(M_j) = \left(\frac{\bar{k}}{K}\right)^{k_j} \left(1 - \frac{\bar{k}}{K}\right)^{K-k_j},$$

Methodology

- Posterior Inclusion Probability

$$P(\beta_i \neq 0|y) = \sum_{j=1}^{2^K} P(M_j|y)$$

$$P(M_j|y) = \frac{P(M_j) T^{k_j/2} SSE_j^{-T/2}}{\sum_{i=1}^{2^K} P(M_i) T^{k_i/2} SSE_i^{-T/2}}$$

- Update inclusion probabilities due to contribution to the goodness of fit

Methodology

- Posterior mean conditional on inclusion

$$E(\beta_i|y) = \sum_{j=1}^{2^K} P(M_j|y)\hat{\beta}_i$$

- Posterior variance conditional on inclusion

$$\text{Var}(\beta_i|y) = E[\text{Var}(\beta_i|y, M_j)|y] + \text{Var}[E(\beta_i|y, M_j)|y].$$

Results CO₂

Name	Posterior Inclusion Probability	Posterior Conditional Inclusion	Mean on Inclusion	Posterior Conditional on Inclusion	st. Err. on inclusion	sign certainty probability	fraction of regression significant	Impact Rank
LGPPC	1.00	5.0160	1.046	1.00	0.94	1		
LGPPCSQ	1.00	-0.5612	0.140	1.00	0.86	4		
ENERGYGDP	1.00	0.7125	0.135	1.00	0.96	3		
LANDAREA	0.61	0.0000	0.000	0.99	0.79	38		
ILLIRT	0.59	0.0049	0.002	0.99	0.66	26		
MINING	0.42	1.2920	0.557	0.99	0.51	2		
YRSOFFC	0.35	0.0141	0.006	0.98	0.17	24		
DICT	0.35	-0.3496	0.145	0.98	0.19	6		
LPOPDENS	0.26	0.0835	0.041	0.97	0.25	14		
GOVSTAB	0.25	0.0619	0.031	0.97	0.42	15		
INEQUAL	0.17	0.0129	0.008	0.95	0.15	23		
FRAC	0.16	0.2626	0.167	0.94	0.11	7		
CRISIS	0.15	0.1571	0.095	0.94	0.01	9		
DURABLE	0.13	0.0014	0.001	0.91	0.29	33		
EUROPE	0.09	-0.0859	0.071	0.88	0.06	10		
SOCIALIST	0.09	0.1731	0.161	0.85	0.25	8		
OILENERGY	0.09	0.0013	0.001	0.88	0.07	32		
CORRUPT	0.09	-0.0304	0.033	0.82	0.11	17		
FDINET	0.08	0.0170	0.016	0.85	0.04	22		
GLOBAL	0.07	0.0637	0.057	0.86	0.16	13		
PRIMEDU	0.06	-0.0016	0.002	0.76	0.02	29		
SYSTEM	0.06	-0.0145	0.026	0.71	0.01	20		
INDSHGDP	0.06	-0.0041	0.006	0.77	0.03	25		
LANDLOCK	0.05	0.0623	0.086	0.77	0.00	12		
GDPGR	0.05	0.0010	0.005	0.59	0.01	27		
ECFREE	0.05	0.0158	0.047	0.64	0.10	19		
POLRIGHT	0.05	0.0134	0.026	0.69	0.13	21		
ABSLATIT	0.05	-0.0003	0.002	0.57	0.08	35		
LFERT	0.05	0.0152	0.054	0.62	0.06	18		
COAST	0.04	0.0001	0.001	0.55	0.02	37		
TRADE	0.04	0.0002	0.001	0.67	0.02	36		
OIL	0.04	0.0572	0.107	0.71	0.05	11		
PRTYIN	0.04	-0.0010	0.002	0.65	0.06	31		
REGICHAN	0.04	-0.1594	0.359	0.67	0.00	5		
EXECL	0.04	-0.0167	0.073	0.59	0.00	16		
DEMOC	0.04	0.0006	0.009	0.54	0.01	28		
INDSHEMP	0.04	-0.0008	0.005	0.56	0.14	30		
URBREL	0.04	0.0005	0.002	0.60	0.15	34		

Results SO₂

Name	Posterior Inclusion Probability	Posterior Conditional Inclusion	Mean on Inclusion	Posterior Conditional on Inclusion	st. Err. on inclusion	sign certainty probability	fraction of regression significant	Impact Rank
LGDPCC	0.97	6.313	1.435	1.00	0.99	1	1	
LGDPCCSQ	0.97	-0.776	0.189	1.00	0.97	5	5	
ENERGYGDP	0.92	0.747	0.224	1.00	0.95	4	4	
ABSLATIT	0.66	0.011	0.004	0.99	0.88	28	28	
LANDAREA	0.44	0.000	0.000	0.99	0.57	38	38	
MINING	0.36	2.310	1.061	0.98	0.59	2	2	
POLRIGHT	0.30	0.099	0.054	0.98	0.41	17	17	
INEQUAL	0.25	0.024	0.013	0.96	0.23	23	23	
REGICHAN	0.17	1.448	0.809	0.96	0.11	3	3	
GDPGR	0.15	-0.014	0.008	0.95	0.22	25	25	
PRTYIN	0.14	-0.012	0.007	0.94	0.11	26	26	
TRADE	0.14	0.002	0.001	0.90	0.11	36	36	
URBREL	0.13	0.007	0.004	0.95	0.25	30	30	
PRIMEDU	0.12	-0.006	0.004	0.93	0.11	31	31	
EXECL	0.08	0.203	0.184	0.85	0.01	8	8	
FDINET	0.08	0.042	0.043	0.82	0.07	20	20	
ILLIRT	0.08	0.004	0.005	0.79	0.09	32	32	
SOCIALIST	0.07	0.289	0.312	0.82	0.21	6	6	
LFERT	0.07	-0.107	0.107	0.84	0.02	13	13	
ECFREE	0.06	0.069	0.098	0.77	0.04	15	15	
FRAC	0.06	0.205	0.417	0.72	0.07	7	7	
INDSHGDP	0.06	-0.007	0.010	0.78	0.04	27	27	
COAST	0.06	-0.002	0.002	0.84	0.04	35	35	
EUROPE	0.05	0.069	0.199	0.62	0.05	12	12	
DICT	0.05	0.116	0.225	0.71	0.01	9	9	
DURABLE	0.05	0.000	0.002	0.53	0.01	37	37	
LPOPDENS	0.05	-0.063	0.079	0.79	0.00	18	18	
OILENERGY	0.05	0.002	0.002	0.79	0.01	34	34	
YRSOFFC	0.05	0.004	0.009	0.68	0.00	29	29	
DEMOC	0.05	0.009	0.016	0.71	0.00	24	24	
INDSHEMP	0.04	0.002	0.011	0.53	0.13	33	33	
OIL	0.04	-0.096	0.231	0.66	0.01	10	10	
SYSTEM	0.04	0.040	0.053	0.77	0.02	19	19	
GOVSTAB	0.04	-0.010	0.070	0.59	0.02	22	22	
GLOBAL	0.04	0.049	0.111	0.68	0.07	16	16	
CORRUPT	0.04	0.015	0.070	0.58	0.06	21	21	
LANDLOCK	0.03	0.047	0.170	0.61	0.00	14	14	
CRISES	0.03	-0.085	0.184	0.68	0.00	11	11	

Results BOD

Name	Posterior Inclusion Probability	Posterior Mean Conditional on Inclusion	Posterior st. Err. Conditional on inclusion	sign certainty probability	fraction of regression significant	Impact Rank
INEQUAL	0.94	-0.020	0.007	1.00	0.99	22
LGDP	0.68	0.884	0.549	0.95	0.23	1
LGDP	0.68	-0.076	0.080	0.83	0.05	13
LFERT	0.66	0.135	0.053	0.99	0.83	11
OILENERGY	0.61	-0.003	0.001	1.00	0.91	31
GLOBAL	0.43	-0.153	0.069	0.98	0.44	9
ECFREE	0.38	0.109	0.057	0.98	0.29	12
SYSTEM	0.34	0.052	0.028	0.98	0.38	20
INDSHEMP	0.34	0.011	0.004	0.98	0.19	24
CRISES	0.33	-0.193	0.095	0.98	0.20	6
ABSLATIT	0.32	0.005	0.002	0.97	0.24	28
FRAC	0.29	-0.360	0.175	0.98	0.27	4
Polright	0.29	-0.081	0.039	0.97	0.13	18
MINING	0.18	0.893	0.517	0.94	0.04	2
DICT	0.17	0.140	0.101	0.92	0.07	8
ENERGYGDP	0.17	0.167	0.103	0.95	0.27	7
GDPGR	0.16	0.000	0.004	0.51	0.01	37
TRADE	0.12	0.001	0.001	0.88	0.16	36
PRTYIN	0.12	-0.004	0.002	0.96	0.16	29
COAST	0.11	0.002	0.001	0.95	0.19	33
ILLIRT	0.11	-0.003	0.002	0.89	0.11	30
DURABLE	0.09	0.001	0.001	0.91	0.10	35
EXECL	0.09	-0.086	0.067	0.89	0.03	14
YRSOFFC	0.09	0.006	0.005	0.88	0.08	27
CORRUPT	0.08	0.071	0.056	0.89	0.30	16
LPOPDENS	0.07	-0.065	0.068	0.81	0.03	15
INDSHGDP	0.07	-0.007	0.007	0.83	0.09	23
SOCIALIST	0.05	0.121	0.172	0.76	0.17	5
DEMOC	0.05	-0.004	0.009	0.68	0.01	25
OIL	0.05	0.093	0.097	0.83	0.00	10
FDINET	0.05	-0.001	0.021	0.51	0.04	26
URBREL	0.04	0.001	0.002	0.63	0.13	34
REGICHAN	0.04	0.167	0.433	0.63	0.01	3
GOVSTAB	0.04	-0.017	0.032	0.71	0.08	21
EUROPE	0.04	-0.023	0.109	0.57	0.08	19
PRIMEDU	0.03	0.001	0.002	0.63	0.06	32
LANDAREA	0.03	0.000	0.000	0.51	0.01	38
LANDLOCK	0.03	-0.035	0.094	0.64	0.00	17

Robustness Check

- Expanded sample (Sample Bias): 135 countries, 1980-2000
- Extreme Bounds Analysis (Sensitivity Analysis Bias)
- Robust Final model estimations (Estimation Technique Bias): Least Trimmed Squares, Reweighted Least Squares

Conclusion

- For Air Pollution:
 - Confirm the Environment Kuznets Curve
 - Highlight importance of energy-efficient manufacturing technologies
- For Water Pollution:
 - Ambiguous results.
- Overall air pollution variables are dominated by production related variables.



Thank You!