Environmental Policy Stringency, Policy interaction and Greenhouse gas emissions : an approach by sector

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Motivation

- Growing importance and number of climate policies.
- Need for robust measures of **Environmental Policy Stringency** (EPS).

➤ An elevated, explicit or implicit cost associated with polluting or environmentally deleterious behaviors (Botta et al. 2014).

Effect of EPS on Carbon emissions

literature Review

Results of the literature:

- Stringency of environmental policies associated with a reduction in CO2 emissions (Angelis et al. 2019).
- Inverted U-shaped relationship between policy stringency and emissions (Wolde-Rufael et al. 2021).
- The impact varies with initial pollution levels (Albulescu et al. 2022).

➤ Results based on the EPS indicator from the OECD.

Literature Gaps - Uncovering hidden assumptions

- Using the EPS for inter- and intra-contry econometric analysis implies 2 assumptions

1. Efficiency Assumption: EPS indicator effectively reveals the efficiency of a policy mix in emission reduction,
2. Proxy Assumption: EPS is a good proxy, allowing for comparison between countries and years.

Research Questions

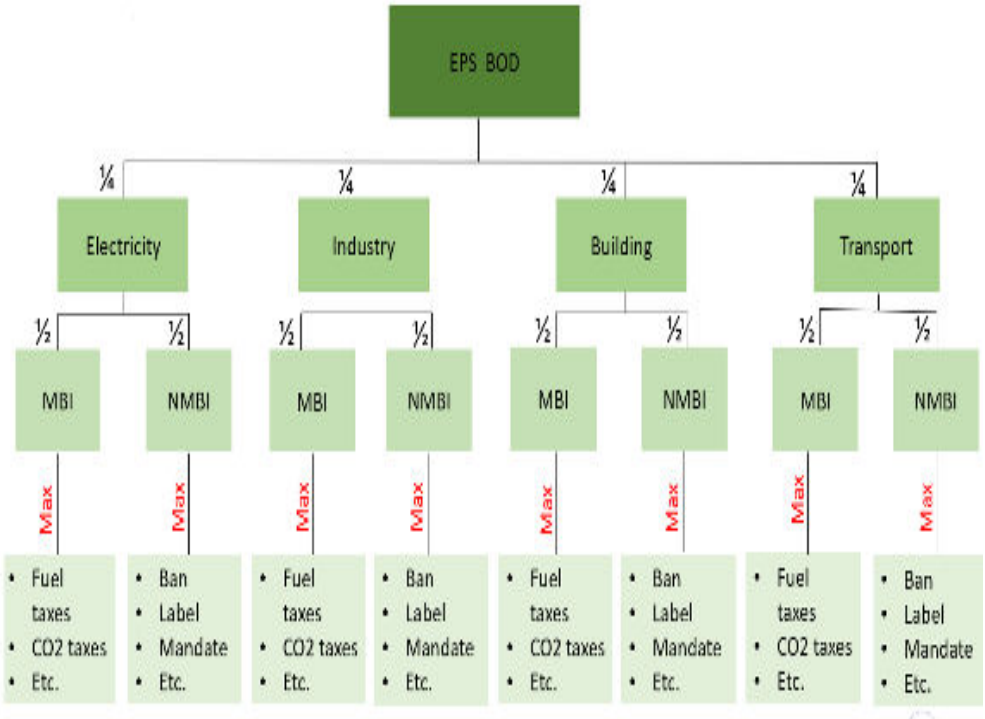
1. **How to capture environmental policy stringency (EPS) of policy mixes?**
   Construction of 4 EPS to compare the effect of measurement choices.

2. **How EPS affects greenhouse gas (GHG) reduction?**
   2-way fixed effects OLS on panel data, with Instrumental Variable.

Methodology

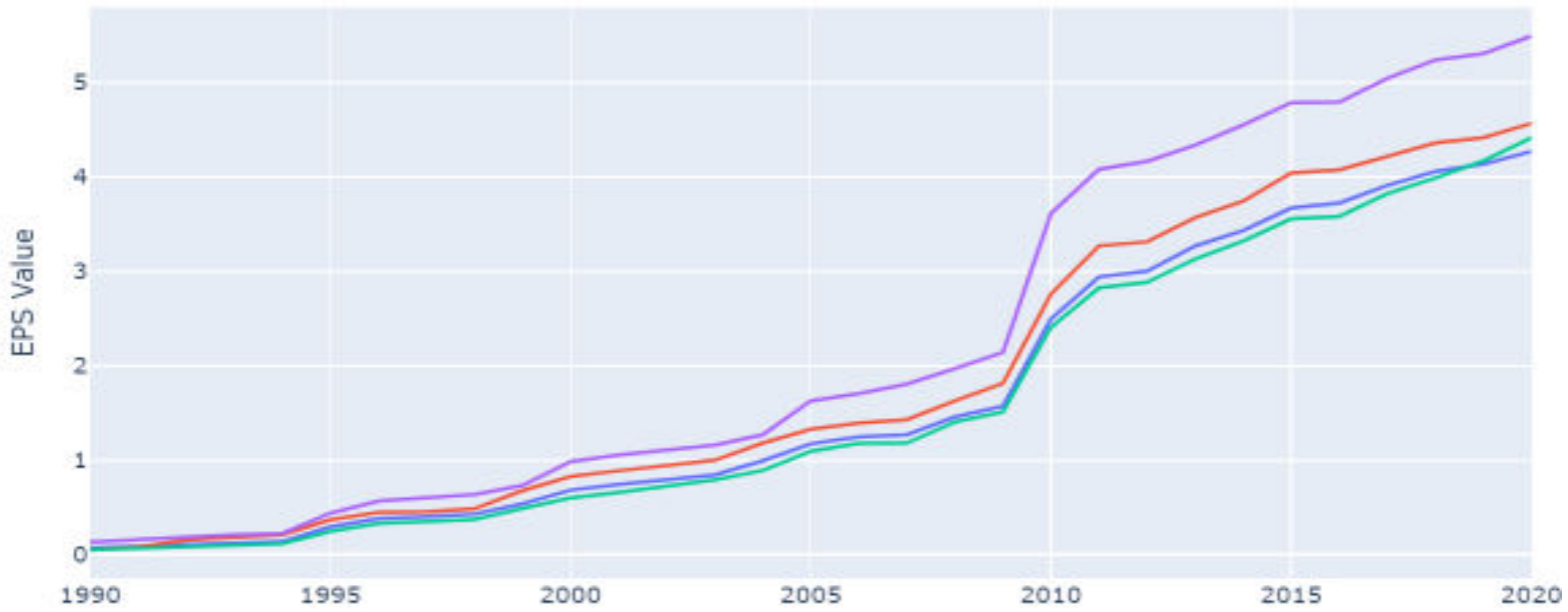
Step 1: Construction of 4 EPS with a sectoral decomposition

- EPS_OECD:
  Equal sectoral weights
- EPS_GHG:
  Weighted by GHG share,
- EPS_GDP:
  Weighted by GDP share,
- EPS_BOD:
  Benefits of the Doubt.



Graph EPS

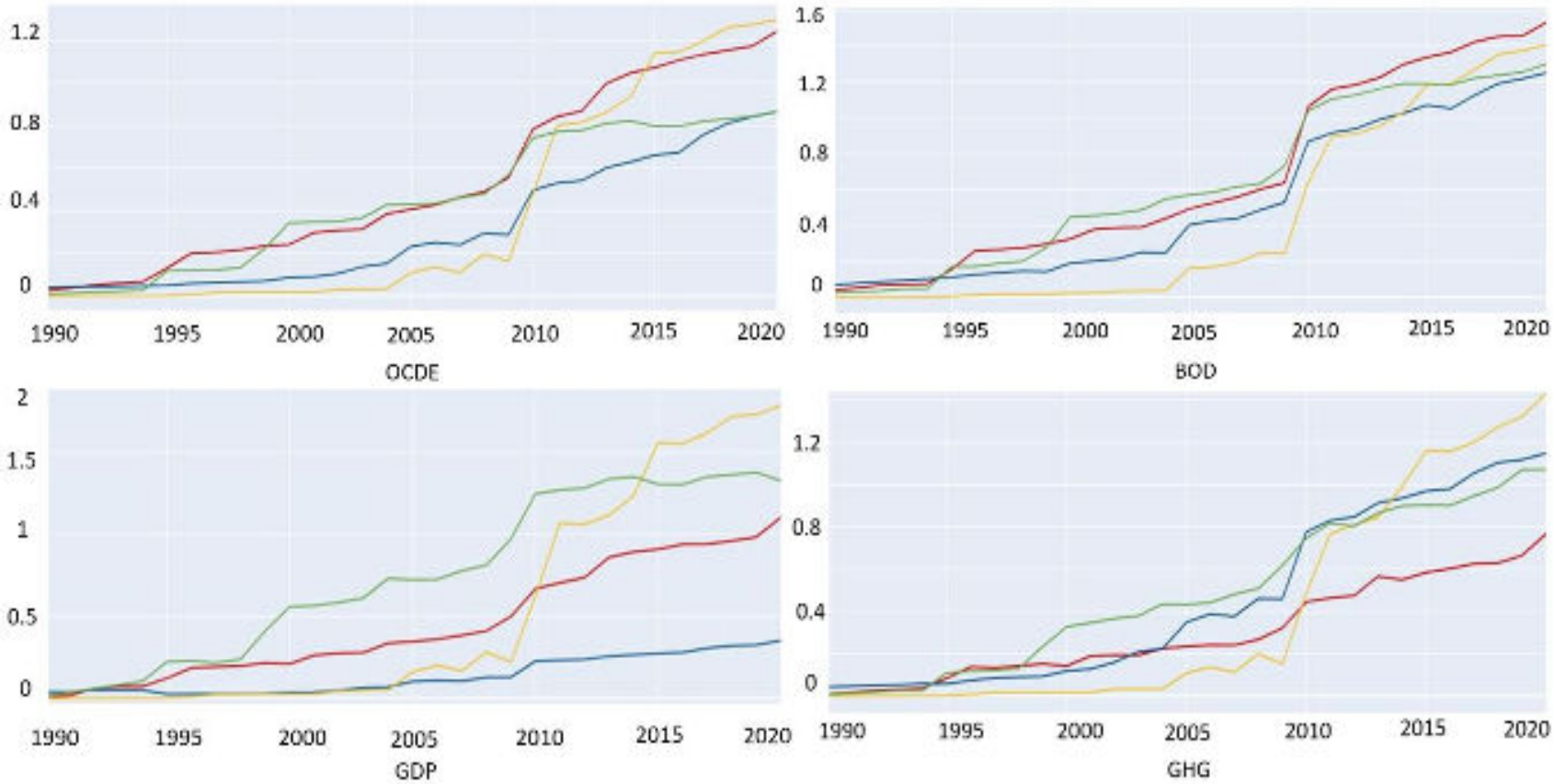
Graphical Comparison of total EPS Indicators



- All indicators show similar upward trends and variations.
- EPS_BOD has higher total values due to score maximization.

EPS_GDP; EPS_OECD; EPS_BOD; EPS_GHG.

Sectoral EPS graphical comparison



Building; *Electricity*;
Industry; *Transport*.

Methodology

Step 2: Two-way fixed effects regressions on GHG with panel data

$$\ln(GHG_{it}) = \beta_0 + \beta_1 X_{it} + \beta_2 Y_{it} + \alpha_i + \gamma_t + \varepsilon_{it}$$

X_{it}: Control variables; Y_{it}: Explanatory variables EPS; α_i, γ_t: Entity and time fixed effects.

- Tests for heteroskedasticity and autocorrelation confirm panel data
- Tests for endogeneity, heteroskedasticity and autocorrelation confirm 2-way fixed effect with Driscoll-Kraay covariance estimator
- Robustness checks: per capita, GHG per GDP.

Methodology

1st Stage 2nd Stage

Step 3: Instrumental Variable using Shift-Share instrument

$$\text{Bartik\_instrument}_{it} = S_i \times Z_t$$

S_i: 1990 GDP share-agriculture and forestry; Z_t: EPS leave-one-out global mean.

First Stage

$$\text{EPS}_{it} = \beta_0 + \beta_1 X_{it} + \beta_B \text{Bartik\_instrument}_{it} + \alpha_i + \gamma_t + u_{it}$$

Tests:

- F-stat and Robust F-stat > 30
- Shock-level decomposition (Borusyak et al. 2022),
- Other causality test: 3-years lagged EPS

Efficiency Assumption: a negative effect of total EPS on GHG

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable		ln_GHG		
Cov. Est		Driscoll-Kraay		
No. Observations		1151		
R-Squared (Within)	0.2311	-0.2266	0.1120	0.3262
R-Squared (Overall)	0.9086	0.8911	0.9046	0.9163
F-statistic	269.98	248.68	263.33	286.89
const	-5.5240***	-6.0375***	-5.7169***	-5.0783***
	(-3.8329)	(-4.8300)	(-3.9693)	(-3.5437)
ln_GDP	0.5299***	0.5608***	0.5277***	0.5350***
	(7.1624)	(7.7185)	(7.1380)	(7.4139)
ln_POP	0.6557***	0.6609***	0.6681***	0.6254***
	(5.6273)	(6.0988)	(5.6314)	(5.0923)
urban_growth	-0.0586***	-0.0592***	-0.0588***	-0.0593***
	(-4.0409)	(-4.1412)	(-3.9763)	(-4.0993)
EPS	-0.0524***	-0.0232**	-0.0457***	-0.0580***
	(-7.0954)	(-2.7124)	(-5.1283)	(-9.1030)
signif. code	0.001 '***'	0.01 '**'	0.05 '*'	0.1 '.'

- Positive effects of GDP and POP, negative of EPS,
- Similar impact and significance for OECD, GHG, and GDP,
- Adjusted impact of scale effect for BOD, less significant

➤ Robust with IV, lag, balanced dataset, and control variables

Efficiency assumption: Strong significance of sectoral interactions

▸ Without Building

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable		ln_GHG - 1119 obs		
Cov. Est		Driscoll-Kraay		
R-Squared (Within)	0.2383	-0.2289	0.2307	0.3670
R-Squared (Overall)	0.9272	0.9021	0.9284	0.9336
F-statistic	168.51	154.49	191.39	178.34
EPS_building	0.0076	0.0895**	-0.1199***	-0.1050***
Aver. effect	-0.0233	0.0281	-0.0504	-0.0579
EPS_elec	0.1654**	0.0679*	0.1056***	0.3964***
Aver. effect	0.0604	0.0530	0.0542	0.0571
EPS_indus	-0.1056***	-0.1084***	0.0056	-0.0550***
Aver. effect	-0.0357	-0.0427	0.0078	-0.0339
transport_elec	-0.1953***	-0.0678***	-0.1547***	-0.2715***
Aver. effect	-0.0585	-0.0541	-0.0613	-0.0437

- General-to-specific framework,
- Interaction term significant and negative.

Efficiency Assumption: An ambiguous effect of Electricity coverage

	EPS_OECD	**EPS_BOD**	**EPS_GHG**	**EPS_GDP**
Dep. Variable		ln_elec_GHG - 1122 obs.		
Cov. Est		Driscoll-Kraay		
R-Squared (Within)	0.0982	0.1385	0.2436	0.2283
R-Squared (Overall)	0.7070	-0.0122	0.7379	0.7764
F-statistic	38.23	22.85	58.29	45.71
F-statistic (robust)	134.22	11.73	246.57	137.63
EPS_building	0.135	0.190	-0.240***	-0.181***
	(1.28)	(1.79)	(-7.35)	(-7.34)
EPS_elec	0.019	0.109*	0.086	0.306**
	(0.26)	(2.32)	(1.54)	(2.61)
EPS_indus	-0.183***	-0.186***	0.020	-0.048
	(-3.58)	(-4.00)	(0.61)	(-1.51)
EPS_transport	-0.127**	-0.266***	-0.280***	-0.107**
	(-3.09)	(-5.30)	(-3.87)	(-2.86)

- Negative contributions from transport and industry sectors,
- Insignificant and positive effect of electricity sector (robust without elec, except for EU).

➤ overlap in Energy policies?

Proxy Assumption: Precision or overlap?

▸ Lagged Variables ▸ Per Capita ▸ GHG per GDP

Sectoral EPS Effects on GHG Emissions

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable		ln_GHG - 1119 obs.		
Cov. Est		Driscoll-Kraay		
R-Squared (Within)	0.2495	-0.2068	0.3139	0.3976
R-Squared (Overall)	0.9184	0.8963	0.9207	0.9299
F-statistic	152.01	148.56	169.35	163.95
EPS_building	0.0194	0.0837*	-0.1162***	-0.0920***
	(0.6659)	(2.4063)	(-9.1258)	(-7.9116)
EPS_elec	-0.0131	-0.0059	-0.0080	0.0594
	(-0.4343)	(-0.2721)	(-0.4620)	(1.5931)
EPS_indus	-0.1174***	-0.1173***	0.0014	-0.0568***
	(-5.2138)	(-7.3459)	(0.0977)	(-6.9474)
EPS_transport	-0.0844***	-0.0428*	-0.1434***	-0.0706***
	(-3.6592)	(-2.1264)	(-8.0934)	(-4.7269)

- EPS_GDP and EPS_GHG better adjusted
- Confirmation with multicollinearity test (VIF)

Proxy Assumption: An unstable indicator

The Borusyak et al. 2022 Shock-Level Decomposition

	OECD	BOD	GHG	GDP
	Period 1 (1991-2000) - 293 obs			
F-statistic	36.45	36.28	36.61	36.68
Robust F-statistic	230.14	250.19	292.50	299.40
predicted_EPS	0.170**	0.107*	0.152**	0.129**
	(2.71)	(2.58)	(3.17)	(3.22)
	Period 2 (2001-2010) - 416 obs			
F-statistic	68.40	68.44	68.42	68.40
Robust F-statistic	129.88	114.67	128.48	126.11
predicted_EPS	-0.109*	-0.050*	-0.125*	-0.144*
	(-2.46)	(-2.25)	(-2.49)	(-2.46)
	Period 3 (2011-2020) - 429 obs			
F-statistic	17.02	17.28	17.17	17.21
Robust F-statistic	89.11	98.51	95.94	90.37
predicted_EPS	-0.449***	25.49***	-0.514***	-0.341***
	(-7.01)	(7.94)	(-7.46)	(-7.14)
	Placebo - 1138 obs			
F-statistic	210.79	210.81	210.80	210.80
Robust F-statistic	146.79	143.76	147.59	145.90
Placebo	-0.113	-0.096	-0.356	-0.073
	(-0.62)	(-0.67)	(-0.63)	(-0.63)

Conclusion

Contribution

- Construction of new EPS to include country-specific features, policy interaction and diffuse emissions policies,
- Confirmation of the Efficiency Assumption,
- On the Proxy Assumption: EPS_GDP is the best indicator, but using a panel of indicators allow for useful comparisons.

Limits:

- Limited database with insufficient representation of countries outside EU,
- Each EPS exhibits a lack of temporal stability.

Discussion

Thank You
for your attention.

Happy to answer your questions!

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Literature Review

▸ EPS effect ▸ Literature gap

Study	Method	Findings
Ahmed et al. 2018	Time series	EPS reduces emissions in China
Angelis et al. 2019	FE PanelOLS	EPS reduces CO2.
Albulescu et al. 2020	FE PanelOLS, GMM estimator	Role of regulation not significant.
Alexandersson 2020	FE PanelOLS	No significant impact of EPS
Wolde-Rufael et al. 2020	PMG-ARDL, Cointegration	Inverted u-shaped between EPS and CO2 : impact takes time.
Sezgin et al. 2021	Cointegration	Bilateral causality, EPS decreases CO2.
Demiral et al. 2021	PooledOLS, FE, RE PanelOLS	Higher EPS increases emissions.
Albulescu et al. 2022	FE PanelOLS in quantile k	Asymetric impact, higher for countries with lower emissions.
Yirong 2022	PMG-ARDL	EPS decrease CO2 in the long run

The OECD EPS

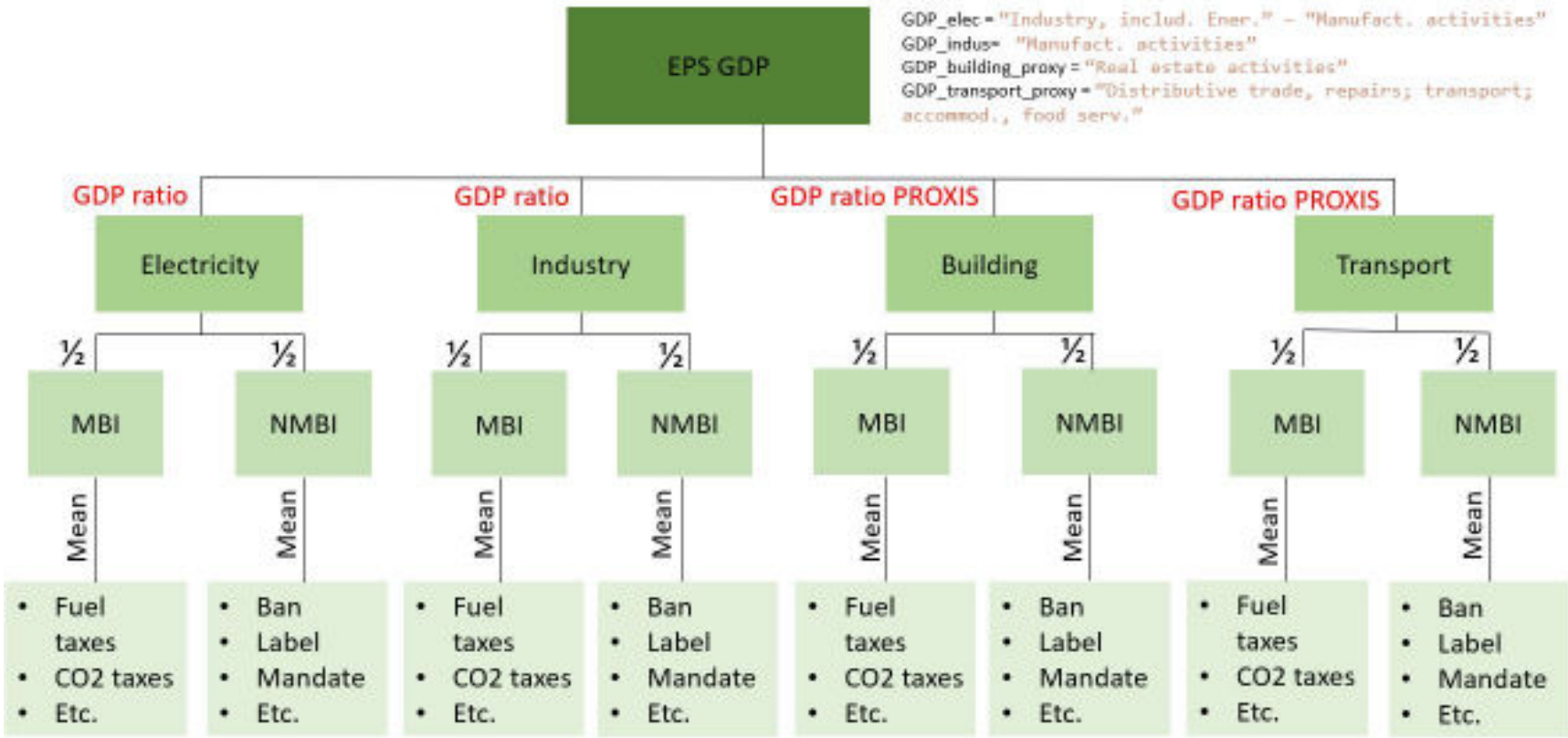
▸ Literature ▸ Methodology

- Existing literature based on the previous OECD EPS:
  - Focuses on energy sector policies,
  - Overlooks policy interactions and diffuse emission sectors,
  - Stops in 2015.

- The new OECD database:
  - Ranges from 0 (no policy) to 10 (highest stringency)
  - Covers the period from 1990 to 2020
  - Includes policies from: Electricity, Industry, Buildings, and Transport

Construction of EPS_OECD, EPS_GHG and EPS_GDP

▸ Methodology



EPS_GDP Structure

Construction of EPS_BOD

Methodology | Calibration

For a country c, a sector s, and a type t), where $y_{c,s,t,i}$ is the i-th policy, with the set of weights$w_{c,s,t} = \{w_{c,s,t,1}, w_{c,s,t,m}\}$

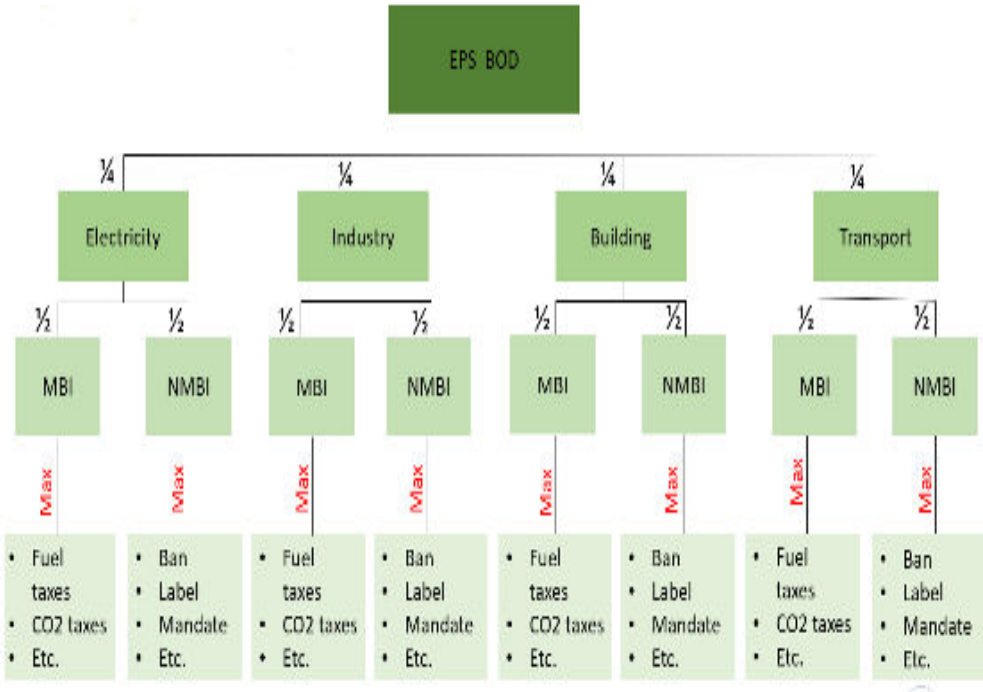
$$\text{EPS\_BOD}_c = \sum_s \sum_t I_{c,s,t}$$

$$I_{c,s,t} = \sum_i w_{c,s,t,i}\, y_{c,s,t,i}$$

$$w_{c,s,t} = \arg\max_{w_{c,s,t}} I_{c,s,t} - \alpha \text{VAR}(I_{c,s,t})$$

s.t.

1. **Positivity constraint:** $w_{c,s,t,i} \geq 0 \quad \forall\, c, s, t, i$
2. **Distribution constraint:** $\sum_i w_{c,s,t,i} \leq 1 \quad \forall\, c, s, t$
3. **Sum-to-one constraint:** $\sum_s \sum_t w_{c,s,t,i} = 1 \quad \forall\, c$



Calibration of the argument alpha

▸ Methodology ▸ EPS_BOD's Construction

	BOD_0var	BOD_10var	BOD_100var
Dep. Variable		ln_GHG - 1308 obs	
R-squared	0.4431	0.4425	0.4697
R-Squared (Within)	0.1271	0.1104	0.3981
Log-likelihood	1157.4	1156.8	1189.4
F-statistic	243.88	243.31	271.44
const	-6.4493***	-6.4926***	-5.5619***
	(-7.9166)	(-7.9744)	(-6.9411)
ln_GDP	0.4135***	0.4143***	0.3803***
	(18.281)	(18.295)	(17.116)
ln_POP	0.7994***	0.8013***	0.7724***
	(15.906)	(15.942)	(15.797)
Urban_growth	-0.0662***	-0.0664***	-0.0650***
	(-11.180)	(-11.213)	(-11.258)
EPS	-0.0150***	-0.0149***	-0.0388***
	(-4.4077)	(-4.2591)	(-9.0438)

An Unbalanced Panel Database

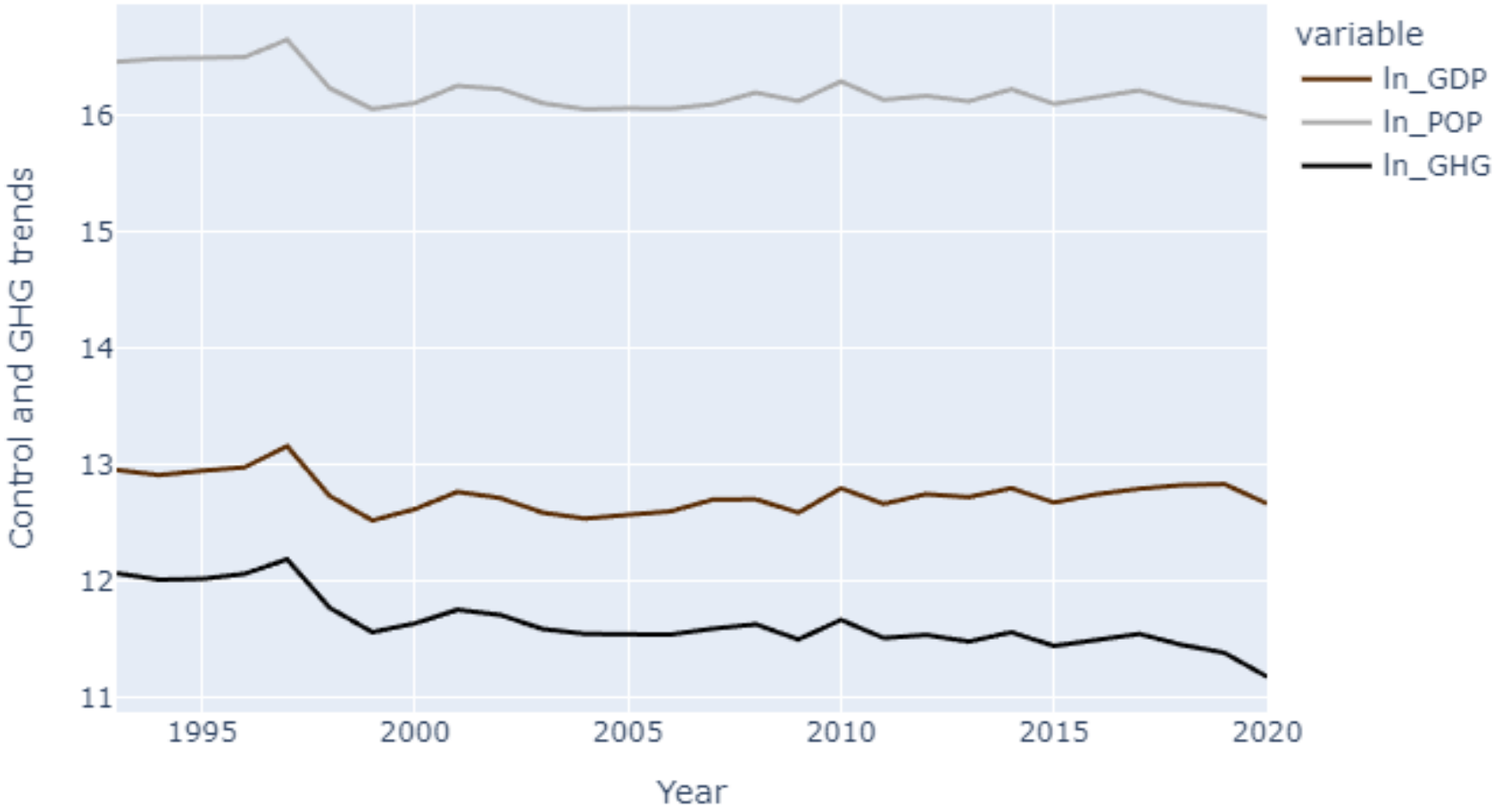
Methodology

Variable	Count	Mean	Std. Dev.	Min	50%	Max
ln_GDP (10^6 USD_{2015})	1119	12.50	1.55	8.80	12.56	15.34
ln_POP (Count)	1119	16.27	1.51	12.50	16.15	21.01
urban_growth (percentage)	1119	0.83	1.02	-3.45	0.78	5.09
ln_GHG (10^3 $CO2_{eq}$)	1119	11.61	1.52	7.52	11.32	14.86
EPS_BOD (0-10 score)	1119	2.69	2.20	0.00	2.07	7.87
EPS_OECD (0-10 score)	1119	2.02	1.70	0.00	1.50	6.23
EPS_GHG (0-10 score)	1119	1.88	1.65	0.00	1.39	6.24
EPS_GDP (0-10 score)	1119	2.08	1.75	0.00	1.51	6.75

- Data from OECD and World Bank, covering 49 countries (1990-2020).
- Unbalanced dataset due to missing data, primarily from 1990-1995.
- Robustness checks with balanced subsets confirm representativeness.

Data Visualization – Control

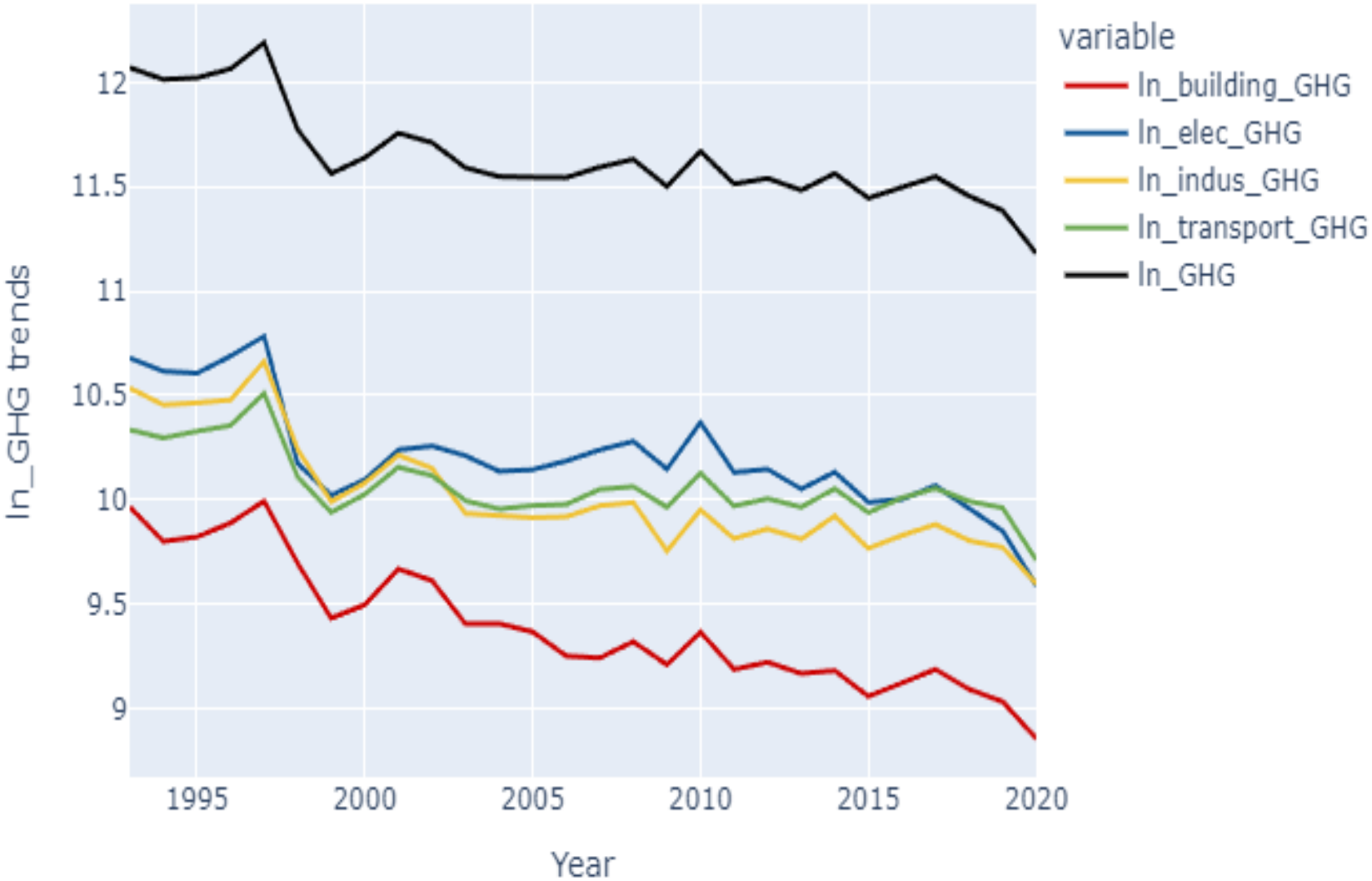
Method



Trends of GHG and control variables

Data Visualization – Carbon trends

▸ Method



Trends of GHG and its sectoral decomposition

Pooled versus random effects versus fixed effects

Methodology

	2-way Fixed Effects	Pooled OLS	Random effects
Dep. Variable		ln_GHG	
No. Observations		1308	
Cov. Est.	Unadjusted	Clustered	Unadjusted
R-squared	0.5028	0.9407	0.7503
R-Squared (Within)	0.5218	0.4112	0.5233
R-Squared (Between)	0.9386	0.9497	0.9457
F-statistic	176.71	2945.8	558.06
P-value (F-stat)	0.0000	0.0000	0.0000
const	-4.4344	-3.0310	-3.4819
	(-5.5211)	(-5.9513)	(-8.0269)
ln_GDP	0.3610	0.4542	0.3587
	(16.624)	(5.7020)	(20.649)
ln_POP	0.7204	0.5682	0.6643
	(14.733)	(7.9463)	(22.295)
urban_growth	-0.0648	-0.1164	-0.0690
	(-11.368)	(-2.4340)	(-12.323)
EPS_OCDE_building	-0.0222	0.0678	-0.0250
	(-1.0128)	(0.4250)	(-1.2290)
EPS_OCDE_elec	-0.0148	-0.2481	-0.0399
	(-0.6308)	(-1.0961)	(-1.7650)
EPS_OCDE_indus	-0.1117	-0.0044	-0.1081
	(-6.3803)	(-0.0417)	(-7.7388)
EPS_OCDE_transport	-0.1306	-0.2140	-0.1120
	(-5.8227)	(-1.3203)	(-6.0033)

- Small autocorrelation: Durbin-Watson 2.40 T-Stat,
- Heteroskedasticity: White test p-value $8.88e^{-12}$, Breush-Pagan test p-value $2.18e^{-2}$

Panel Model Choice

Methodology

	RE	FE Entity	FE Time	FE Entity/Time
Dep. Variable		ln_GHG - 1119 obs.		
Cov. Est.		Driscoll-Kraay		
R-squared	0.7826	0.5045	0.9440	0.5064
R-Squared (Within)	0.5045	0.5045	-0.1279	0.2495
R-Squared (Overall)	0.9412	0.9413	0.9417	0.9176
AIC	-2154.16	-2194.63	890.32	-2354.97
BIC	-2114.00	-2154.47	930.48	-2314.81
	(-4.7229)	(-4.3170)	(-8.1323)	(-3.9653)
EPS_OECD_building	-0.0312	-0.0306	0.1085	0.0194
	(-1.1263)	(-1.1175)	(1.5753)	(0.6659)
EPS_OECD_elec	-0.0503	-0.0498	-0.1300	-0.0131
	(-2.0613)	(-2.1936)	(-1.6067)	(-0.4343)
EPS_OECD_indus	-0.1120	-0.1123	0.0754	-0.1174
	(-5.3138)	(-5.0189)	(0.6368)	(-5.2138)
EPS_OECD_transport	-0.1130	-0.1122	-0.3176	-0.0844
	(-3.7525)	(-3.6392)	(-4.0620)	(-3.6592)

- Hausman test insignificant but intuition of endogeneity confirmed in AIC and BIC,
- Aautocorrelation: Breush-Godfroy test p-value $4.05e^{-6}$,
- Heteroskedasticity: Breush-Pagan test p-value $2.19e^{-11}$

IV 1st Stage Results

Method

	EPS_BOD	EPS_OECD	EPS_GHG	EPS_GDP
Cov. Estimator		Driscoll-Kraay		
No. Observations		1106		
F-statistic	30.177	39.927	37.115	29.887
F-statistic (robust)	87.436	62.541	56.234	46.822
const	37.079***	27.174***	26.078***	31.281***
	(6.9401)	(7.3152)	(7.6228)	(5.9968)
ln_GDP	-0.3170	-0.5117**	-0.8034***	-0.2966
	(-1.5369)	(-3.0781)	(-5.0709)	(-1.2949)
ln_POP	-1.8412***	-1.1333***	-0.8541***	-1.5462***
	(-5.5896)	(-4.5523)	(-3.9970)	(-4.2453)
urban_growth	-0.0596	-0.0375	-0.0315	-0.0583
	(-0.8466)	(-0.7171)	(-0.4998)	(-0.9323)
SS_instrument	-0.0299***	-0.0275***	-0.0241***	-0.0265***
	(-10.767)	(-11.612)	(-7.6537)	(-8.4157)
signif. code	0.001 '***'	0.01 '**'	0.05 '*'	0.1 '.'

IV 2nd Stage Results

Method

	BOD	OECD	GHG	GDP
Dep. Variable		ln_GHG - 1106 obs		
Cov. Estimator		Driscoll-Kraay		
R-Squared (Within)	-1.3480	-1.3621	-1.3651	-1.3597
R-Squared (Overall)	0.8789	0.8777	0.8772	0.8781
F-statistic	212.53	213.49	213.67	213.27
F-statistic (robust)	832.17	1039.7	1072.9	1010.7
const	-3.2245	-3.0725	-2.5423	-2.4821
	(-1.6018)	(-1.5560)	(-1.2195)	(-1.1451)
ln_GDP	0.4608***	0.4189***	0.3580***	0.4479***
	(6.5562)	(5.5598)	(4.1923)	(6.3199)
ln_POP	0.5756***	0.5997***	0.6158***	0.5419***
	(4.8153)	(5.3250)	(5.6291)	(4.3233)
urban_growth	-0.0506***	-0.0500***	-0.0501***	-0.0528***
	(-4.5286)	(-4.5134)	(-4.5120)	(-4.7625)
pred_EPS	-0.0913**	-0.1320***	-0.1587***	-0.1330***
	(-3.2728)	(-3.5654)	(-3.6486)	(-3.4486)
signif. code	0.001 '***'	0.01 '**'	0.05 '*'	0.1 '.'

Sectoral decomposition for European countries

Results

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable		ln_GHG - 717 obs.		
Cov. Est		Driscoll-Kraay		
R-Squared (Within)	0.4076	0.3001	0.2942	0.4897
R-Squared (Overall)	0.3591	0.0092	0.3405	0.2622
F-statistic	13.70	12.03	13.13	17.01
F-statistic (robust)	14.58	22.49	21.36	30.94
EPS_building	-0.025	0.006	-0.038	-0.081**
	(-0.77)	(0.21)	(-1.47)	(-3.12)
EPS_elec	-0.091*	-0.080**	-0.056*	-0.354**
	(-2.52)	(-2.95)	(-2.38)	(-3.09)
EPS_indus	-0.033	-0.022	-0.005	-0.018
	(-1.00)	(-1.16)	(-0.25)	(-1.19)
EPS_transport	-0.028	-0.007	-0.055.	0.001
	(-0.77)	(-0.31)	(-1.92)	(0.05)

- Negative and significant impact of EPS_elec

Causality Test: 3-year lag

Methodology | Sectoral Results

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable		ln_GHG - 988 obs.		
Cov. Est		Driscoll-Kraay		
R-Squared (Within)	0.0583	-0.2899	0.0128	0.2493
R-Squared (Overall)	0.9352	0.9297	0.9406	0.9358
Log-likelihood	1120.6	1119.9	1134.5	1147.5
F-statistic	108.74	108.40	115.56	122.12
EPS_building_lag	0.0101	0.0666*	-0.0993***	-0.0660**
	(0.4515)	(2.2752)	(-9.4029)	(-2.8004)
EPS_elec_lag	0.0037	0.0146	-0.0121	0.0899**
	(0.1225)	(0.6238)	(-0.8881)	(2.5684)
EPS_indus_lag	-0.0953**	-0.1165**	0.0240	-0.0502***
	(-2.0410)	(-3.1296)	(1.1380)	(-3.2705)
EPS_transport_lag	-0.1005***	-0.0563*	-0.1231***	-0.0850***
	(-3.9083)	(-2.2346)	(-8.1391)	(-5.0178)

Per Capita

▸ Methodology ▸ Sectoral Results

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable	ln_GHG_per_capita - 1118 obs.			
Cov. Est	Driscoll-Kraay			
R-Squared (Within)	0.3872	0.0869	0.4266	0.4585
R-Squared (Overall)	0.4207	0.4011	0.4790	0.4259
F-statistic	93.324	89.176	104.89	103.13
const	-2.6855***	-2.7353***	-2.8187***	-2.6339***
	(-8.4751)	(-9.2956)	(-9.7263)	(-8.5662)
ln_GDP_per_cap	0.4816***	0.4835***	0.4426***	0.4873***
	(5.5349)	(5.7809)	(5.6143)	(5.8962)
POP_growth	0.0499	0.0523	0.0321	0.0378
	(1.7789)	(1.9340)	(1.2730)	(1.5131)
urban_growth	-0.0997***	-0.1047***	-0.0717***	-0.0886***
	(-5.1281)	(-5.4290)	(-3.9034)	(-4.7905)
EPS_building	0.0194	0.0793*	-0.1233***	-0.0903***
	(0.7108)	(2.2661)	(-7.9270)	(-7.5739)
EPS_elec	-0.0080	0.0013	-0.0104	0.0616
	(-0.2778)	(0.0648)	(-0.5590)	(1.7724)
EPS_indus	-0.1215***	-0.1205***	-0.0034	-0.0574***
	(-5.2213)	(-7.0064)	(-0.2468)	(-6.6744)
EPS_transport	-0.1006***	-0.0567*	-0.1417***	-0.0766***
	(-3.7620)	(-2.3889)	(-8.1154)	(-4.6492)

GHG/GDP

▸ Methodology ▸ Sectoral Results

Dep. Variable	ln_GHG_per_GDP -1118 obs.			
Cov. Est	Driscoll-Kraay			
R-Squared (Within)	0.3872	0.0869	0.4266	0.4585
R-Squared (Overall)	0.4207	0.4011	0.4790	0.4259
Log-likelihood	1186.4	1176.7	1212.6	1208.7
F-statistic	93.324	89.176	104.89	103.13
const	-2.6855***	-2.7353***	-2.8187***	-2.6339***
	(-8.4751)	(-9.2956)	(-9.7263)	(-8.5662)
ln_GDP_per_hab	0.4816***	0.4835***	0.4426***	0.4873***
	(5.5349)	(5.7809)	(5.6143)	(5.8962)
POP_growth	0.0499	0.0523	0.0321	0.0378
	(1.7789)	(1.9340)	(1.2730)	(1.5131)
urban_growth	-0.0997***	-0.1047***	-0.0717***	-0.0886***
	(-5.1281)	(-5.4290)	(-3.9034)	(-4.7905)
EPS_building	0.0194	0.0793*	-0.1233***	-0.0903***
	(0.7108)	(2.2661)	(-7.9270)	(-7.5739)
EPS_elec	-0.0080	0.0013	-0.0104	0.0616
	(-0.2778)	(0.0648)	(-0.5590)	(1.7724)
EPS_indus	-0.1215***	-0.1205***	-0.0034	-0.0574***
	(-5.2213)	(-7.0064)	(-0.2468)	(-6.6744)
EPS_transport	-0.1006***	-0.0567*	-0.1417***	-0.0766***
	(-3.7620)	(-2.3889)	(-8.1154)	(-4.6492)

Sectoral decomposition with interactions without building

Policy Interactions

	EPS_OECD	EPS_BOD	EPS_GHG	EPS_GDP
Dep. Variable		ln_GHG		
No. Observations	1308	1308	1265	1151
R-squared	0.5270	0.4974	0.5149	0.5336
R-Squared (Within)	0.4987	0.3994	0.2577	-0.0394
Log-likelihood	1264.2	1224.5	1228.8	1249.6
F-statistic	227.25	201.90	208.89	203.80
P-value (F-stat)	0.0000	0.0000	0.0000	0.0000
const	-4.6577***	-5.1658***	-5.9090***	-4.9181***
	(-6.1134)	(-6.6189)	(-7.8529)	(-6.5271)
ln_GDP	0.3067***	0.3208***	0.2731***	0.5097***
	(13.904)	(13.889)	(12.145)	(18.195)
ln_POP	0.7709***	0.7903***	0.8700***	0.6299***
	(16.620)	(16.703)	(18.710)	(13.691)
Urban_growth	-0.0683***	-0.0704***	-0.0537***	-0.0638***
	(-12.430)	(-12.322)	(-9.4467)	(-11.872)
EPS_elec	0.1878***	0.1175***	0.1348***	0.3486***
	(5.7719)	(4.7064)	(10.195)	(7.9970)
EPS_indus	-0.1078***	-0.0891***	-0.0061	-0.0584***
	(-6.7027)	(-5.9061)	(-0.5042)	(-8.5068)
transport*elec	-0.2434***	-0.0921***	-0.1923***	-0.2676***
	(-10.210)	(-6.9429)	(-15.097)	(-8.8200)

Multicolinearity test

Sectoral Results

VIF Comparison Across Sectoral Models

Variable	**EPS_OECD**	**EPS_BOD**	**EPS_GHG**	**EPS_GDP**
ln_GDP	7.66	7.47	7.37	7.03
ln_POP	6.13	5.98	6.49	5.87
urban_growth	1.24	1.19	1.09	1.20
EPS_building	7.87	10.15	2.54	3.19
EPS_elec	5.69	8.35	2.26	1.50
EPS_indus	6.40	6.91	3.28	2.35
EPS_transport	4.81	6.62	2.93	3.26
Year	4.29	3.98	4.03	4.31