Beyond inducement in climate change:
Does environmental performance spur environmental technologies?
A regional analysis of cross-sectoral differences

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Overview

Aim of the paper

Literature Overview

Empirical Strategy

- Data
- Model
- Variables description

Econometric results

Aim of the paper

- Most of the literature analysing determinants of environmental innovation has been grounded on the *induced innovation approach*
  - stringent environmental regulation → an incentive to firms to introduce innovations

- Our aim: Contribute the debate on the inducement of Green Technologies (GT)

- Context: fragile environmental regulatory framework

- We investigate the extent to which, in a context with a *weak* environmental regulatory framework, an inducement of environmental technologies can still be at stake.

Aim of the paper (II)

- Italy, a fragile environmental regulatory framework (according to Johnstone, 2010)

RQ: Are there any inducement mechanisms also in policy weak contexts?

- Exogenous (policy) vs endogenous inducement mechanisms
- Is there any evidence of relationships between environmental performances and the **generation** of GTs?
- ✓ we argue that inducement mechanisms are likely to work through user-producer dynamics based on the derived demand of polluting agents for cleaner technologies rather than through their direct innovating efforts.

Why Italy?

- Italy is one of the countries reporting lower levels in the indicator of environmental policy regime stability and transparency, thus facing less stringent environmental policies as compared to other OECD countries (Johnstone et al., 2009).

- Greenhouse Gases (GHG) emission is indeed still far from reaching the 2012 Kyoto target, having reduced its overall GHG emissions only by 3.5% (UNFCC).

- IT is the European country of the G8 group which is performing worst: has reached a reduction in GHG which is lower even than the European Union average
  - The target for Italy was to reach by 2012 a total Gg of Co2 equivalent in GHG equal to the 92% of the emissions recorded into 1990.- Only the 3.5% reduction refers to the year 2010, having as a reference year 1990.

Literature Overview

- Induced Innovation Hypothesis (Hicks 1932): changes in the relative price of production factors (K & L) induce technological change (cost reduction)

- «Green» Induced innovation Hypothesis: a stringent environmental policy, changes (in a sense) the relative factor prices, inducing technological change.

Tax on air emissions raises p, inducing emission saving technologies to be developed

→ induced innovation hypothesis in climate change has been investigated by a wide strand of literature, which assesses the role of environmental regulation on knowledge generation.

Originality

- we test whether the regional air emissions structure (not the policy) affects its green knowledge generation, controlling for relevant economic variables

- *emphasis* on the importance of vertical linkages and the role of *derived demand* in stimulating the generation of GT.

- GT may be endogenously pulled by the derived demand of vertically related sectors featuring bad environmental performance.

Empirical Strategy - Data

- 454 Observations:
- 20 Italian Regions
- 23 Nace A- O Sectors

Dataset

- EPO – PATSTAT (World Patent Statistical Database) : Patent applications by italian inventors
- EPO - REGPAT : Region (patent)
- Bureau van Dijk - ORBIS, through OECD HAN correspondence tables : Sector (patent)
- WIPO (World intellectual Property Organization) - IPC Green Inventory: Green Tag (patent) in 'Environmentally Sound Technologies'

Green Patents (GT i,j)
(cumulated 2005-2007)

- ISTAT - National Account Matrix Including Environmental Accounts: Air Emissions
- ISTAT - Regional Economic Accounts: Regional economic accounts
- ISTAT - Input Output Use/Supply Table: Related Air Emissions

Empirical Strategy – Model

Count dependent variable → COUNT DATA MODEL CLASS

→ Poisson assumption of conditional variance = conditional mean **violated**

→ NB to account for the over-dispersion of the alpha coefficient

→ Vuong test *** : excess of zeros in GT is generated by a different process than the count values

Zero Inflated Negative Binomial (ZINB)

two simultaneous equations:

1. LOGIT models the zeros in GT, to differentiate the 0s between those regions and sectors creating no patents and those creating only non environmental patents
2. NB to model the count data

Empirical Strategy – Model (2)

$$(GT_{ij}) = \beta_0 + \beta_1(EM_{ij}) + \beta_2(W_{j,l\neq j}EM_{i,l\neq j}) + \beta_3(PURD_i) + \beta_4(POL_i) + \beta_5(VA_{ij}) +$$

$$+ \beta_6(DENSITY_i) + \beta_7(EXPORT\_UE_i) + \beta_8(DIRTY_i) + \sum \rho_i + \varepsilon_{ij}$$

$$EM_{ij} = \log\left(\frac{\mathbf{EMISSIONS}_{ij2005}}{VA_{ij2005}}\right)$$

EMISSIONS:

1. GHG = Greenhousegases (mainly CO2, CH4 and N2O)
2. ACID = AcidifyingGases (mainlyNOx and NH3)
3. OZ = Tropospherericozone (mainly caused by NOx, COVNM, CO, CH4)
4. PM10= Particulates <10µm

Related Emissions

$$\mathrm{RelEM}_{\mathrm{ij2005}} = \log\left(\frac{\sum_{\mathrm{l}\neq\mathrm{j}} \mathrm{W}_{\mathrm{j,l}\neq\mathrm{j}} * \mathrm{EMISSION}_{\mathrm{i,l}\neq\mathrm{j,2005}}}{\mathrm{VA}_{\mathrm{ij2005}}}\right)$$

- **Step A:** Input Output Tables→ W*= Matrix of Weights of Sector Relatedness (National Level, 2005)

Measure of the relatedness among sectors, through flows of intermediate goods, used and supplied among sectors (drawing on Fan & Lang, 2000)

- **Step B:** Matrix W* x Matrix Emissions$\mathrm{W}_{\mathrm{j,l}} = \frac{1}{2}\left(\frac{\mathrm{F}_{\mathrm{j,l}}}{\sum_{j=1}^{n} \mathrm{F}_{\mathrm{j,l}}} + \frac{\mathrm{F}_{\mathrm{l,j}}}{\sum_{l=1}^{m} \mathrm{F}_{\mathrm{l,j}}}\right)$

Measure of the emissions of sectors related to j, weighted by their degree of relatedness to j

Variables Description

Variable	Description	Year
GT	Cumulative count of green technologies in Region i and Sector j in the years 2005 to 2007	2005-2007
AC	Emission intensity of Acidifying Gases (mainly NOx, SOx and NH3), given by the natural logarithm of the ratio between AC and the real value added of Region i, Sector j	2005
ENERGY	Natural Logarithm of the ratio between mean Energy Consumption of Sector j in 2003-2005 and its mean value added in 2003-2005	2003-2005
GHG	Emission intensity of Greenhouse Gases (mainly CO2, CH4 and N2O), given by the natural logarithm of the ratio between GHG real value added of Region i, Sector j	2005
OzTr	Emission intensity of Tropospheric ozone precursors (mainly caused by NOx, COVNM, CO, CH4) given by the natural logarithm of the ratio between OzTr real value added of Region i, Sector j	2005
PM10	Emission intensity of PM10 (Particulates< 10µm), given by the natural logarithm of the ratio between GHG and the lagged real value added of Region i, Sector j, in t-1	2005
W*AC	Emission intensity of AC in 2005 from vertically integrated sectors	2005
W*ENERGY	Mean Energy Consumption of vertically integrated sectors on mean value edded in 2003-2005	2003-2005
W*GHG	Emission intensity of GHG in 2005 from vertically integrated sectors	2005
W*OzTr	Emission intensity of OzTr in 2005 from vertically integrated sectors	2005
W*PM10	Emission intensity of PM10 in 2005 from vertically integrated sectors	2005

Variables Description (II)

Variable	Description	Year
DENSITY	Given by the ratio of mean population in the Region i on the area of i in 2003-2005	2003-2005
DIRTY	Dummy equal to one for the most polluting sectors. In the NACE Revision 1.1 respectively : A, DF, DG, DI, E, I.	2005
EXPORT_UE	Natural Logarithm of the ratio between average Export (within European Union) 2003-2005 and mean value added 2003-2005.	2003-2005
METRO	Dummy equal to one for Regions to which belong one of the following metropolitan areas: Milano, Roma, Torino, Napoli	2005
POL	Natural Logarithm of the ratio between average expenditure for environmental protection (only capital expenditure) in 2004-2005 of Region i and the mean value added of Region i in 2004-2005.	2004-2005
PURD	Given by the natural logarithm of the ratio between real mean Public R&D and mean Total R&D (Business R&D + Public R&D+ Universities R&D) in 2003-2005	2003-2005
ρ_i	4 locational dichotomous variables: NORTHEAST, NORTHWEST, SOUTH and CENTER (benchmark).	
VA	Natural Logarithm of the mean real value added of Region i, Sector j 2003-2005	2003-2005

Correlation

		1	2	3	4	5	6	7	8	9	10	11
1	GT	1										
2	GHG	-0.0282	1									
3	PM10	-0.0988*	0.6944*	1								
4	OzTr	-0.0534	0.843*	0.7287*	1							
5	AC	-0.0706	0.9094*	0.8583*	0.8192*	1						
6	ENERGY	-0.2871*	0.4379*	0.257*	0.4359*	0.3461*	1					
7	VA	0.3095*	-0.4117*	-0.2493*	-0.424*	-0.3236*	-0.995*	1				
8	PURD	-0.1272*	0.0561	0.0646	0.0625	0.0619	0.1957*	-0.1965*	1			
9	DENSITY	0.2508*	-0.0907	-0.0948	-0.0459	-0.0963	-0.5366*	0.5398*	-0.1798*	1		
10	POL	-0.3007*	0.0704	0.1208*	0.0911	0.1208*	0.4456*	-0.4471*	0.3189*	-0.609*	1	
11	EXPORT_UE	0.2602*	-0.0005	-0.0819	-0.0828	-0.0524	-0.2216*	0.2214*	-0.5155*	-0.0541	-0.4496*	1

Econometric Strategy

- Given the high correlation among EMISSIONS: separate inclusion in regressions (Column I to IV) [Results A]

- As robustness: inclusion of

  - METRO [Results B]
  - ENERGY and W*ENERGY [Results C]
  - Principal component analysis on EMISSIONS [Results D]

Results A

	(I)	(II)	(III)	(IV)
GHG	-0.5715			
	(0.3841)			
W*GHG	1.1484***			
	(0.4087)			
PM10		-1.8422***		
		(0.6615)		
W*PM10		1.4823*		
		(0.8130)		
OzTr			-0.6823**	
			(0.3340)	
W*OzTr			1.1372***	
			(0.3950)	
AC				-2.1572*
				(1.2424)
W*AC				2.8542**
				(1.4255)

Results A (cont.)

	(I)	(II)	(III)	(IV)
VA	0.6525***	0.4763**	0.6804***	0.5391***
	(0.1907)	(0.1928)	(0.2441)	(0.1830)
PURD	0.6547*	0.6978*	0.6061	0.7217*
	(0.3898)	(0.3951)	(0.3818)	(0.4037)
DENSITY	-0.0812	0.3114	-0.1060	0.1780
	(0.5976)	(0.5952)	(0.6182)	(0.6153)
DIRTY	0.1230	0.0658	0.1067	0.0367
	(0.4672)	(0.3414)	(0.4179)	(0.3840)
POL	-3.6634	-2.2849	-3.6687	-3.2615
	(4.1181)	(4.2125)	(4.1062)	(4.4774)
EXPORT_UE	0.5729	0.6247	0.5480	0.5551
	(0.4530)	(0.4526)	(0.4470)	(0.4560)
NORTHWEST	0.8026	0.5623	0.8366	0.6773
	(0.5340)	(0.5478)	(0.5278)	(0.5593)
NORTHEAST	-0.1791	-0.3045	-0.0918	-0.3130
	(0.4487)	(0.4470)	(0.4454)	(0.4524)
SOUTH	-0.7283	-0.7170	-0.8506	-0.6439
	(0.6338)	(0.6522)	(0.6344)	(0.6378)

Results B

	(I)	(II)	(III)	(IV)
GHG	-0.6016			
	(0.3792)			
W*GHG	1.2563***			
	(0.4070)			
PM10		-2.0648***		
		(0.6667)		
W*PM10		1.7543**		
		(0.8023)		
OzTr			-0.8263**	
			(0.3327)	
W*OzTr			1.3378***	
			(0.3986)	
AC				-2.3252*
				(1.2269)
W*AC				3.0559**
				(1.3960)

Results C

	(I)	(II)	(III)	(IV)
GHG	-0.6721*			
	(0.3964)			
W*GHG	1.3581***			
	(0.4545)			
PM10		-1.8818***		
		(0.6748)		
W*PM10		1.9819**		
		(1.0017)		
OzTr			-0.7282**	
			(0.3519)	
W*OzTr			1.2293***	
			(0.4190)	
AC				-2.2769*
				(1.2752)
W*AC				4.2012**
				(1.8355)
ENERGY	-4.7427	2.2641	-5.3562	-5.3980
	(36.0608)	(31.7458)	(29.0462)	(46.8024)
W*ENERGY	-0.6266	-7.9814	0.9905	-2.8441
	(26.9952)	(24.1452)	(22.6012)	(33.6626)

Results D

	(I)	(II)	(III)	(IV)	(V)
F1_DIRECT	-0.3802**	-0.4273**	-0.4012**	-0.3898**	-0.4069**
	(0.1679)	(0.1679)	(0.1743)	(0.1645)	(0.1664)
F2_RELATED	0.6234**	0.7083***	0.7820***	0.6431***	0.7841***
	(0.2446)	(0.2438)	(0.2892)	(0.2119)	(0.2402)
ENERGY			-11.1750		-15.5135
			(46.2253)		(76.7143)
W*ENERGY			2.9506		11.9643
			(33.6447)		(82.6422)

Conclusions

- we proposed a complementary framework to the standard inducement argument in climate change that acknowledges that some endogenous mechanisms are at stake in the presence of a weak exogenous policy framework.
- We then qualify the mechanisms through which inducement mechanisms may be working
- The dynamics by which an inducement on polluting firms displays its effects passes through the user-producer relationships, i.e. those established between polluting firms operating downstream and those firms generating green technologies operating upstream.

Conclusions

- vertical linkages along the value chain are relevant: increases in the derived demand engendered by the inducing factor trigger the production of green technologies by supplier firms.
  - regional polluting agents are induced to commit resources to technologies enabling the improvement of environmental performance
  - 2 co-occurring mechanisms of an increased social and environmental responsibility, and an opportunistic pre-emptive reaction to future regulations.

- Our results call for further analyses at micro-level, to investigate the extent to which firms are stimulated to adopt GTs by the prospective gains in terms of reputation, and hence increase sales, or stock market value.

THANKS FOR YOUR ATTENTION

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VAR	N	mean	sd	min	max
GT	454	1.500	7.566	0	130
GHG	454	0.479	0.619	0.012	3.300
W*GHG	454	0.778	0.818	0.043	4.276
PM10	454	0.206	0.353	0.002	2.804
W*PM10	454	0.382	0.510	0.020	3.473
OzTr	454	1.260	0.996	0.036	5.821
W*OzTr	454	1.621	1.119	0.268	6.239
AC	454	0.091	0.197	0.001	1.489
W*AC	454	0.184	0.318	0.005	2.474
VA	454	6.639	1.783	-1.563	10.819
PURD	454	-1.981	0.552	-3.135	-0.674
DENSITY	454	-1.912	0.636	-3.283	-0.857
DIRTY	454	0.220	0.415	0	1
POL	454	0.091	0.091	0.011	0.311
EXPORT_UE	454	4.433	0.812	1.839	5.249
METRO	454	0.198	0.399	0	1
ENERGY	400	0.097	1.016	0.000	20.099
W*ENERGY	400	0.118	1.364	0.000	27.081

Sector (Nace Rev 1.1)	GHG	OzTr	AC	PM10	GT	Freq(GT)
A	1.643	7.391	0.883	1.538	4	1%
B	1.361	25.880	0.396	1.951	3	0%
C	0.465	2.090	0.030	0.115	37	5%
DA	0.487	2.698	0.023	0.062	0	0%
DB	0.477	0.924	0.021	0.048	9	1%
DC	0.180	7.194	0.009	0.026	2	0%
DD, DH, DN	0.201	3.250	0.011	0.032	56	8%
DE	0.522	1.992	0.009	0.026	1	0%
DF, DG	3.067	9.699	0.317	0.264	62	9%
DI	4.039	11.119	0.315	1.475	5	1%
DJ	0.611	3.613	0.039	0.509	29	4%
DK, DL, DM	0.145	0.954	0.007	0.017	282	41%
E	6.157	6.591	0.250	0.223	21	3%
F	0.064	1.408	0.007	0.080	12	2%
G	0.140	1.064	0.014	0.064	18	3%
H	0.072	0.390	0.006	0.023	0	0%
I	0.453	4.055	0.085	0.257	8	1%
J	0.019	0.109	0.002	0.007	17	2%
K	0.031	0.201	0.003	0.014	102	15%
L	0.045	0.473	0.006	0.028	3	0%
M	0.018	0.059	0.001	0.003	0	0%
N	0.047	0.125	0.002	0.006	0	0%
O	0.773	1.927	0.032	0.046	10	1%
P	missing	missing	missing	missing	0	0%