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The impact of environmental research networks on green exports: an analysis of a sample of European countries

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Outline

- Contribution of the study
- Conceptual framework
- Empirical specification and methodology
- Main results
- Conclusions and policy implications
- Related research

Contribution of the study

- We study the impact of green innovation and the participation in European environmental research programs on green exports for 26 European countries over the period 2004 – 2015
- We relate networks to green export competitiveness
- Thanks to the information on the institutional sectors participating in European research networks, we also explore the single and joint impact of firms, universities and public research centres, which allows us to draw implications on the existence of different types of complementarities
- We combine data on participation in FPs with data on green patents to investigate the relative importance of green domestic innovation and green international cooperation for environmental competitiveness and to test for the existence of complementarities associated with domestic absorptive capacity
- We frame the research within the technology gap approach to trade

The framework

- We investigate the **export impact of green research cooperation within a technology gap export model (**Soete, 1981; Dosi et al. 1990; Amendola et al. 1993; Laursen and Meliciani, 2000; 2002; 2010; Dosi et al. 2015)
- We consider the important role of **collaborative research/open innovation** for green innovation. (Ghisetti et al. 2015; Fabrizi et al. 2018; De Marchi, 2012; De Marchi and Grandinetti, 2013; Cainelli et al., 2015)
- In the context of green innovation, **the interaction and hybridisation between three institutional spheres: 'industry', 'university' and 'government'** (Triple Helix, Etzkowitz and Leydesdorff, 2000) in an innovation system approach (Ranga and Etzkowitz, 2013) is particularly important due to the heterogeneity of knowledge required for finding green solutions, the role of regulation in directing green efforts and the necessity of adopting a systemic approach.

Green research networks and eco-open innovation

Substantial literature has focused on the differences between green and standard innovation, stressing the importance of collaborative innovation particularly in the case of green innovation (Ghisetti et al. 2015; Fabrizi et al. 2018);

This literature draws on the idea that environmental innovations require more heterogeneous sources of knowledge with respect to other innovations (Horbach et al., 2013);

In general, the eco-open innovation with a heterogeneity of partners is fundamental because ecological transition requires **diversified knowledge** that can be produced by interorganizational learning, as in the case of FPs (Albort-Morant et al., 2016).

Empirical analyses have supported this view: **environmentally innovative firms cooperate on innovation with external partners to a greater extent than other innovative firms** (De Marchi, 2012; De Marchi and Grandinetti, 2013; Cainelli et al., 2015) and the breadth of the firm's knowledge sourcing has a positive effect on environmental innovation (Ghisetti at al., 2015);

The base model

We estimate a technology gap export model that incorporates green network effects:

$$\boldsymbol{EnvEXPSH_{it}} = \beta_0 + \beta_1 ULC_{it-1} + \beta_2 INV\_EMP_{it-1} +$$

$$\beta_3 POP_{it-1} + \beta_4\, EXC_{it-1} + \boldsymbol{\beta_5\, EPAT\_POP_{it-1}} + \boldsymbol{\beta_6\, EnvNET_{it-1}} +$$

$$+ \boldsymbol{\beta_7\, EPAT\_POP_{it-1}\, x\, EnvNET_{it-1}} + \gamma_t + v_{it} \quad (1)$$

All variables are expressed in logarithms and are expressed in relative terms with respect to the average across countries;

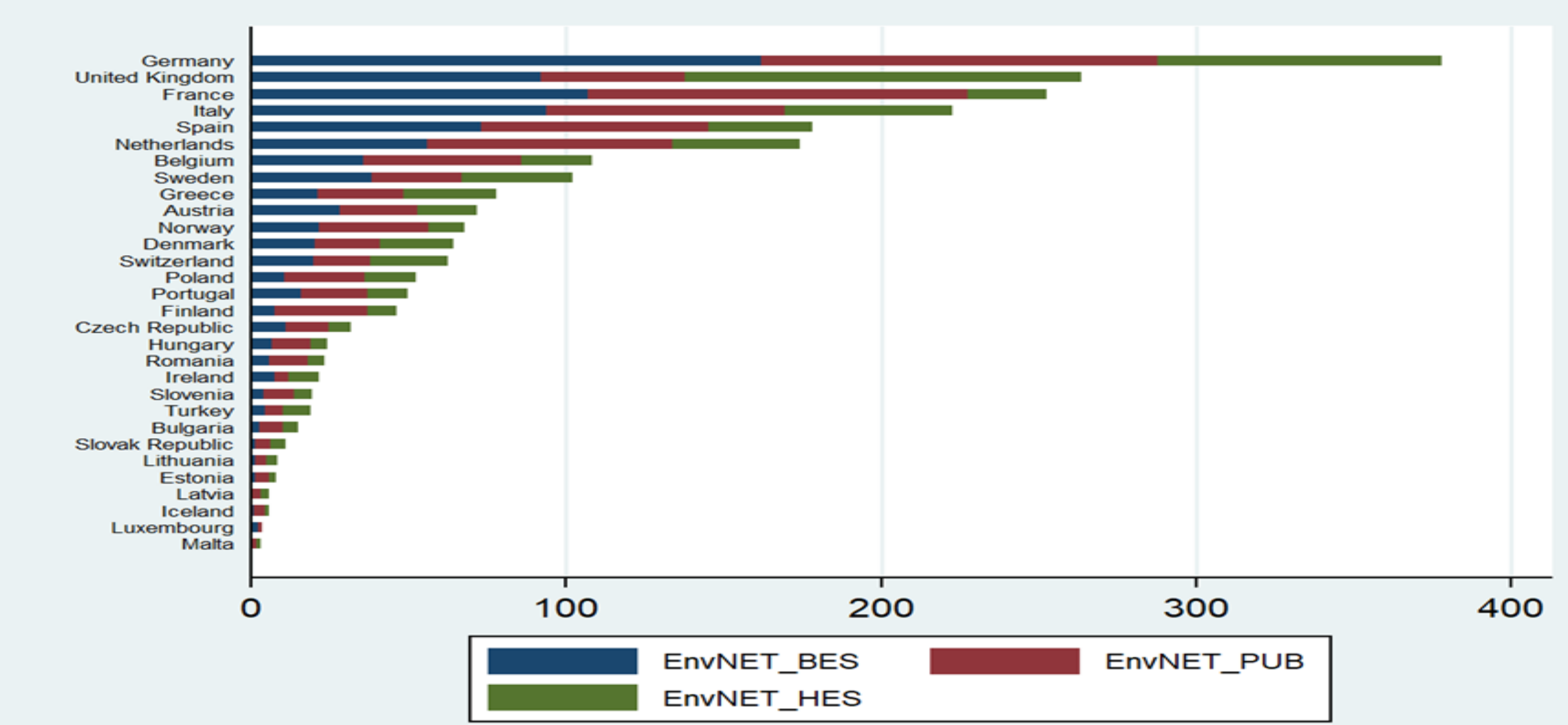
EnvEXPSH is environmental (or green) goods export market shares in current USD; **ULC** is unit labor costs expressed as the ratio of total labor compensation per hour worked to output per hour worked; **INV_EMP** is investment per employee; **POP** is population of a given country; **EXCH** is national currency per US dollar; **EPAT_POP** is the green triadic patents intensity; **EnvNET** stands for the standardized total number of members of green research networks promoted by the EC.

We also include a dummy for non-EUcountries to control the different institutional context.

Data and econometric method

- Due to the short time dimension of the data, we pool the data over time and use the feasible generalized least squares (GLS) estimator to fit the model. We test robustness with fixed effects and GMM.
- **We focus on 26 European countries over the period 2004-2015**
- **Environmentally-related Framework Programmes (FPs) research networks are constructed using EU open data** (FP5, FP6 and FP7). Our data are related to projects that have green aspects. As in Fabrizi et al. (2018), our choice of these projects is based on two characteristics: 1) they are strongly related to the environmental goal; 2) they stress the importance of technological development in achieving environmental goals.

Figure 1: Mean of FPs environmental projects' participants by institutional sectors (2003 – 2014)



FPs green projects (mean value 2003 – 2014)

Country	Green projects	Total participants	Total BES participants	Total GOV participants	Total HES participants	EnvLinks
Austria	48	73	28	25	19	366
Belgium	80	132	36	50	23	578
Bulgaria	13	16	3	8	5	123
Czech Republic	26	32	11	13	7	225
Denmark	40	65	20	21	23	325
Estonia	8	9	1	4	2	83
Finland	30	47	8	30	9	261
France	111	262	107	120	25	758
Germany	144	382	162	126	90	917
Greece	52	79	21	27	29	403
Hungary	20	24	7	12	5	175
Iceland	5	6	1	4	1	45
Ireland	16	22	8	5	10	147
Italy	102	227	94	76	53	702
Latvia	6	6	1	3	3	58
Lithuania	8	9	1	4	4	83
Luxembourg	4	4	2	2	0	28
Malta	4	3	1	1	1	32
Netherlands	92	177	56	78	40	661
Norway	40	69	22	35	12	323
Poland	41	53	11	26	16	340
Portugal	34	51	16	21	13	277
Romania	19	24	6	12	5	168
Slovak Republic	11	11	2	4	5	94
Slovenia	14	19	4	10	5	123
Spain	93	185	73	72	33	648
Sweden	62	102	38	29	35	474
Switzerland	44	64	20	18	25	331
Turkey	15	19	5	6	9	140
United Kingdom	118	269	92	46	126	795

Environmental exports, OECD source

(i) Air pollution control,

(ii) Environmental monitoring, analysis and assessment equipment,

(iii) Management of solid and hazardous waste and recycling systems,

(iv) Noise and vibration abatement,

(v) Waste water management and potable water treatment,

(vi) Cleaner or more resource efficient technologies and products,

(vii) Environmentally preferable products based on end use or disposal characteristics,

(viii) Clean up or remediation of soil and water,

(ix) Heat and energy management,

(x) Natural resources protection

(xi) Renewable energy plant

Table 1: technology gap export model that incorporates green network effects

	(1)	(2)	(3)	(4)	(5)
	BASE	**NET**	**EPAT x NET**	**LAG3**	**LAG5**
EPAT_POP	0.0481***	0.0613***	0.528***	0.579***	0.466***
	(4.36)	(4.96)	(4.98)	(5.47)	(4.22)
EnvNET		0.0591**	0.623***	0.741***	0.561***
		(2.28)	(4.71)	(5.45)	(4.09)
EPAT_POP x EnvNET			0.0455***	0.0520***	0.0388***
			(4.41)	(5.00)	(3.61)

Table 2: Complementarity

	(1)	(2)	(3)	(4)	(5)	(6)
	BES	**GOV**	**HES**	**BES x GOV**	**GOV x HES**	**BES x HES**
EPAT_POP	0.279***	0.475***	0.482***	0.0661***	0.0593***	0.0708***
	(3.13)	(4.76)	(5.60)	(5.47)	(4.92)	(5.59)
EnvNET_BES	0.236**			0.153		0.205*
	(2.39)			(1.48)		(1.81)
EnvNET_GOV		0.507***		0.186*	0.328**	
		(4.33)		(1.70)	(2.42)	
EnvNET_HES			0.474***		0.299**	0.212*
			(5.01)		(2.31)	(1.89)
EPAT_POP x EnvNET_BES	0.0180**					
	(2.28)					
EPAT_POP x EnvNET_GOV		0.0371***				
		(4.12)				
EPAT_POP x EnvNET_HES			0.0352***			
			(4.90)			
EnvNET_BES x EnvNET_GOV				0.0140		
				(1.44)		
EnvNET_GOV x EnvNET_HES					0.0266**	
					(2.24)	
EnvNET_BES x EnvNET_HES						0.0176*
						(1.73)

Summary of the results

- We empirically show the existence of a **"green" technology gap export model**, opening research fields on the technological determinants of green competitiveness;

- Eco-open innovation/green research networks supported by public initiatives favors international environmental competitiveness: the coefficient of ***EnvNET*** is significant and positive, confirming the effectiveness of eco-open innovation at international level (Ghisetti et al. 2015) and of international green networks dedicated to technology (Li Y. et al. 2021);

- We find evidence of **complementarity** between the green knowledge transfer generated by FPs and the green domestic capacity: the coefficient of the interaction term **EPAT_POP x EnvNET** is significant and positive. Complementarities are found for each institutional sector;

- There emerges **an important role for academic institutions** as an intermediator between private and public sectors and between business and research activities;

- The predominance of universities in the abovementioned complementarities confirms the sophistication of the knowledge-intensive green innovation processes (Cainelli et al., 2015).

Contribution to the literature

We contribute to the literature in several respects:

this is the first paper relating **green networks/eco-open innovation** (proxied by cooperation in FPs) **to green export competitiveness;**

thanks to the information on the institutional sectors participating in European research networks, we also explore **the single and joint impact of firms, universities and public research centres**, which allows us to draw implications on the existence of different types of complementarities;

we combine data on participation in FPs with data on green patents to investigate the relative importance of **green domestic innovation and green international cooperation** for environmental competitiveness and to test for **the existence of complementarities associated with domestic absorptive capacity.**

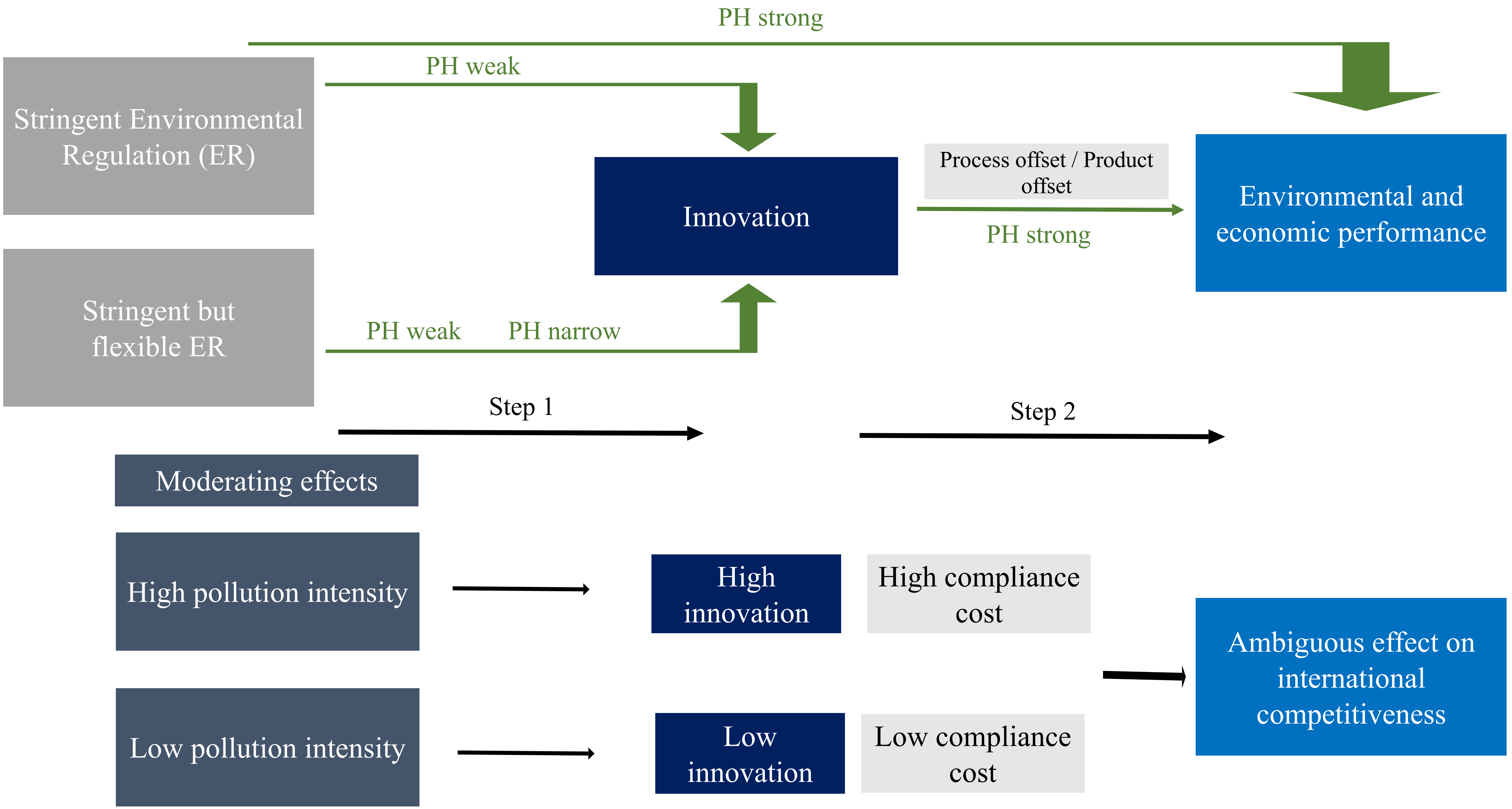
Policy implications

At international level the achievement of SDGs is strictly linked to the implementation of green technological cooperation that permits to generate a win-win strategy with improvements in terms of both environmental sustainability and international competitiveness;

at national level, governments should support the international cooperation activities of universities because they generate important spillovers for business and government sectors with a trickle-down effect on the country's green international competitiveness.

Complementary Work

- Adding the role of environmental regulation testing the weak and strong Porter Hypotheses
- Test the direct and indirect (through innovation) impact of environmental regulation on export dynamics
- Looking at the mediating role of pullution intensity


PH strong
PH weak
Stringent Environmental Regulation (ER)
Innovation
Process offset / Product offset
PH strong
Environmental and economic performance
Stringent but flexible ER
PH weak
PH narrow
Step 1
Step 2
Moderating effects
High pollution intensity
High innovation
High compliance cost
Ambiguous effect on international competitiveness
Low pollution intensity
Low innovation
Low compliance cost

Econometric model: simultaneous-two equation model with an interaction term

TRADE EQUATION

$$EXPSH_{it} = \beta_0 + \beta_1 ULC_{it-1} + \beta_2 INV\_EMP_{it-1} + \boldsymbol{\beta_3 PAT\_POP_{it-1}} +$$

$$\beta_4 POP_{it-1} + \beta_5\, EXC_{it-1} + \beta_6 EPS_{it-1} + + \beta_7 GHG\_GDP_{it-1} + \boldsymbol{\beta_8 EPS_{it-1}\ x\ GHG\_GDP_{it-1}} + \alpha_i + \gamma_t \text{ (a)}$$

KNOWLEDGE PRODUCTION FUNCTION

$$\boldsymbol{PAT\_POP_{it-1}} = \beta_0 + \beta_1 RD\_GDP_{it-1} + \beta_2 POP\_D_{it-1} + \beta_3 EPS_{it-1} + \beta_4 GHG\_GDP_{it-1} + \beta_5 \boldsymbol{EPS_{it-1}\ x\ GHG\_GDP_{it-1}}\ \alpha_i + \gamma_t$$

(b)

where, respectively, i = 1, …., 34 stands for OECD countries, t = 1991…, 2020 refers to years. The time interval of the analysis depends on the availability of the **Environmental Stringency Policy Index.**

The outlined simultaneous-equation system model allows us to link a technology gap approach to the trade model (equation (a)) and a knowledge production function (equation (b)) through innovation (Griliches, 1990; Nagaoka, Motohashi & Goto, 2010; Di Cagno et al. 2014; Fabrizi et al. 2018). In fact, the output of the simplified knowledge production function, the patent intensity, is also considered among the dependent variables of the country's international competitiveness model (Laursen and Meliciani, 2010).

		(1) BASE (LAG1)	(2) EPS_TOT (LAG1)	(3) EPS_TOT&GHG (LAG1)	(4) (LAG2)	(5) LAG3
Equation 1.a						
EXP market share						
ULC		0.0970	-0.0250	-0.0682	-0.119	-0.112
		(1.12)	(-0.27)	(-0.74)	(-1.23)	(-1.17)
INV_EMP		0.311***	0.272***	0.198***	0.139**	0.104
		(6.95)	(5.78)	(3.78)	(2.26)	(1.58)
TPAT_POP		0.227***	0.226***	0.243***	0.266***	0.254***
		(9.47)	(9.72)	(9.70)	(10.84)	(10.49)
POP		-1.315***	-1.483***	-1.604***	-1.642***	-1.685***
		(-8.34)	(-8.81)	(-8.96)	(-9.70)	(-10.75)
EXC		0.261**	0.166	0.206**	0.143	0.124
		(2.56)	(1.64)	(2.08)	(1.54)	(1.39)
EPS	(1)		0.115***	0.0897***	0.107***	0.105***
			(5.21)	(3.77)	(4.64)	(4.79)
GHG_GDP	(2)			-0.192***	-0.215***	-0.214***
				(-3.48)	(-4.06)	(-4.06)
EPS x GHG_GDP	(3)			0.0609***	0.0612***	0.0781***
				(2.77)	(2.96)	(4.09)
Country dummies		*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time dummies		*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant		-1.491***	-1.957***	-2.314***	-3.057***	-3.256***
		(-4.59)	(-5.80)	(-6.25)	(-8.97)	(-9.91)
Equation 1.b						
Patent intensity						
RD_GDP		0.950***	0.880***	0.930***	0.907***	0.852***
		(6.11)	(5.62)	(5.95)	(5.87)	(5.43)
POPD		-0.702	-0.878	-0.785	-0.434	-0.354
		(-1.48)	(-1.64)	(-1.19)	(-0.68)	(-0.53)
EPS	(4)		0.173***	0.116*	0.112*	0.100*
			(3.07)	(1.81)	(1.83)	(1.65)
GHG_GDP	(5)			-0.0391	-0.0510	-0.0165
				(-0.31)	(-0.42)	(-0.14)
EPS x GHG_GDP	(6)			0.318***	0.313***	0.300***
				(3.73)	(3.92)	(3.79)
Country dummies		*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time dummies		*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant		-3.035***	-3.346***	-3.149***		0.322
		(-3.87)	(-3.89)	(-3.00)		(0.32)

The technology gap export model is generally supported both in the original form and in all other integrations.

The weak version is strongly verified with a significance level of 1% for all correspondent coefficients in the short and medium term.

Positive direct impact of green regulation on exports which is coherent with the theoretical and empirical contributions arguing that the ecological transition can improve the non-price competitiveness of exports (Green Thirlwall Law),

Concluding remarks and policy implications

Green policies should be combined with trade policies (Anzolin and Lebdioui, 2021) by promoting a holistic vision and implementing a multi-tool strategy for sustainable competitiveness. For instance, the European Union is working to address the trade policy according to the European Green Deal framework (European Union, 2021).

Green regulation can turn out to be instrumental for international competitiveness thanks to innovation processes, **by transforming the ecological issues from a burden to a business opportunity**.

This path can **represent a win-win perspective for all trade partners only with an international cooperation on technological transfer and institutional capacity building.**

Green innovation policies can sustain a general framework of competitiveness not based on low cost strategies, but rather on technological capabilities, allowing for the pursuit of the social sustainability of international trade. This policy perspective becomes necessary for establishing international trade agreements conforming to social and environmental sustainability.

The implementation of green standards generates international economic advantages in the medium and long term, therefore **governments should set green policy strategies according to the first mover advantage approach** (Porter and van der Linde,1995b).