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Firms-level and industry-level factors as drivers of environmental innovations

Valentina De Marchi,
Roberto Grandinetti, James Cordeiro

valentina.demarchi@unipd.it

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Aim of the paper (1)

- Increasing pressure on firms to reduce environmental impacts by modifying the production processes and product's offer (environmental innovations, EIs)
- Growing literature on EIs to understand the specific determinants of their introduction:
 - Initially great focus on industry-specific factors (regulatory and stakeholder pressures) (e.g., Porter and Var Der Linde, 1995; Brunnermeier and Cohen, 2003; Borghesi et al, 2012)
 - Emerging focus on firm's-level factors, i.e., resources, capabilities and strategic elements (e.g., Orsato, 2009; De Marchi, 2012; Berrone et al, 2013)
- Empirical evidence points to significant differences in the greening propensity of firms facing similar external pressures, focused on the same industry



- Where they are usually addressed separately, we investigate the role of both industry and firm-level determinants of EIs:
 - ✓ What is the role of industry-level determinants when considering for firm-level characteristics? What are the most relevant determinants at the different levels?
- Broader cognizance of EI:
 - Propensity vs. proactiveness of EI introduction - role of (overall) company strategy (Orsato 2009)
 - Beyond technological innovations
 - Innovations tackling environmental impacts at production process or product's use levels (Kammerer 2009, Horbach et al 2012)



Defining environmental innovations

- EI are “the production, application or exploitation of a *good*, service, production, process, organizational structure or management of business method that is *novel* to the firm or user and which results, throughout its life cycle, in a *reduction of environmental risk*, pollution and the negative impacts of resource use compared to relevant alternatives” (Kemp and Pearson, 2008:7)



Is green different?

- EI are peculiar with respect to “general” innovation in several ways (Rennings, 2000; De Marchi, 2012; Cainelli et al 2015):
 1. Externalities
 - ✓ environmental other than knowledge externalities
 2. Drivers (*industry-level*)
 - ✓ regulatory push/pull factors other than demand-pull and technology push factors
 3. Development (*firm-level*)
 - ✓ More complex (higher level of novelty, uncertainty and variety with respect to the traditional technological or market domain the firm usually competes within)



(Environmental-specific) industry-level determinants of EIs

1. Policy stringency and regulatory pressure

- ✓ Need for policy intervention to overcome the higher costs and externalities disincentives (Rennings 2000, Jaffe et al 2005)
- ✓ (Well-designed) policy boosting competitiveness via EI introduction - Porter hypothesis, even if empirical evidence is not consistent (see Ambec et al 2013)

2. Clean tech vs. end-of-pipe emphasis

- ✓ Investments in capabilities for clean tech yielding higher profit and innovation opportunities (Hart & Dowell, 2011), yet higher costs and less recurrent
- ✓ Institutional pressure for conformity to secure legitimacy (Delmas & Toffel, 2004) and support competitiveness



(General) industry-level determinants of EIs

3. Industry growth (munificence)

- ✓ In higher-growth industries, the prediction of fast development support the investment in pollution prevention technologies (Russo & Fouts 1997)
- ✓ Likely to be younger, dynamic and innovative companies, aiming at build reputation via differentiation on environmental performance



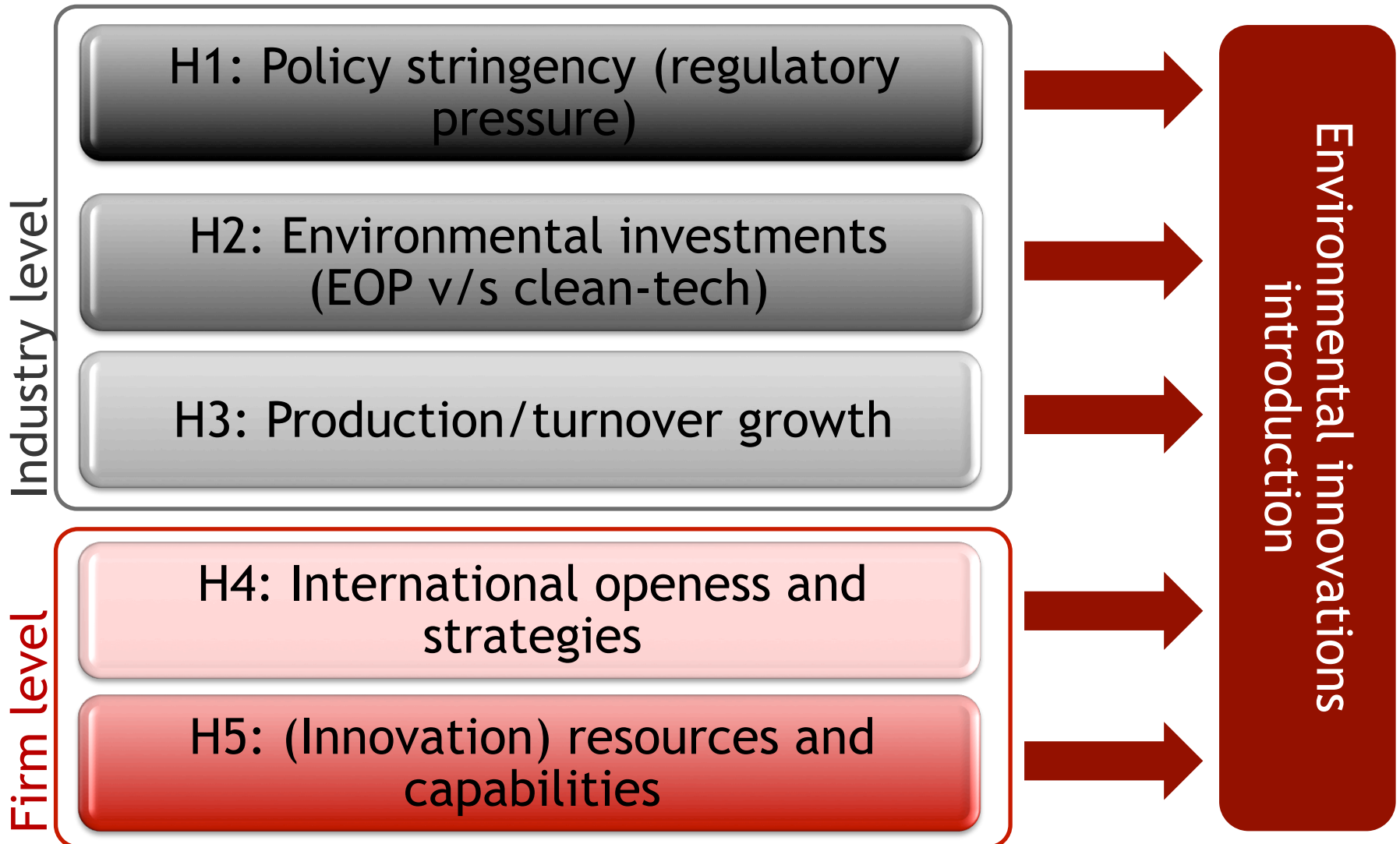
1. (Innovation) internal resources & strategies
 - ✓ Higher need for financial, human and technological resources because of novelty & complexity, since EI is a technological frontier that entails high market & technological uncertainties (de Medeiros 2014, Cainelli et al 2015)
 - ✓ resources and capabilities for exploitation and exploration and to support absorptive capacity for externally developed knowledge (De Marchi & Grandinetti 2012)
 - ✓ Tension between developing resources internally and 'outsourcing' them, driving empirical mixed result considering for EI types and complexity level



2. International openness and internationalization strategies

- ✓ Different countries entails different technological readiness, stakeholder pressure, policy stringency
- ✓ Upstream internationalization: provides learning possibilities and production costs advantages but may harm reputation and branding strategies (Chiarvesio et al, 2014)
- ✓ Downstream internationalization: may provide higher exposure to market and regulatory (environmental) requests, especially toward more environmentally-conscious countries (Jeppesen & Hansen 2004)

The hypotheses: a summary





- Italian Community Innovation Survey (CIS) data
 - ✓ contains information on firms' structural characteristics, innovation strategies and eco-innovation performance over the years 2006-2008
 - ✓ Sample survey for companies with 10-250 employees, census survey for companies 250+
 - ✓ Stratified random sample based on industry, firm size, geographical location
- Subjective approach to (environmental) innovation measurement
- Focus on 5,531 manufacturing firms that have developed (and not merely adopted) innovations



- Dependent variable based on environmental benefits tackled by firm's innovative activities:
 - ✓ EI propensity (dummy INN_ENV, at least one EI among the nine listed)
→ logit regression
 - ✓ Specific EI innovation propensity (each of the nine EI listed)
→ logit regression
 - ✓ Proactive environmental strategies (count INN_BREADTH, how many of the nine types)
→ zero inflated model



The dependent variables

Name	Description	Mean	S.D.
inn_env	Introduced any innovation with positive environmental effects (D)	0.48	0.50
El breadth	Number of EI introduced (0 - 9)	4.22	2.36
<i>Introduction of EI with benefits in the production phase</i>		<i>0.45</i>	<i>0.50</i>
Material	Reduced material use per unit of output (D)	0.17	0.37
Energy	Reduced energy use per unit of output (D)	0.20	0.4
Co2	Reduced CO2 emissions (D)	0.16	0.37
Materials	Substitutions of traditional materials with eco-friendly ones (D)	0.16	0.37
Pollution	Reduction of air, water, noise or soil pollution (D)	0.29	0.46
Recycle	Recycled materials, waste or water (D)	0.29	0.45
<i>Introduction of EI with benefits for the firm's products</i>		<i>0.39</i>	<i>0.49</i>
Prod-efficiency	Reduced energy use at product (D)	0.25	0.43
Prod-pollution	Reduction of air, water, noise or soil pollution of product (D)	0.27	0.44
Prod-recycle	Improved after use recycling of products (D)	0.23	0.42



The variables used

	Name	Description	Mean	SD	
Industry level	H1: Regulatory pressure	IND-ETS	The industry belong to a ETS regulated industry	0.24	0.43
		IND-PERCEVED	The industry average perceived stringency & availability of public incentives	0.32	0.10
	H2: EOP v/s clean-tech inv.	IND-EOP	Standardized differences between expenditures on pollution prevention and end of pipe (EoP)/ EoP expenditures (ISTAT data)	0.69	0.33
	H3: Production/turnover growth	IND-GROWTH	Industry growth rate (munificence) 2002-2008	0.03	0.03
Firm level	H4: International openness and strategies	GROUP	Belongs to a group	0.32	0.47
		FOREIGN GROUP	Belongs to a foreign group	0.09	0.29
		EXPORT	Export to foreign markets	0.63	0.48
	H5: (Innovation) resources, capabilities, strategies	R&D	In-house R&D expenses higher than 75pct industry (Htl)	0.35	0.48
		TECH PURCHASE	Purchase of external knowledge and technology (equipment, R&D or other technology) (Htl)	0.47	0.50
		TRAINING	Training on innovation (Htl)	0.29	0.45
	INN INT	% total innovation expenses on firm's turnover	0.03	0.06	
	LNTURN	Size of the firms (logarithm of 2008 turnover)	1.91	1.84	



Main results: EI propensity vs proactiveness

		(I)		(II)	
		INN_ENV		INN_ENVBREADTH	
		Coef.	S.E.	Coef.	S.E.
H1 (Regulatory pressure)	IND-PERCEIVED	1.684***	(0.545)	0.294**	(0.143)
	IND-ETS	0.164***	(0.042)	0.050*	(0.026)
H2 (EOP focus)	IND-EOP	-0.259**	(0.104)	0.023	(0.023)
H3 (growth)	IND-GROWTH	-1.496	(0.972)	-0.665	(0.417)
H4 (intern. strategies)	GROUP	0.005	(0.081)	-0.019	(0.022)
	FOREIGN-GR	0.270**	(0.126)	0.013	(0.031)
	EXPORT	0.121*	(0.071)	-0.079***	(0.030)
H5 (inn resources & strategies)	R&D	0.223**	(0.104)	0.079***	(0.026)
	TECH_PURCHASING	0.352***	(0.101)	0.049**	(0.022)
	TRAINING	0.259***	(0.084)	0.105***	(0.022)
	INN_INTENSITY	1.147*	(0.630)	0.568***	(0.177)
	LN-TURN	0.152***	(0.022)	0.073***	(0.010)
		-1.108***	(0.217)	1.085***	(0.053)
	Observations	5480		5480	
	Pseudo R-squared	0.0672			
	ll	-3538		-9188	

Clustered standard errors in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$



El propensity vs proactiveness: comparing just innovative firms

		(Ib) INN_ENV		(IIb) INN_ENVBREADTH	
		Coef.	S.E.	Coef.	S.E.
H1 (Regulatory pressure)	IND-PERCEIVED	0.939	(0.609)	0.294**	(0.141)
	IND-ETS	0.259***	(0.058)	0.050*	(0.026)
H2 (EOP focus)	IND-EOP	-0.334**	(0.130)	0.023	(0.023)
H3 (growth)	IND-GROWTH	-2.821**	(1.284)	-0.668	(0.423)
H4 (intern. Strategies)	GROUP	0.271***	(0.097)	-0.016	(0.021)
	FOREIGN-GR	0.214	(0.136)	0.013	(0.031)
	EXPORT	-0.126*	(0.065)	-0.080***	(0.030)
H5 (inn resources & strategies)	R&D	-0.102	(0.119)	0.079***	(0.026)
	TECH_PURCHASING	-0.148	(0.114)	0.050**	(0.022)
	TRAINING	-0.025	(0.097)	0.104***	(0.022)
	INN_INTENSITY	-0.269	(0.526)	0.555***	(0.177)
	LN-TURN	0.105***	(0.030)	0.072***	(0.010)
	Constant	0.335	(0.214)	1.087***	(0.052)
Observations		4193		4193	
Pseudo R-squared		0.0231			
ll		-2713		-8361	



Main results: EI propensity vs proactiveness (2)

- Industry level variables plays a key role when considering EI propensity but loses importance when EI are getting at the core of the firm strategy
 - ✓ Policy stringency playing a larger role when considering also (financial) incentives
- Exporting negatively related to EI
 - ✓ The closer to the customers the better able to pursuit a credible green strategy
 - ✓ Local (Italian) awareness vs foreign awareness?
- Entering global flows of knowledge via being part of a foreign group is not supportive of intense EI strategies
- Innovation resources and capabilities may be even more relevant than industry level factors to explain EI intensity, also when comparing among innovators



Examining differences within types of EI considered

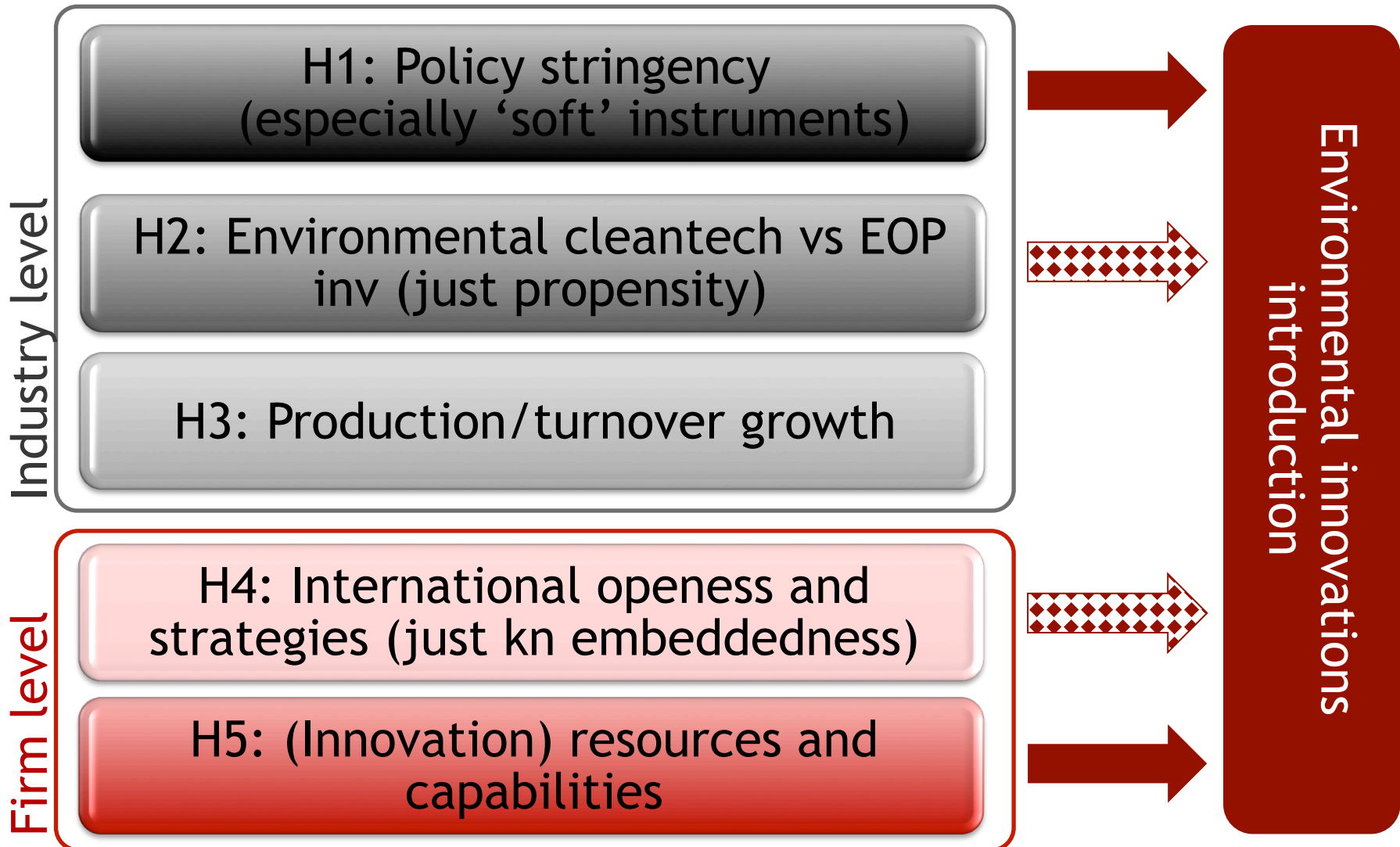
	Base dy/dx	EI with process related benefits					EI with product related			
		i) Materials dy/dx	ii) Energy dy/dx	iii) CO2 dy/dx	iv) pollution dy/dx	v) Matsubst dy/dx	vi) recycl dy/dx	vii) energy dy/dx	viii) pollution dy/dx	ix) recycl dy/dx
IND-PERCEIV	0.420***	0.194***	0.199**		0.384**	0.139**	0.262***	0.168**	0.301**	0.254***
IND-ETS	0.041***			0.023***	0.086***		0.071***		0.051***	
IND-EOP	-0.065**	-0.039***						-0.045***		
IND-GROW GROUP						-0.617***	-1.083***			
FOREIGNGR EXPORT	0.067**	0.045**		-0.018**				0.046***		
R&D	0.056**	0.069***	0.040***		0.052***	0.048***		0.043***	0.056***	0.035**
TECH_PURC	0.088***	0.045***	0.050***	0.028**	0.053**	0.061***	0.045**		0.047***	0.048***
TRAINING	0.065***	0.033**	0.057***	0.057***	0.072***	0.020**	0.056***	0.065***	0.048***	0.032***
INN_INT		0.227***	0.286***	0.157***		0.160**	0.221***	0.308***		0.147**
LN-TURN	0.038***	0.017***	0.034***	0.035***	0.044***	0.018***	0.036***	0.042***	0.038***	0.013***
Observations	5480	5480	5480	5480	5480	5480	5480	5480	5480	5480
Pseudo R2	0.0672	0.0831	0.106	0.0811	0.0848	0.055	0.0563	0.0812	0.0654	0.0281
ll	-3538	-2275	-2461	-2219	-3033	-2291	-3103	-2819	-2958	-2850



Examining differences within types of EI considered

- Differences emerges when considering EI types, suggesting industry specificities in patterns of EI adoption:
 - ✓ Variables capturing the role of internal resources and strategies are the most consistent across models
- Patterns specific to EI types for industry-related variables
 - ‘Soft’ policy instruments being the most important determinant for EIs implying the implementation of LCA approaches (recyclability and substitution of materials) and pollution prevention
 - Innovation intensity the most important for eco-efficiency and product related EI

Firm-level vs. industry-level factors





- Firm-level variables as necessary complement of industry-level variables in explaining why firm develop (and not merely adopt) EIs:
 - ✓ Managerial implication: importance of proactive strategies in influencing environmental innovation
 - ✓ Policy implications: important to consider firm-level characteristics when designing policy/incentives for EI adoption
- Important to study EI determinants after accounting for different EI types (product vs. process, LCA-related vs. eco-efficiency,...) and intensity (strategic vs. reactive approach)



- Focus on single country, with limited number of control variables
 - ✓ Including more industry-relevant variables
 - ✓ Study how key variables interact
 - ✓ Comparing different countries (internationalization strategies)
- Methodology improvements:
 - ✓ Control for possible selection bias
 - ✓ Compare the role of industry vs. firm level variables considering for intensity and EI type