

Do Eco-Innovations Harm Productivity Growth through Crowding Out?

Results of an Extended CDM Model for Italy

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Outline of the paper

- Description of **(eco-)innovation patterns** of **Italian patenting** firms, with a specific focus on eco-innovations
- Assessment of the **effect of eco-innovations** on firms' **productivity**
⇒ potential **crowding-out**
- Structural empirical model (**CDM model**) to describe innovation patterns at the firm level
- Use of **administrative data** (**balance sheet**, **patent** applications)
- **Evidence** of **crowding out**, particularly **severe** for **polluting** firms and sectors

Eco-innovation and crowding-out

- **Technological change** and eco-innovation are **crucial** to address **environmental issues**
- **Eco-innovation** ⇒ innovations characterized by (**wanted** or **unwanted**) an **improvement** in **environmental performance** compared to relevant alternatives (**Kemp and Pearson, 2007**)
- R&D performed to obtain eco-innovations might **crowd-out** **general R&D** employed in other (**possibly more profitable**) projects (**Popp and Newell, 2009**)
- If crowding out occurs, eco-innovations will have a **lower positive effect** on productivity than other innovations or even a **insignificant** or **negative** effect
- **Porter hypothesis** (Porter and Van der Linde, 1995) ⇒ under certain **conditions** (uncertainty, asymmetric information, etc) policies triggering **environmental innovations** promote might have strong **positive effects on competitiveness**

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CDM model to describe innovation patterns (I)

- The **CDM** (Crepon, Duguet and Mairesse, 1998 NBER WP) model is an **empirical structural model** to describe innovation patterns at the **firm level**
- Determinants of **innovation inputs** (R&D) \Rightarrow determinants of **innovation output** (product-process innovations, innovative sales, patent applications) \Rightarrow effect of innovation output on **productivity**
- Sort of **IV approach** to account for endogeneity arising from actual **simultaneity** of firms' decisions and from possible **reverse causality**

CDM model to describe innovation patterns (II)

The model is composed by three distinct stages:

- **R&D** equation
- **Innovation** equation(s) (knowledge production function)
- **Productivity** equation

R&D equation

- Which are the drivers of **innovation (input)** intensity of firms? ⇒ firm **size**, **capital** intensity, **age**, **market share**, sector and time **fixed effects**
- **Few firms report R&D** expenditure ⇒ firms perform formal R&D only if the expected returns pass an **unobservable threshold** ⇒ **Heckman sample selection** model for R&D intensity

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CDM model to describe innovation patterns (III)

Innovation equation(s)

- **Knowledge production function** \Rightarrow introduction of innovations (dummy), share of innovative sales, patent applications (count variable) \Rightarrow **patent applications count**
- (Predicted) innovation **inputs** (R&D from the first step) and **other factors** (**size**, local **knowledge stock**, sector and time **fixed effects**)
- **Poisson** and **Negative Binomial** models (to account for **overdispersion**)

Productivity equation

- Extended **production function** \Rightarrow (predicted) **patent intensity**, **capital intensity**, sector and time **fixed effects**)
- **OLS** with sector and time fixed effects, allowing for **non-constant returns to scale**

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Extension to the CDM model

- Distinction between **environmental patent** applications and other applications \Rightarrow **two** distinct **patent equations** and separate effect on productivity
- Is the **effect** of **eco-innovation** on productivity **homogeneous** for all firms? \Rightarrow check whether the effect differ systematically for firms with **large combustion plants** ('polluter') or for **emission - intensive sectors** ('polluting sectors')

Data

- **Balance sheet** information from **AIDA** (Bureau van Dijk) for about **73k Italian manufacturing** firms in **2000-2007**
- **Patent applications** to the European Patent Office (**EPO**) from PATSTAT (for matching procedure, [Marin, 2011](#)) ⇒ about **4k EPO applicants** and **18k EPO applications** ⇒ environmental patents identified according to their **IPC** class (OECD, WIPO)
- Firms with **polluting plants** were identified mainly through the **E-PRTR** registry for Large Combustion Plants by the European Environment Agency
- Focus on **firm/year pairs** with **positive patent** applications ⇒ problem of **excess zeros** in count models
- **Selection bias** ⇒ results on the **full sample** are qualitatively very **similar**
- **Exclusion** of very **big** (2000 employees) and very **small** (5 employees) firms and exclusion of **outlier** observations ⇒ **5582** observations

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Table: First step: R&D equation

Dep: $\ln(R\&D/L)$	OLS	Heckman
$\ln(L)$	-0.237*** (0.0291)	-0.548*** (0.0378)
Market share	1.794*** (0.633)	3.058*** (0.789)
$\ln(K/L)$	0.129*** (0.0324)	0.115*** (0.0352)
Constant	-0.115 (0.230)	2.293*** (0.280)
First step Heckman		
$\ln(L)$		-0.0146 (0.0440)
Market share		-1.712*** (0.387)
$\ln(K/L)$		-0.0800*** (0.0214)
$\ln(\text{book value})$		0.405*** (0.0407)
Age		0.000713 (0.00146)
Constant		-3.163*** (0.220)
Chi sq		282
Sigma		2.174
Rho		-0.805
Chi sq Rho		237
P-value Rho		1.75e-53
Lambda		-1.749
log likelihood		-10680.6
N	3857	5582

Table: Third step: productivity equation (Env = all environmental patents)

Dep: ln(VA/L)	(1)	(2)	(3)	(4)
ln(K/L)	0.0978*** (0.00750)	0.0977*** (0.00750)	0.0976*** (0.00741)	0.0980*** (0.00748)
ln(L)	0.343*** (0.0552)	0.398*** (0.0575)	0.379*** (0.0562)	0.394*** (0.0572)
ln(Patent_tot*/L)	0.449*** (0.0757)			
ln(Patent_no_env*/L)		0.537*** (0.0801)	0.535*** (0.0772)	0.526*** (0.0796)
ln(Patent_env*/L)		-0.0146 (0.0190)	-0.0322 (0.0222)	-0.00367 (0.0194)
Polluter x ln(Patent_env*/L)			-0.0681** (0.0287)	
Polluter			-0.401** (0.203)	
Polluting_sect x ln(Patent_env*/L)				-0.0507*** (0.0171)
Polluting_sect				-0.356*** (0.115)
Constant	3.975*** (0.0912)	4.014*** (0.117)	3.955*** (0.123)	4.064*** (0.121)
Net effect on polluter / polluting sectors			-0.1002*** (0.0340)	-0.0543** (0.0247)
R sq	0.156	0.158	0.160	0.159
F	69.40	64.79	58.20	57.53
N	5582	5582	5582	5582

Conclusions

- The **effect** of **usual drivers** of innovation output **differs systematically** between **environmental** innovations and other innovations
- **Innovation output** of Italian **polluting** firms and sectors is significantly **biased** towards environmental innovations as opposed to other firms and sectors
- **Environmental innovations** generally have **insignificant or negative effect on productivity** while other innovation have a strong positive effect ⇒ **crowding out!**
- Crowding out is **more severe** for **polluting** firms and sectors

Figure: Kernel distribution of log of employees count (firms with positive patents vs all firms)

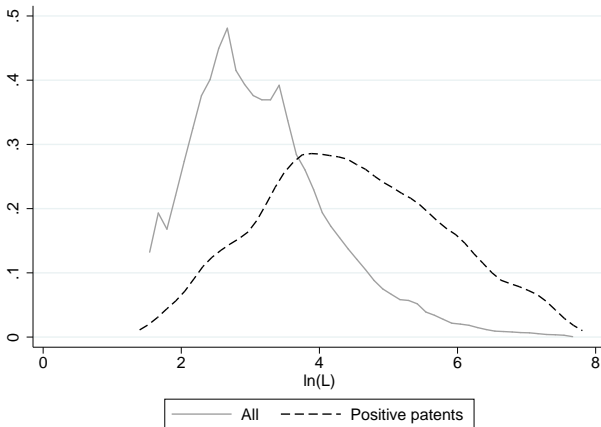


Figure: Kernel distribution of log of value added per employee (firms with positive patents vs all firms)

