Innovation and stringency of environmental regulation in waste management: a patent-based analysis

Nicoletta CORROCHER
ICRIOS, Bocconi University, Milan
Grazia CECERE
Telecom Ecole de Management, Institut Mines Telecom, Paris

INTELLECTUAL PROPERTY, MANAGING GREEN TECHNOLOGIES AND CCMT

Bocconi University

10 October 2018

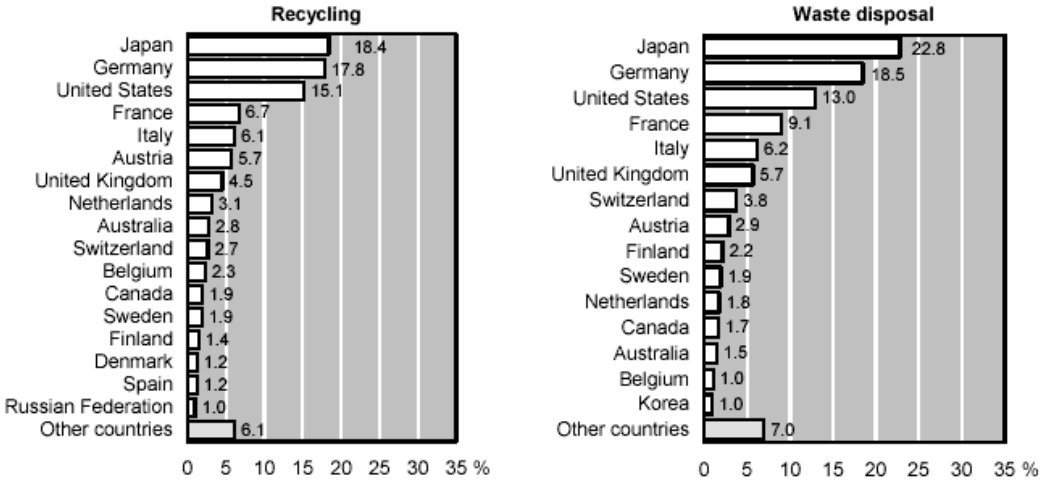
Bocconi

MOTIVATION

- Over the last few decades, the topic of sustainable development has received increasing attention not only from scholars in academia, but also from the civil society, policy makers and businesses
  - Publication of the Brundtland Report 1987 : principal guidelines for sustainable development
  - Earth Summit in Rio de Janeiro (1992) → United Nations Framework Convention on Climate Change → adoption of the Kyoto Protocol (1997)
- The growing interest in the topic has paved the way for an *important debate concerning the relationship between environmental regulation and innovation*

OBJECTIVE AND CONTEXT OF THE PAPER

- **OBJECTIVE OF THE PAPER**: **test the (weak version of the) Porter hypothesis**, by analyzing the relationship between stringency of environmental regulation and environmental innovation in waste management
- *Waste management* → very important issue in relation to sustainable development for scholars, businesses and policy makers
- Important area of innovation (% of patents over total environmental-related patents, OECD countries)



Bocconi

INNOVATION AND ENVIRONMENTAL REGULATION (1)

- Traditional perspective → trade-off between regulation and innovation
  - Regulation is an extra cost for firms (negative impact on productivity, competitiveness and the development of innovations) ➡ environmental management as a cost minimization exercise aimed at regulatory compliance
- Porter (1991); Porter & van der Linde (1995) → *Porter hypothesis*: tough regulations and the establishment of strict environmental standards can represent an incentive to innovation, leading to a competitive advantage at the country level
  - **Narrow vs. strong version**: regulation triggers innovation vs. regulation provides a competitive advantage

INNOVATION AND ENVIRONMENTAL REGULATION (2)

- Why is regulation needed?
  - To provide incentives for innovation
  - To improve the environmental quality when innovations and improvements in resource productivity do not completely offset compliance costs
  - To increase the awareness of resource inefficiencies
  - To increase the likelihood that innovations will be environmentally friendly
  - To create demand for environmental improvement until companies and customers are able to better evaluate resource inefficiencies and the true cost of pollution
  - To have a "level playing field" during the transitional phase towards innovation-based environmental solutions, ensuring that companies do not gain positions by avoiding environmental investments

INNOVATION AND ENVIRONMENTAL REGULATION (3)

- Mixed reactions to the Porter Hypothesis
  - Initial evidence based on anecdotes and industry case-studies (e.g. Dutch flower industry; cell battery, printing ink, electronics manufacturing, pulp and paper and refrigerator industries)
  - Strong assumption according to which firms would systematically overlook opportunities for improving their environmental performance which would also increase their competitiveness
  - Problems with the idea that regulatory regimes are able to design stringent and at the same time efficient environmental regulation (e.g. Wagner, 2003)
- More empirical evidence supporting the narrow version (see Jaffe et al., 2002), than the strong version (see Brunnermeier and Levinson, 2004; Rexhäuser and Rammer, 2013) → *even if regulation triggers innovation that might increase profits, these innovations may crowd out other more profitable investments*

WASTE MANAGEMENT IN EUROPE

- Each year 3 billion tonnes of waste in EU (6 tonnes of solid waste per capita). Treating and disposing of all this material - without harming the environment – is a crucial issue
- Between 1990 and 1995, the amount of waste generated in Europe increased by 10%, most of which is either burnt in incinerators, or dumped into landfill sites (67%)
- **EU's Sixth Environment Action Programme**: waste prevention and management as one of four top priorities → new waste prevention initiatives, better use of resources, and encouraging a shift to more sustainable consumption patterns. 3 main principles:
  - **Waste prevention**: reduce the amount of waste generated AND its hazardousness → simpler disposal → prevention closely linked with improving manufacturing methods and influencing consumers to demand greener products and less packaging
  - **Recycling and reuse**: EU directives now require Member States to introduce legislation on waste collection, reuse, recycling and disposal of these waste streams
  - **Improving final disposal and monitoring**: strict guidelines for landfill management (e.g. ban of certain types of waste + targets for reducing quantities of biodegradable rubbish) and tough limits on emission levels from incinerators

METHODOLOGICAL ISSUES (1)

- How can we measure stringency of environmental regulation?
  - **Pollution abatement costs** → often self-reported by firms, can be biased and/or signal inefficiency more than stringency of regulation (Bhatnagar & Cohen, 1997; Xing and Kolstad, 2002)
  - **Government monitoring** → can be due to higher coverage in reporting and data collection (Bhatnagar & Cohen, 1997)
  - **Environmental stringency indexes** (e.g. Index of Environmental Sensitivity Performance - Cagatay and Mihci, 2003; de Vries & Withagen, 2005) → "problems "with time series
  - **Membership to international treaties** → international agreements are often void of effective enforcement mechanisms + self selection bias: only those countries that are able to satisfy the requirements established in the agreement will opt in (de Vries & Withagen, 2005; Aichele & Felbermayr, 2011)

METHODOLOGICAL ISSUES (2)

- **Stringency of environmental regulation cannot be observed directly, but can be inferred from the observation of country-specific "environmental behaviour"**
- Chimeli et al. (1999); Xing & Kolstad (2002) → environmental stringency can be evaluated looking at actual emission levels of pollutants over a period of time
  - Intuition: after controlling for size, relatively larger emission levels will be associated with laxity of environmental stringency, whereas relatively smaller emission levels will signal deeper engagement in environmental policy
- **NOTE**: what actually matters is the ***change*** in emission levels, more than their absolute value – stocks may be relatively constant over time, thus poorly capturing shifts in regulation/policy

METHODOLOGICAL ISSUES (3)

Innovation in waste management → patents

- *" […] the European Patent Office (EPO) has established a new classification scheme for technical attributes or technologies that can be loosely referred to as clean energy technologies – a specific sub-sector of climate change mitigation technologies, whose 200 or so new categories make it much easier to retrieve information."* Clean energy and patents - European Patent Office, 2010)
- However, the process of re-classification is still ongoing and the field of waste management is not yet available → WIPO Green Inventory, **waste mangement category**:
  - Waste disposal
  - Treatment of waste
  - Consuming waste by combustion
  - Reuse of waste materials
  - Pollution control

Bocconi

EMPIRICAL ANALYSIS (1)

Stringency of environmental regulation → Yearly flows of ***waste recycling*** in EU27 countries (waste recycling vs. waste generation)

Environmental innovation → Count of ***granted patents*** (EPO) in the *waste management* category between 1995 and 2006

$$\mathbf{PATENTS_{i,t} = \beta_1 (STRINGENCY_{i,t-1}) + \beta_2(X_{i,t-1}) + \alpha_i + \varepsilon_{i,t}}$$

STRINGENCY is introduced also with its **quadratic term** to test for non linearity

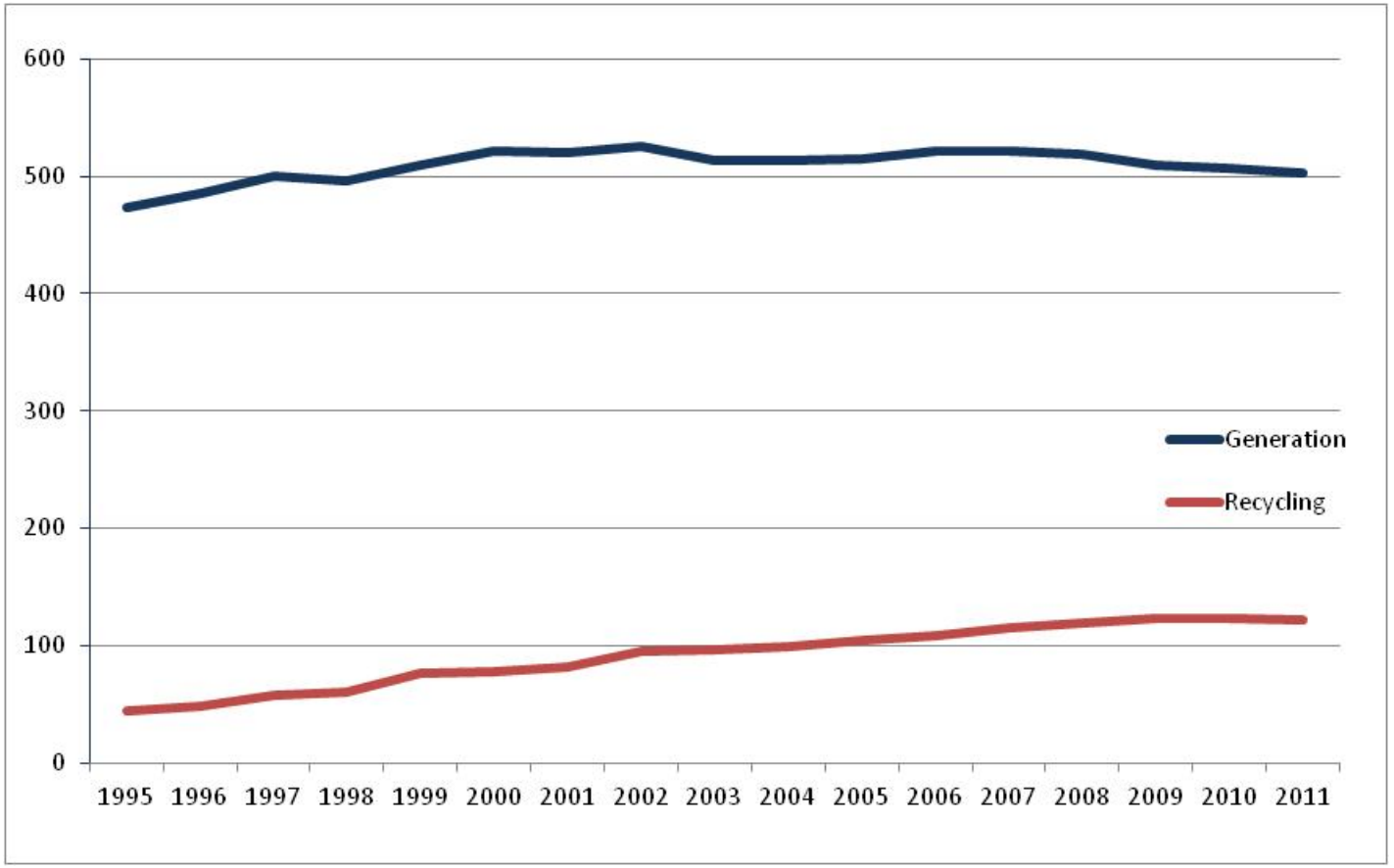
$X_{i,t-1}$ → time varying control variables: GDP per capita, R&D per capita, air emissions per capita, value added in polluting sectors (construction + mining/quarrying)

α_i → country fixed effects: performance in terms of recycling - to what extent a country exceeds the target set by the EU (dummy variable: 1 if a country is above the mean, 0 otherwise)

Estimation technique: Negative binomial with random effects

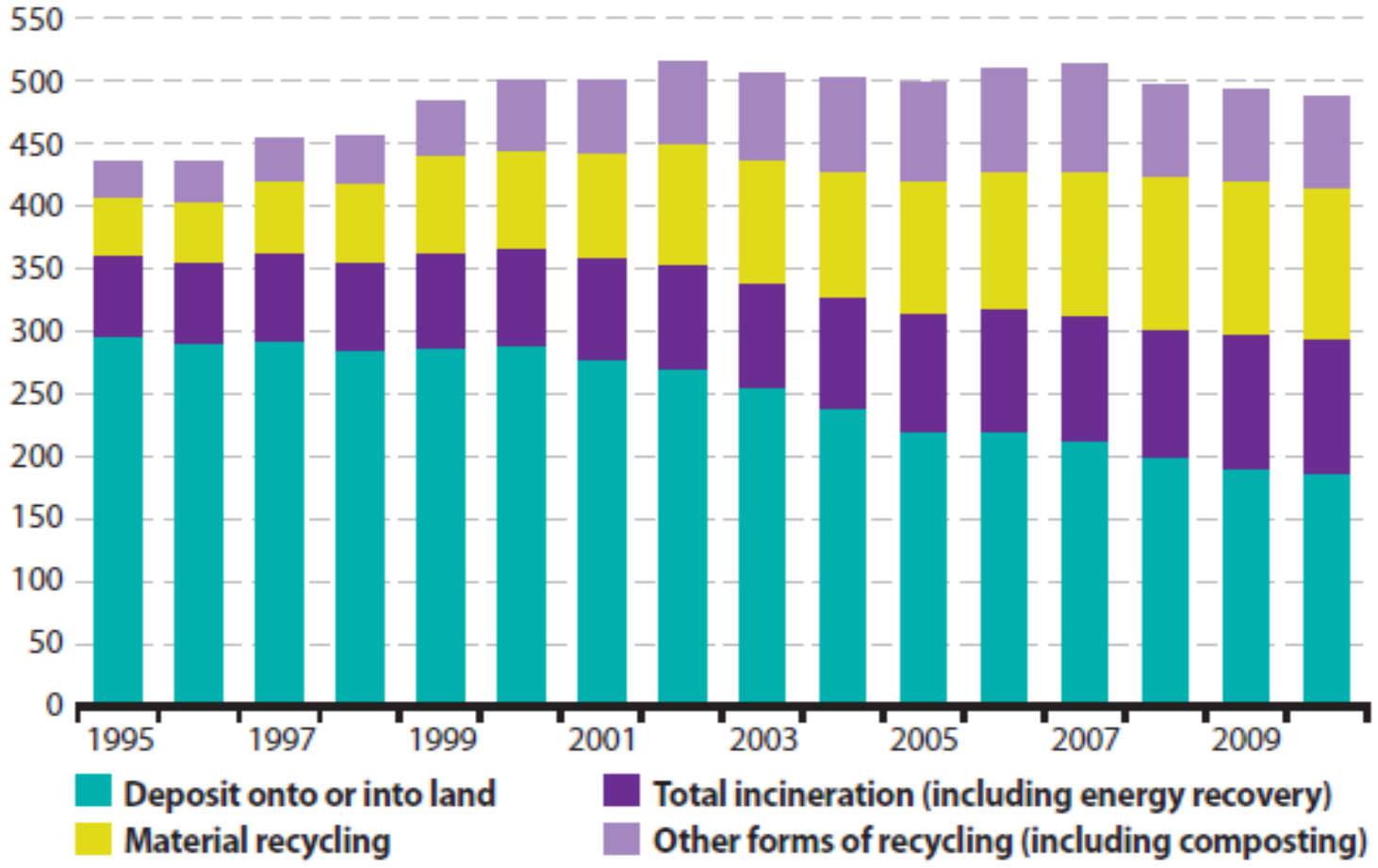
Bocconi

WASTE GENERATION AND RECYCLING (1995-2011, kg per capita – EU countries)



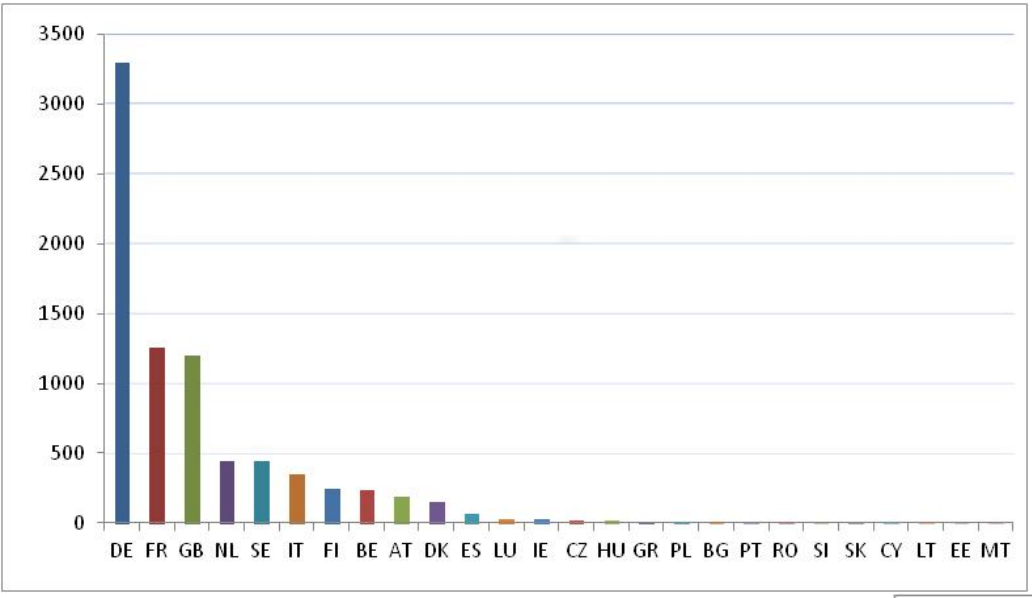
Bocconi

WASTE TREATMENT PER INHABITANT (1995-2010 – EU countries)



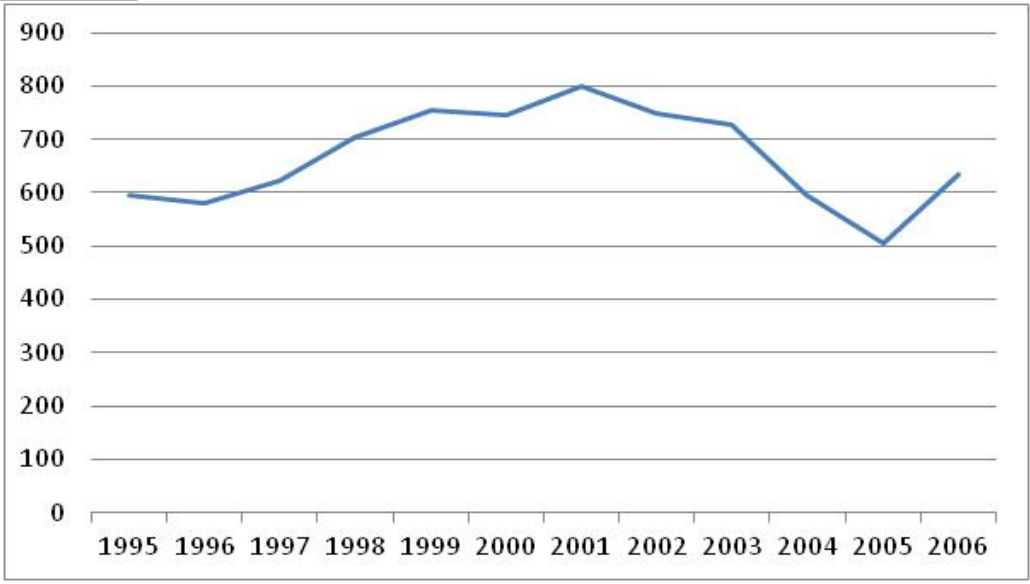
Bocconi

WASTE MANAGEMENT PATENTS (1995-2006)



Number of granted patents by country

Number of granted patents per year



EMPIRICAL ANALYSIS (2)

Possible endogeneity issue

Dependent variable: count of patents listed in the waste management category

Independent variable: flows of waste recycling (*per se* less endogenous than waste generation)

Increasing waste recycling may be due to larger availability of waste management technologies → source of potential reverse causality

Independent variables are introduced with different time lags (up to three years) → results are robust to different specifications

***DEP. VARIABLE*: PATENTS IN WASTE MANAGEMENT**

	(1)	(2)	(3)
STRINGENCY	0.009***		
	(0.002)		
STRINGENCYt-1		0.008***	
		(0.002)	
STRINGENCYt-2			0.008***
			(0.002)
STRINGENCY²	-0.000**		
	(0.000)		
STRINGENCY²t-1		-0.000**	
		(0.000)	
STRINGENCY²t-2			-0.000**
			(0.000)
GDP	0.374**		
	(0.177)		
GDPt-1		0.379***	
		(0.141)	
GDPt-2			0.433***
			(0.145)
R&D	0.954***		
	(0.046)		
R&Dt-1		0.967***	
		(0.037)	
R&Dt-2			0.947***
			(0.037)
EMISSIONS	-0.015***		
	(0.004)		
EMISSIONSt-1		-0.017***	
		(0.003)	
EMISSIONSt-2			-0.018***
			(0.003)
MIN_ratio	-0.000		
	(0.002)		
MIN_ratiot-1		0.002	
		(0.001)	
MIN_ratiot-2			0.001
			(0.001)
CO_ratio	-0.060**		
	(0.029)		
CO_ratiot-1		-0.079**	
		(0.034)	
CO_ratiot-2			-0.015
			(0.034)
TARGET	-0.100*	-0.119*	-0.150**
	(0.057)	(0.063)	(0.072)
_cons	-5.156**	-3.795	-5.968***
	(2.219)	(5.143)	(1.438)
Year dummies	Yes	Yes	Yes
ln_r _cons	5.843***	7.913	6.807***
	(1.404)	(4.956)	(1.167)
ln_s _cons	3.423***	4.221***	4.903***
	(0.868)	(0.778)	(1.027)

Stringency of regulation

Environmental behaviour

RESULTS

Waste recycling → positive effect on patents

→ *stringency of regulation positively affects innovation*

⟶ confirmation of the weak version of the Porter Hypothesis

→ *the effect is non-linear*, suggesting the existence of an optimal cap to the stringency of regulation.

→ *the overall environmental conditions of the country*, as well as the *presence of highly polluting sectors* hinder the development of environmental innovations

CONCLUSIONS

Theoretical background: ongoing debate on the relationship between environmental regulation and innovation (and competitiveness)

Test of the Porter Hypothesis in a very important field of environmental policy – *waste management*

- Environmental regulation → indirect measure: *waste recycling*
- Data from WIPO green inventory → *patents in waste management*

Support to increasingly strict legislative regimes and evidence against the traditional idea that rigidity in environmentally related lawmaking is detrimental to innovation – however, need to think about a *cap on regulation*