# What determines the Investment in Environmental Innovation?









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## Motivation

- \* The Strategy EU2020 sets out guidelines for a new economy where the crisis should be turned into an opportunity for creating jobs, building a smarter and greener economy that rest on innovation and better use of resources (Europe 2020, 2014).
- The Paris Agreement sends a clear signal to investors, businesses, and policy-makers that the global transition to clean energy is here to stay and resources have to shift away from polluting fossil fuels.

### **INNOVATION AS A DRIVER**



## Green innovation: what is it?

- Similar to conventional innovations (van Leeuwen & Mohnen 2013)
- Double externality problem --> regulatory push/pull effect (Rennings 2000)
- \* Porter hypothesis (Porter & van der Linde 1995):
  highlights stringency of env regulation in triggering green inno.



### Green innovation: Spanish context

- Aim to use green innovation to boost the economy (Barranco 2013)
- Moderate innovator (Hollanders & Es-Sadki 2013)
  - Spanish gross domestic R&D expenditure 0.5% below the EU average (Eurostat 2013)
  - \* 1,23% 2013

#### \* Advanced in green innovation

- \* Composite index of eco-innovation scoreboard
- Voluntary green certifications: ISO14001 (1<sup>st</sup> Europe, 3<sup>rd</sup> World), EMAS



# Some Spanish Evidence

- Around 3% of annual private R&D investment devoted to environmental objective (Total industry) in the period 2008-2013.
- \* All industry sectors invest in environmental R&D.
  - Main sectors: Repair and Installation of Machinery and Equipment (10.9% in 2013), Paper, publishing and printing (9.3% in 2013); Non-metallic mineral products (8%); Metal products (5.5%).
- \* 22.6% of firms consider of high importance the innovation objective: "To reduce environmental impact"



# **Research questions**

#### WHICH DRIVERS FOSTER ENVIRONMENTAL R&D INVESTMENT?

#### FIRST SET OF DRIVERS: Environmental Firm strategies (to prevent pollution) (Wagner, 2009; Hart, 1995)

- \* Investment in the production process
- \* Investment at the end-of-pipe
- \* Acquisition of energy products
- \* Env Management system EMS

### SECOND SET OF DRIVERS: Regulation and other policy measures (Del Río, 2009; Horbach et al., 2012; Veugelers, 2012; Marin, 2014)

- \* Public funds to support R&D (not specific for environmental R&D. No information)
- \* Energy taxes
- Environmental taxes (pollution and resources)
- \* Stringency of environmental regulation (Constantini and Crespi, 2008; Marin, 2014)
- \* Objective of innovation: Meeting regulatory requirements (Campí et al. 2014)

# **Empirical Strategy**

### Data

- Empirical analysis of eco-innovation faces data availability problems (Del Río, 2009; Veugelers, 2012). Particularly, data on private environmental R&D investment are usually reported only by the economic sector.
- \* We have compiled a database with **different sources** and asking statistical office of Spain for specific exploitation of data
- \* Database: Panel data. Industry level data (22 sectors). Period 2008-2013. Spain
  - \* Community Innovation Survey for Spain (Oslo Manual),
  - \* Industrial Companies Survey,
  - \* Environmental Protection Activities Survey,
  - \* Environmental Taxes Account and
  - \* Air Emission Account

# **Empirical Strategy**

#### **MODEL AND VARIABLES**

 $R\&D_{it} = \beta_0 + \beta_1 Firm/Markets/Tech_{it} + \beta_2 Stragies_{it} + \beta_3 Regulation_{it} + \mu_i + e_{it}$ 

#### DEPENDENT VARIABLE: Environmental private R&D expenditure.

Private R&D investment in control and care of the environment (distribution by socioeconomic objectives according to the purpose of the R&D programme or project). Source: R&D Survey for Spain (Frascati Manual)

EXPLANATORY VARIABLES: general industry R&D and environmental R&D drivers

Control for individual heterogeneity (sectors). Time dummies to control for cyclical effects.

# **Empirical Strategy**

### **METHODOLOGY**

- Random effects.
  - First problem: Are x and μ<sub>i</sub> correlated?
    - \* Hausman test reject Ho: no correlation of explanatory variables with  $\mu_i$ Solution: We include explicitly that correlation using  $\mu_i = \lambda \overline{X}_1 + v_i$
  - \* Robustness:
  - \* Is there any x endogenous?
    - \* Use funds, investment prod process lagged one period
  - \* Placebo test: R&D investment.

### Table 1. Effect of Environmental Strategies to Prevent Pollution

o     Investin the prod. processo     Investin the end-of the pipes     Investin the productso     Investin the productso     Investin the end-of the pipes     Acq_of energy productso     EMSs     TOTALs       Investment processo     0.258****¶     0     0     0     0     0.248****¶     0     0     0     0     0.194¶       Investment processo     0.0020     0     0     0     0.239****¶     0     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0     0.0021¶     0.01810     0.01870     0     0.01810§     0.01810§     0.01810§     0.01811§     0.0181§     0.0181§     0.0541§     0.01610§ <th>¤</th> <th colspan="3">Random-effects¤</th> <th>۵</th> <th colspan="3">KE-Mundlak<sup>a</sup></th> <th>a</th> <th>α )</th>	¤	Random-effects¤			۵	KE-Mundlak <sup>a</sup>			a	α )
prod. processo     end-of-the-pipeo     productso     end-of-the-pipeo     productso     0	α	Invest in the	Invest in the	Acq. of energy	EMS¤	Invest-in-the-	Invest in the	Acq. of energy	EMS∝	TOTALa
Investment:     processo     0.258***¶     0     0     0.248***¶     0     0     0.1044p       processo     (0.080)0     (0.080)0     (0.080)0     (0.080)0     (0.080)0     (0.042)0     0     0.0221     (0.142)0       Investment:     end-of-     (0.076)0     0     0.0799***¶     0     0     0.0239***¶     0     0     0.00221     (0.142)0     0     0.0243***¶     0     0.0022***¶     0     0.002***¶     0     0.0243***¶     0     0.002***¶     0     0.085***¶     0     0.085***¶     0     0.085***¶     0     0.085***¶     0     0.085***¶     0     0.085***¶     0.068***¶     0.085***     0.085***     0.085*		prod. processa	end-of-the-pipe∝	products¤		prod processo	end-of-the-pipe¤	products¤		
processo     (0.082)o     (0.144)o       Investment end-of- he-pipeo     0     0.250***¶     0     0.239***¶     0     0     0.0221       Acquisition: energy- productoo     0     0.799***¶     0     0     0.0330     (0.142)o     (0.137)o     (0.161)o     (0.161)o     (0.250***¶     0     0     0.085***¶     0.1281     (0.187)o     (0.187)o     (0.187)o     (0.187)o     (0.161)o     (0.250***]     (0.161)o     (0.250*       Constanto     8.203***¶     7.596***¶     -1.722     4.077     8.826***¶     8.051***¶     -1.152     (2.765)o     (4.719)o       Log Saleso     -0.035     0.007     (0.181)o     (0.199)o     (0.413)o     (0.401)o     (0.389)o     (0.54***]     0.54***¶     0.339     (0.54***¶     0.339     (0.527)o     (0.415)o     (0.317)o     (0.319)o     (0.527)o     (0.401)o     (0.389)o     (0.54***¶     0.54***¶     0.54***¶	Investment prod.	0.258***	٥	۵	Q	0.248***	٥	Q	0	-0.194
Investment:     end-of- (0.076)c     p     0.250***¶ (0.076)c     0     0     0.259***¶ (0.083)c     0     0.0027 (0.083)c       Acquisition:     energy products0     0     0.799***¶ (0.187)c     0     0     0.743***¶ (0.195)c     0     0.0027** (0.073)a       ISO140010     0     0     0     0.476**** (0.187)c     0     0     0     0.855*** (0.161)c     0.022** (0.0260c       CONTROLS0	processo	(0.082)				(0.086)¤				(0.144)
the-pipeo     (0.076)a     (0.142)a     (0.142)a       Acquisition: energy     a     a     0.799***¶     a     a     0.743***¶     a     0.902***¶       products <sup>a</sup> (0.187)a     a     a     a     a     0.1287     (0.127)a     0.1281       ISO140010     a     a     a     a     a     a     0.085***¶     0.1281       CONTROLSa     (0.187)a     (0.187)a     (0.187)a     (0.187)a     (0.187)a     (0.161)a     (0.260)a       Constanto     8.203***¶     7.596***¶     -1.7221     4.071     8.826***¶     8.051***¶     -1.1521     0.8551     -7.6761       Log Salesa     -0.0351     0.0071     0.182¶     0.3001     0.199¶     0.133¶     0.2907     -0.699¶     -0.514¶       (0.178)a     (0.176)a     (0.181)a     (0.188)a     (0.187)a     (0.187)a     (0.187)a     (0.339)a     (0.543)a     (0.327)a       Human RD intensityo     0.148***¶     0.1654***¶     0.006¶     0.0076     0.539***¶     0.031¶	Investment end-of-	2	0.250***¶	۵	۵		0.239***	Q	۵	0.022
Acquisition     energy productso     α     0.799***¶ (0.187)c     α     α     α     0.743***¶ (0.195)c     α     0.902***¶ (0.195)c     α     0.902***¶ (0.195)c     α     0.902***¶ (0.195)c     α     0.902***¶ (0.195)c     α     0.902***¶ (0.195)c     α     0.902***¶ (0.195)c     0.073***¶ (0.195)c     α     0.902***¶ (0.195)c     0.073***¶ (0.195)c     0.073***¶ (0.195)c     0.073***¶ (0.195)c     0.074***¶ (0.187)c     0.071****¶ (0.260)c     0.825***¶ (0.187)c     0.071****¶ (3.887)c     -1.152¶ (4.982)c     0.855*¶ (2.765)c     -7.676¶ (4.719)c       Log Saleso     -0.033¶     0.007¶     0.182¶     0.300¶     0.199¶     0.133¶     0.290¶     -0.644***¶     0.804***¶     0.544***¶     0.804***¶     0.547*c       Human RD intensityo     0.148***¶     0.162***¶     0.190***¶     0.076¶     0.559***¶     0.754***¶     0.544***¶     0.804***¶     0.804***¶     0.804***¶     0.804***¶     0.804***¶     0.804***¶     0.027     0.2720°       Human RD intensityo     0.148***¶     0.004¶     0.004¶     0.011¶     -0.007¶     -0.011¶     -0.021¶     -0	the-pipe <sup>o</sup>		(0.076)¤				(0.083)¤			(0.142)
productso     (0.187)c     (0.187)c     (0.195)c     (0.373)c       ISO140010     0     0     0.476***     0     0     0.883***     0.128       CONTROLSo     (0.187)c     0     0     0.803***     0.128     (0.260)c       Constanto     8.203****     7.596***     1.722     4.077     8.826***     8.051**     -1.152     0.855     -7.676       (3.262)c     (3.427)c     (4.424)c     (3.504)c     (3.913)c     (3.887)c     (4.982)c     (2.765)c     (4.719)c       Log Saleso     -0.035     0.007     0.182     0.300     0.190     0.133     0.290     -0.699     0.514       (0.178)c     (0.176)c     (0.181)c     (0.189)c     (0.413)c     (0.401)c     (0.3399)c     (0.543)c     (0.543)c       Human RD intensityo     0.148***     0.162****     0.106%     (0.060)c     (0.060)c     (0.060)c     (0.180)c     (0.187)c     (1.517)c     (1.340)c     (1.172)c     (1.612)c     (1.631)c     (1.437)c     (1.403)c       Importance: <td>Acquisition energy</td> <td>۵</td> <td>٥</td> <td>0.799***¶</td> <td>۵</td> <td>٥</td> <td>~</td> <td>0.743***¶</td> <td>۵</td> <td>0.902***¶</td>	Acquisition energy	۵	٥	0.799***¶	۵	٥	~	0.743***¶	۵	0.902***¶
ISO14001α     α     α     α     α     0.476****     α     α     α     0.128 <sup>+</sup> 0.028 <sup>+</sup> 0.028 <sup>+</sup> 0.028 <sup>+</sup>	productso			(0.187)¤				(0.195)¤	/ľ	(0.373)¤
CONTROLSO     (0.187)c     (0.161)c     (0.260)c       Constanto     8.203****[     7.596****[     4.077[     8.826****[     8.051***[     -1.152[     0.855]     (4.719)c       Log Saleso     -0.035[     0.007[     0.187[     0.300[     0.199[     0.133[     0.209[     -0.6999[     -0.514[       Muman RD intensityo     0.176[co     (0.181)c     (0.187)c     (0.412)c     (0.401)c     (0.389)c     (0.543)c     (0.543)c     (0.547)c       Human RD intensityo     0.162****[     0.162****[     0.162****[     0.54****[     0.804***[     0.804***[     0.804***]     0.804***[     0.804***     0.804***     0.804***     0.804***     0.804***     0.804***     0.	ISO140010	۵	٥	Ø	0.476***¶	۵	۵	Q	0.683****	0.128
CONTROLS     Constanto     8.203***¶     7.596***¶     4.077¶     8.826***¶     8.051**¶     -1.152¶     0.855¶     -7.676¶       Log Sales     -0.035¶     0.007¶     0.182¶     0.300¶     0.199¶     0.133¶     0.290¶     -0.699¶     -0.7876¶     -0.7876¶       Log Sales     -0.035¶     0.007¶     0.182¶     0.300¶     0.199¶     0.133¶     0.290¶     -0.699¶     -0.7878**       Human RD-intensity     0.148***¶     0.162***¶     0.199***¶     0.076¶     0.539***¶     0.754***¶     0.84***¶     0.804***¶     0.804***¶     0.804***¶     0.780***¶       (0.060)     (0.060)     (0.061)     (0.076)     (0.188)     (0.175)     (0.319)     (0.327)       Foreign capitalo     -0.699¶     -0.479¶     -1.477¶     -0.119¶     -0.095¶     -0.339¶     0.51***¶     0.329     0.227)     0.2201     0.2031     0.003¶     0.006¶     0.011¶     -0.007¶     -0.011¶     -0.037     0.339     0.027)     0.327)     0.237)     0.027)     0.0237     0.003¶     0					(0.187)¤				(0.161)	(0.260)0
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	CONTROLSO									
(3.262)     (3.427)     (4.424)     (3.504)     (3.913)     (3.887)     (4.982)     (2.765)     (4.719)       Log Sales     -0.035¶     0.007¶     0.182¶     0.300¶     0.199¶     0.133¶     0.290¶     -0.699¶     -0.514¶       (0.178)     (0.176)     (0.181)     (0.181)     (0.189)     (0.413)     (0.401)     (0.389)     (0.543)     (0.579)     (0.543)     (0.579)     (0.579)     (0.579)     (0.579)     (0.579)     (0.579)     (0.319)     (0.327)     (0.327)     (0.327)     (0.327)     (0.327)     (1.606)     (1.547)     (1.515)     (1.340)     (1.727)     (1.642)     (1.651)     (1.477)     (1.403)       Importance:	Constanto	8.203***¶	7.596***¶	-1.722	4.077¶	8.826***	8.051**	-1.152	0.855¶	-7.676
Log Sales     -0.035¶     0.007¶     0.182¶     0.300¶     0.199¶     0.133¶     0.290¶     -0.699¶     -0.514¶       Human RD intensityc     0.148***¶     0.162***¶     0.199**¶     0.076¶     0.559***¶     0.754***¶     0.544***¶     0.805*1%     1.4030*     1.4030*     1.4030*     1.4030*     1.4030*     1.4030*     1.4030*     1.4030* <td></td> <td>(3.262)0</td> <td>(3.427)¤</td> <td>(4.424)¤</td> <td>(3.504)¤</td> <td>(3.913)¤</td> <td>(3.887)¤</td> <td>(4.982)o</td> <td>(2.765)¤</td> <td>(4.719)¤</td>		(3.262)0	(3.427)¤	(4.424)¤	(3.504)¤	(3.913)¤	(3.887)¤	(4.982)o	(2.765)¤	(4.719)¤
(0.178)α     (0.176)α     (0.181)α     (0.189)α     (0.413)α     (0.401)α     (0.389)α     (0.543)α     (0.547)α       Human RD intensityα     0.148***¶     0.162***¶     0.190***¶     0.076¶     0.559***¶     0.754***¶     0.544***¶     0.806***¶     0.806***¶     0.806****¶     0.806****¶     0.806	Log Sales	-0.035¶	0.007	0.182	0.300	0.199¶	0.133	0.290	-0.699¶	-0.514
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	-	(0.178)	(0.176)¤	(0.181)0	(0.189)¤	(0.413)¤	(0.401)	(0.389)¤	(0.543)	(0.547)¤
(0.060)     (0.060)     (0.061)     (0.076)     (0.188)     (0.187)     (0.175)     (0.319)     (0.327)       Foreign capital     -0.699¶     -0.479¶     -1.477¶     -0.119¶     -0.095¶     0.091¶     -0.339¶     0.522¶     -0.260¶       Importance:     to:     0.008¶     0.003¶     0.006¶     0.011¶     -0.007¶     -0.007¶     -0.011¶     -0.004¶     -0.0119     -0.014%     -0.065**¶     -0.054***¶     -0.054***¶     -0.054***¶     -0.0168     <	Human RD intensity	0.148***	0.162***	0.190***	0.076	0.559***	0.754***¶	0.544***¶	0.804***	0.780***¶
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		(0.060)	(0.060)¤	(0.061)¤	(0.076)¤	(0.188)¤	(0.187)¤	(0.175)¤	(0.319)	(0.327)¤
(1.606)     (1.547)     (1.515)     (1.340)     (1.727)     (1.642)     (1.651)     (1.457)     (1.403)       Importance:     to:     0.008¶     0.003¶     0.006¶     0.011¶     -0.007¶     -0.007¶     -0.011¶     -0.004¶     -0.003¶     -0.037¶     -0.065**¶     -0.037*%     -0.065**¶     -0.038%     -0.038%     -0.038%     -0.038%     -0.038%     -0.038%     -0.038%     -0.038%     -0.	Foreign capitalo	-0.699¶	-0.479	-1.477	-0.119	-0.095¶	0.091	-0.339	0.522¶	-0.260
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	_	(1.606)	(1.547)¤	(1.515)¤	(1.340)¤	(1.727)¤	(1.642)¤	(1.651)0	(1.457)¤	(1.403)¤
reduce: env. impacto     (0.013)o     (0.012)o     (0.012)o     (0.011)o     (0.017)o     (0.016)o     (0.016)o     (0.013)o     (0.013)o     (0.013)o     (0.013)o     (0.013)o     (0.013)o     (0.015)o     (0.016)o     (0.016)o<	Importance: to:	0.008	0.003	0.006	0.011¶	-0.007¶	-0.007¶	-0.011	-0.004¶	-0.003¶ )
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	reduce env. impacto	(0.013)	(0.012)0	(0.012)¤	(0.011)¤	(0.017)¤	(0.016)	(0.016)¤	(0.013)	(0.015)¤
M(Foreign)     O <tho< td=""><td>M(Human RD)</td><td>۵</td><td>٥</td><td>Q</td><td>۵</td><td>-0.447***¶</td><td>-0.654****</td><td>-0.377**</td><td>-</td><td>-0.665**¶)</td></tho<>	M(Human RD)	۵	٥	Q	۵	-0.447***¶	-0.654****	-0.377**	-	-0.665**¶)
M(Foreign)o     O <tho< th="">     O     <tho< td=""><td>   </td><td></td><td></td><td></td><td>   </td><td>(0.199)¤</td><td>(0.198)¤</td><td>(0.188)0</td><td>0.806***¶</td><td>(0.347)¤</td></tho<></tho<>						(0.199)¤	(0.198)¤	(0.188)0	0.806***¶	(0.347)¤
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $									(0.332)¤	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	M(Foreign)	٥	٥	Q	Q	-0.263¶	0.735	-3.075	0.485¶	4.901¶
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $						(4.304)¤	(4.103)¤	(3.982)¤	(3.826)	(4.655)¤
Impact)o     (0.027)o     (0.027)o     (0.025)o     (0.021)o     (0.025)o       M(lsales)o     a	M(Reduce env.)	۵	0	Q	۵	0.026	0.011	0.038¶	0.037*¶	0.049**
M(lsales)     0     0     0     -0.261¶     -0.123¶     -0.106¶     1.084**¶     1.044**¶       N: observations     1300     1290     1360     800     1300     1290     1360     800     750	Impact)¤					(0.027)¤	(0.027)¤	(0.025)¤	(0.021)¤	(0.025)¤
N: observations     1300     1290     1360     800     1300     1290     1360     800     750	M(lsales)	۵	0	Q	۵	-0.261¶	-0.123	-0.106	1.084**	1.044**
N. observations 1300 1290 1360 800 1300 1290 1360 800 750						(0.461)¤	(0.454)¤	(0.442)¤	(0567)¤	(0.565)¤
	N. observations	130¤	1290	136¤	800	130¤	129¤	1360	80a	75¤

#### Table 3. Effect of Regulation and Policy Measures

۵	Random effects				RE-Mundlaka				
a	Public <sup>.</sup>	Energy:	Env.	Stringencya	Public <sup>.</sup>	Energy:	Env.	Stringencyc	TOTAL°
	Fundsa	taxesa	Taxesa	υ.	Fundsa	taxesa	Taxesa		
Subsidies	0.613***¶	o	۵	٥	0.746***¶	۵	a	٥	0.486****
	(0.116)°				(0.111)°				(0.140)a
Energy Taxo	Q	0.331¶	۵	٥	۵	0.365¶	٥	۵	-0.382¶
		(0.254)¤				(0.305)¤			(0.272)¤
Pollution Tax©	o	o	0.283***¶	٥	۵	۵	0.304*¶	۵	0.187***
			(0.127)¤				(0.179)¤		(0.092)¤
CO2¤	۵	۵	۵	0.396***¶	۵	۵	٥	0.393***¶	0.221*¶
				(0.145)¤				(0.142)¤	(0.132)
CONTROLS									
Constanto	5.583*¶	3.579¶	11.19***¶	3.331¶	4.555¶	5.731¶	11.26**¶	3.126¶	5.345***
	(2.974)¤	(4.183)¤	(3.314)¤	(3.624)	(2.973)o	(4.673)¤	(5.614)¤	(4.011)0	(2.495)¤
Log-sales¤	0.032¶	0.285¶	0.034¶	0.336*¶	0.516¶	0.498¶	0.031¶	0.525¶	0.224¶
	(0.151)0	(0.216)	(0.187)	(0.196)	(0.377)¤	(0.357)¤	(0.422)0	(0.353)¤	(0.531)
Human RD	-0.034¶	0.087	0.374***¶	0.119*¶	0.550***¶	0.612***¶	0.381¶	0.631****	0.182¶
intensity¤	(0.057)¤	(0.078)¤	(0.122)¤	(0.070)¤	(0.170)0	(0.185)¤	(0.318)¤	(0.184)¤	(0.382)¤
Foreign capital	0.084¶	-1.008¶	0.753¶	-0.729¶	2.036¶	0.116¶	0.608¶	0.234¶	1.071¶
	(1.470)¤	(1.275)¤	(1.148)¤	(1.213)0	(1.609)	(1.317)¤	(1.264)¤	(1.299)¤	(1.700)¤
Importance to:	0.023***¶	0.003¶	-0.006¶	-0.002¶	-0.016¶	-0.005¶	0.003¶	-0.004¶	0.009¶
reduce: env.	(0.011)0	(0.014)¤	(0.011)¤	(0.013)¤	(0.015)	(0.017)¤	(0.017)¤	(0.017)¤	(0.022)¤
impacto									
M(Human RD)	a	a	۵	٥	-0.628***¶	-0.551***¶	-0.003¶	-0.550***¶	-0.031¶
<b>`</b>					(0.181)°	(0.204)¤	(0.355)¤	(0.194)¤	(0.380)¤
M(Foreign)¤	۵	Q	۵	٥	-4.316	-4.407¶	-0.040¶	-3.010	-0.624¶
					(3.238)0	(4.652)0	(5.371)0	(3.548)a	(2.371)0
M(Reduce env.	D	o	۵	٥	0.068***¶	0.011¶	-0.016¶	-0.001¶	-0.002¶
impact)¤					(0.021)0	(0.028)¤	(0.032)¤	(0.025)¤	(0.025)¤
M(lsales)	a	o	۵	٥	-0.498¶	-0.174¶	0.010)¶	-0.133¶	-0.036¶
					(0.406)¤	(0.443)¤	(0.508)¤	(0.416) <sup>o</sup>	(0.537)¤
Nobservations	1360	<b>89</b> 0	60¤	89¤	1360	89a	60°	89º	<b>60</b> 0
_									

#### Table:4, Robustness Diagnostics¶

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×	IVa	Hausman	IV¤	Hausman	Placebo-	3
		Taylor		Taylor	Testo	
Dependent	Log	Log∙of∙	3			
Variable≍		R&D-	L			
					Investments:	
Investment in	0.473***¶	0.120¶	×	×	×	3
production	(0.124)¤	(0.096)⊭				L
process¤						L
Subsidies¤	×	×	1.072***¶	0.564***¶	0.892***¶	3
			(0.139)¤	(0.143)¤	(0.090)≓	L
Energy Tax¤	×	×	×	×	-0.286***¶	3
					(0.114)¤	L
Pollution Tax¤	×	×	×	×	0.014¶	1
					(0.039)¤	L
CO2¤	×	×	×	×	0081 <b>*</b> ¶	1
					(0.055)¤	L
CONTROLS	×	×	×	×	×	P
Constant¤	4.615¶	11.206***¶	1.433¶	6.427** <b>1</b>	0.152¶	5
	(3.463)¤	(4.720)¤	(2.593)¤	(3.577)¤	(1.151)¤	ł
Log·Sales¤	0.083¶	0.279¶	0.547¶	0.479¶	-0.001¶	P
	(0.572)¤	(0.400)¤	(0.522)¤	(0.369)¤	(0.223)¤	Ł
Human RD	0.379¶	0.531***¶	0.576***¶	0.538***¶	0.213¶	P
intensity¤	(0.282)	(0.183)¤	(0.258)	(0.167)≓	(0.161)¤	Ł
Foreign capital¤	-0.086¶	0.103	2.701¶	1.634	2.401****	P
-	(2.043)¤	(1.671)⊭	(1.896)¤	(1.587)¤	(0.713)¤	Ł
Importanceto:	-0.012¶	-0.006¶	-0.019¶	-0.014¶	-0.004¶	P
impact¤	(0.020)≓	(0.016)⊨	(0.018)¤	(0.015)¤	(0.009)¤	
M(Human RD)	-0.251¶	-0.426***¶	-0.736***¶	-0.574***¶	-0.164¶	b
	(0.291)¤	(0.199)⊭	(0.272)⊭	(0.183)⊭	(0.159)¤	L
M(Foreign)¤	-2.797	1.110	-6.027**¶	-3.369	-0.575¶	3
	(3.905)⊭	(5.082)≓	(3.063)⊭	(3.708)⊭	(0.994)¤	
M(Reduce env.	0.025¶	0.028	0.075***¶	0.063***¶	0.016*¶	3
impact)¤	(0.026)¤	(0.131)¤	(0.022)¤	(0.024)⊭	(0.010)⊨	
M(lsales)¤	-0.094¶	-0.374¶	-0.474¶	-0.480¶	0.160¶	3
	(0.599)¤	(0.472)¤	(0.541)¤	(0.410)¤	(0.225)¤	
N observations⊠	108⊭	130🛛	113¤	136¤	<u>60</u> ⊨	3
Instruments:¤	Lprevec	×	Lfunds.i=	×	×	ß
Rho¤	0.375¤	0.719¤	0.302¤	0.616	×	3
<b>Σ</b> α°	0.627¤	1.084¤	0.476¤	0.813¤	×	3
<b>G</b> 2	0.809¤	0.677¤	0.725¤	0.643¤	0.093¤	1
						111

### Table:4, Robustness Diagnostics¶



×	IV¤	Hausman-	IV¤	Hausman-	Placebo-	Þ
-	Taylor <sup>1</sup> Taylor <sup>2</sup>				Testo	-
Dependent	Log	Log-ot-	8			
Variables					R&D.	
<b>T</b>	0.4720005	0.1005			Investments	1
investment in	0.4/3****	0.120	8	8	8	P
production	(0.124)9	(0.090)R				L
piocessix Subscidient			1.0706665	0.554000	0.0000000	┨
Subsidiese	8	8	1.0/2004	0.304111	0.892	18
Deserve Trees		~	(U 139)6	(0.143)B	(0.090)2	┨
Energy-Taxo	8	8	8	8	-0.280	18
Delles Delle					(0.114)	Ł
Pollution Taxe	8	8	8	8	0.014	9
					(0.039)8	١.
CO28	8	8	8	8	0081*1	12
0.00 777 0.0					(0.055)¤	-
CONTROLSE	8	×.	×	R .	×	- 7
Constanto	4.015	11.200****	1.433	0.42/***	0.152	9
	(3.403)R	(4.720)8	(2.593)8	(3.577)8	(1.151)	4
Log-Saless	0.083	0.279	0.547	0.479	-0.001	9
	(0.572)	(0.400)	(0.522)	(0.369)¤	(0.223)	4.
Human RD	0.379	0.531	0.5/0	0.538****	0.213	2
intensitys	(0.282)¤	(0.183)	(0.258)	(0.167)	(0.161)	4
Foreign capitals	-0.080	0.103	2.701	1.034	2.401	12
-	(2.043)8	(1.671)	(1.896)	(1.587)8	(0.713)8	4
Importanceto:	-0.012	-0.000	-0.019	-0.014	-0.004	8
impacte	(0.020)≅	(0.016)¤	(0.018)¤	(0.015)¤	(0.009)¤	
M(Human RD)=	-0.251¶	-0.426***¶	-0.736***¶	-0.574***¶	-0.164¶	1
	(0.291)	(0,199)	(0.272)	(0.183)	(0.159)	
M(Foreign)≋	-2.797¶	1.110¶	-6.027**¶	-3.369T	-0.575¶	1
	(3.905)	(5.082)	(3.063)⊭	(3.708)	(0.994)	L
M(Reduce env.)	0.025¶	0.028	0.075***¶	0.063***¶	0.016 <sup>+</sup> ¶	1
impact)¤	(0.026)	(0.131)	(0.022)⊨	(0.024)⊭	(0.010)	L
M(lsales)¤	-0.094¶	-0.374¶	-0.474¶	-0.480	0.160¶	1
	(0.599)	(0.472)	(0.541)	(0.410)	(0.225)	L
N observations⊨	1080	130	113¤	136	60⊭	1
Instruments:@	Lprevec	×	Lfunds.i=	×	×	1
Rhog	0.375	0.719¤	0.302⊭	0.616	×	1
Σap	0.627¤	1.084	0.476¤	0.813¤	×	1
Ge?	0.809⊭	0.677¤	0.725k	0.643¤	0.093¤	1
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#### Table:4, Robustness Diagnostics¶ ¶



×	IV¤	Hausman-	IVa	Hausman	LINCEDO.
		Taylor		Taylor	Test≃
Dependent	Log	Log-of-			
Variable¤		R&D-			
					Investments≃
Investment in	0.473***¶	0.120¶	α	×	×
production	(0.124)¤	(0.096)¤			
process¤					
Subsidies¤	x	×	1.072***¶	0.564***¶	0.892***¶
			(0.139)¤	(0.143)¤	(0.090)¤
Energy Tax¤	×	×	×	×	-0.286***¶
					(0.114)¤
Pollution Tax¤	×	×	×	×	0.014¶
					(0.039)¤
CO2¤	×	×	×	×	0081 <b>*</b> ¶
					(0.055)¤
CONTROLS¤	×	×	×	×	×
Constant¤	4.615¶	11.206***¶	1.433¶	6.427**¶	0.152¶
	(3.463)¤	(4.720)⊭	(2.593)¤	(3.577)¤	(1.151)¤
Log·Sales¤	0.083¶	0.279¶	0.547¶	0.479¶	-0.001¶
	(0.572)¤	(0.400)¤	(0.522)¤	(0.369)¤	(0.223)¤
Human RD	0.379¶	0.531***¶	0.576***¶	0.538***¶	0.213¶
intensity¤	(0.282)¤	(0.183)¤	(0.258)¤	(0.167)¤	(0.161)¤
Foreign capital¤	-0.086¶	0.103¶	2.701¶	1.634¶	2.401***¶
	(2.043)¤	(1.671)¤	(1.896)¤	(1.587)¤	(0.713)¤
Importance:to:	-0.012¶	-0.006¶	-0.019¶	-0.014¶	-0.004¶
reduceenv.	(0.020)¤	(0.016)¤	(0.018)¤	(0.015)¤	(0.009)⊭
impact¤					
M(Human RD)≍	-0.251¶	-0.426***¶	-0.736***¶	-0.574***¶	-0.164¶
	(0.291)¤	(0.199)¤	(0.272)¤	(0.183)¤	(0.159)¤
M(Foreign)¤	-2.797¶	1.110¶	-6.027**¶	-3.369¶	-0.575¶
	(3.905)¤	(5.082)¤	(3.063)¤	(3.708)¤	(0.994)¤
M(Reduce env.	0.025¶	0.028¶	0.075***¶	0.063***¶	0.016*¶
impact)¤	(0.02 <b>6</b> )¤	(0.131)¤	(0.022)¤	(0.024)⊭	(0.010)⊨
M(lsales)¤	-0.094¶	-0.374¶	-0.474¶	-0.480¶	0.160¶
	(0.599)¤	(0.472)¤	(0.541)¤	(0.410)¤	(0.225)¤
N•observations¤	108⊭	130¤	113¤	136¤	<u>60</u> ⊨
Instruments:¤	Lprevec.i=	×	Lfunds.t=	×	× .
Rho¤	0.375¤	0.719¤	0.302⊭	0.616¤	× .
Σa <sup>p</sup>	0.627¤	1.084¤	0.476⊭	0.813¤	× .
Q_P	0.809¤	0.677¤	0.725¤	0.643¤	0.093¤
(T)					

## Conclusions



# **Policy Implications**

- The use of subsidies to stimulate environmental innovation represents a key factor to develop green technologies.
  Instruments as environmental taxes or stringency are more effective than general ones.
- \* The design of policy and regulatory measures is determinant to foster companies to be green, it should be implemented using prizes instead of punishments and in the case of punish, the better is to use specific environmental taxes.

# Thank you for keep on green!!!