

# What determines the Investment in Environmental Innovation?





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# Motivation

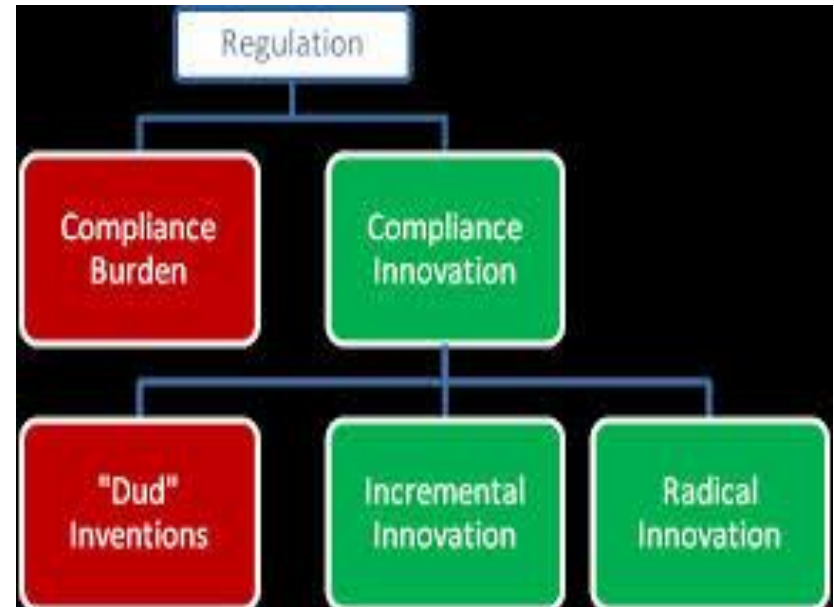
- \* **The Strategy EU2020 sets out** guidelines for a new economy where the crisis should be turned into an opportunity for creating jobs, **building a smarter and greener economy that rest on innovation and better use of resources** (Europe 2020, 2014).
- \* **The Paris Agreement** sends a clear signal 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



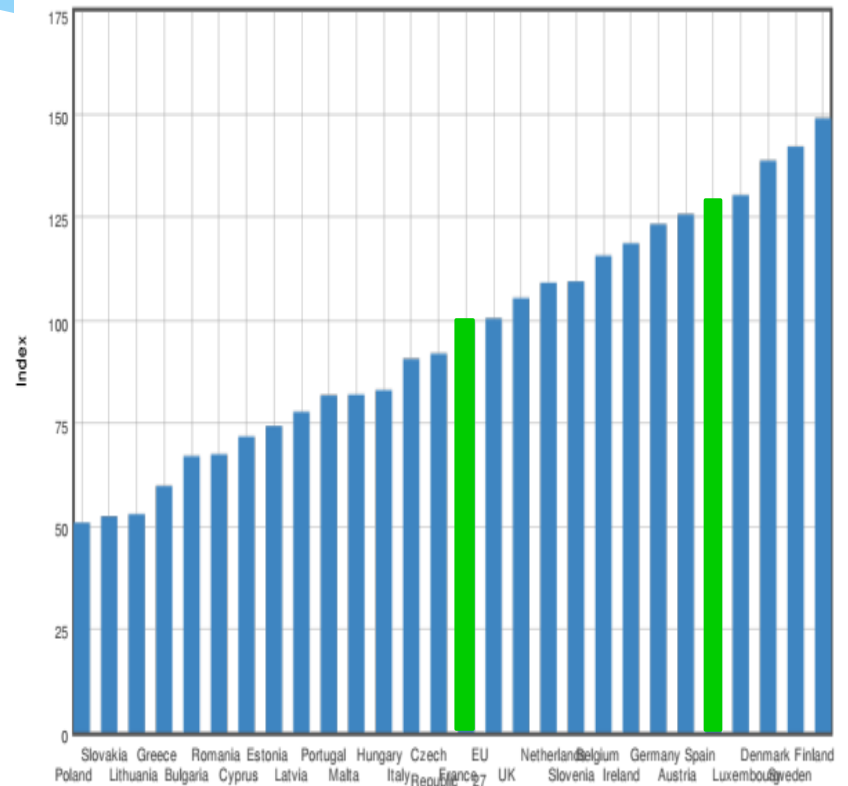
# Green innovation: what is it?

- \* **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

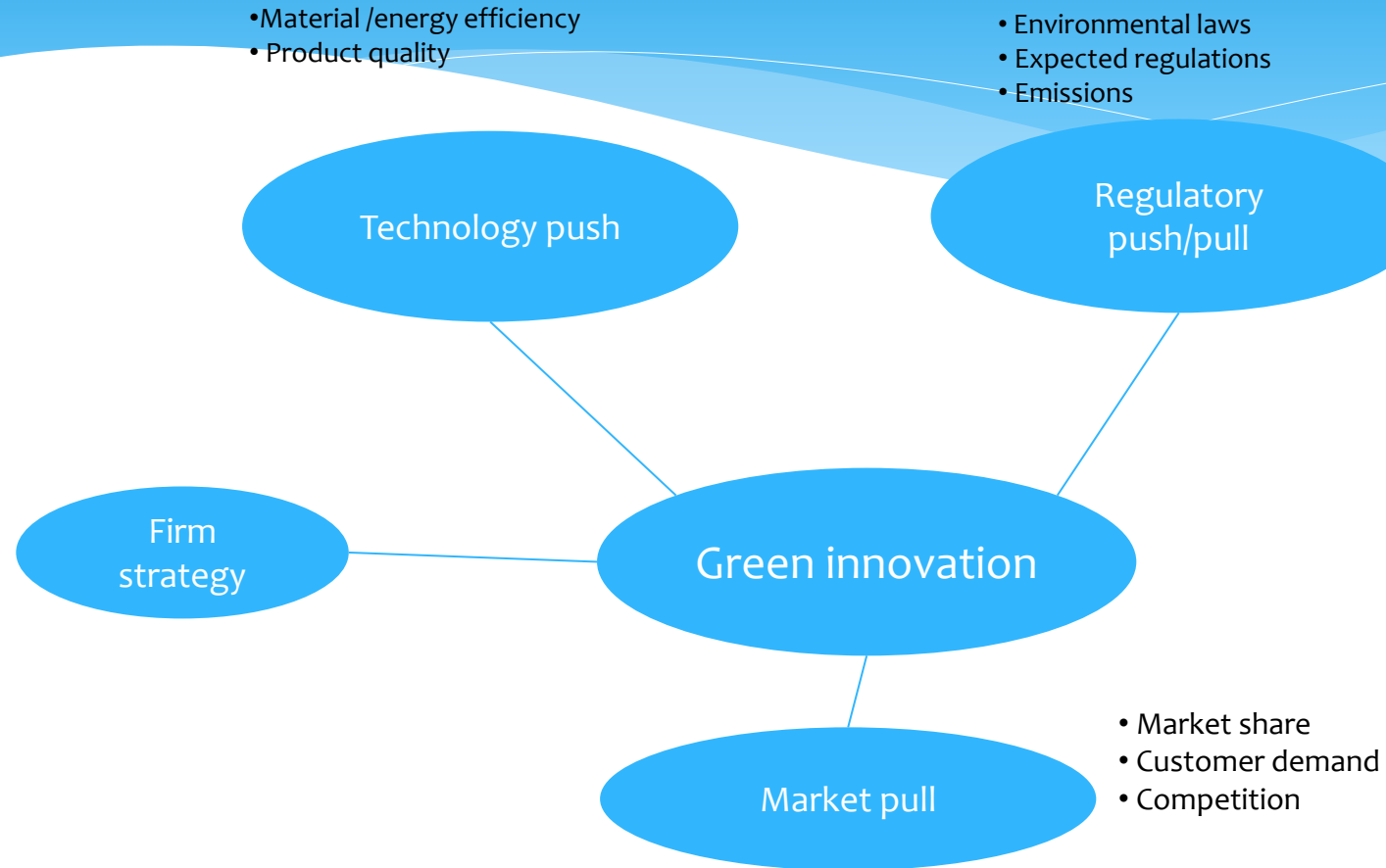
- \* **Aim to use green innovation to boost the economy** (Barranco 2013)
- \* **Moderate innovator** (Hollanders & Es-Sadki 2013)
  - \* Spanish gross domestic R&D expenditure 0.5% below the EU average (Eurostat 2013)
  - \* 1,23% 2013
- \* **Advanced in green innovation**
  - \* Composite index of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

# The MODEL





# 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

$$R\&D_{it} = \beta_0 + \beta_1 \text{Firm/Markets/Tech}_{it} + \beta_2 \text{Stragies}_{it} + \beta_3 \text{Regulation}_{it} + \mu_i + e_{it}$$

DEPENDENT VARIABLE: Environmental private R&D expenditure.

Private R&D investment in control and care of the environment (distribution by socio-economic 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  $\mu_i$  correlated?
    - \* Hausman test reject  $H_0$ : no correlation of explanatory variables with  $\mu_i$   
Solution: We include explicitly that correlation using  $\mu_i = \lambda \bar{X}_i + v_i$
- \* 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

	Random-effects				RE-Mundlak				TOTAL
	Invest-in-the-prod.-process	Invest-in-the-end-of-the-pipe	Acq.-of-energy-products	EMS	Invest-in-the-prod.-process	Invest-in-the-end-of-the-pipe	Acq.-of-energy-products	EMS	TOTAL
Investment prod.-process	0.258*** (0.082)				0.248*** (0.086)				-0.194 (0.144)
Investment end-of-the-pipe		0.250*** (0.076)				0.239*** (0.083)			0.022 (0.142)
Acquisition energy-products			0.799*** (0.187)				0.743*** (0.195)		0.902*** (0.373)
ISO14001				0.476*** (0.187)				0.685*** (0.161)	0.128 (0.260)
CONTROLS									
Constant	8.203*** (3.262)	7.596*** (3.427)	-1.722 (4.424)	4.077 (3.504)	8.826*** (3.913)	8.051** (3.887)	-1.152 (4.982)	0.855 (2.765)	-7.676 (4.719)
Log-Sales	-0.035 (0.178)	0.007 (0.176)	0.182 (0.181)	0.300 (0.189)	0.199 (0.413)	0.133 (0.401)	0.290 (0.389)	-0.699 (0.543)	-0.514 (0.547)
Human RD-intensity	0.148*** (0.060)	0.162*** (0.060)	0.190*** (0.061)	0.076 (0.076)	0.559*** (0.188)	0.754*** (0.187)	0.544*** (0.175)	0.804*** (0.319)	0.780*** (0.327)
Foreign capital	-0.699 (1.606)	-0.479 (1.547)	-1.477 (1.515)	-0.119 (1.340)	-0.095 (1.727)	0.091 (1.642)	-0.339 (1.651)	0.522 (1.457)	-0.260 (1.403)
Importance to reduce env. impact	0.008 (0.013)	0.003 (0.012)	0.006 (0.012)	0.011 (0.011)	-0.007 (0.017)	-0.007 (0.016)	-0.011 (0.016)	-0.004 (0.013)	-0.003 (0.015)
M(Human RD)					-0.447*** (0.199)	-0.654*** (0.198)	-0.377*** (0.188)	-	-0.665*** (0.347)
M(Foreign)					-0.263 (4.304)	0.735 (4.103)	-3.075 (3.982)	0.485 (3.826)	4.901 (4.655)
M(Reduce env. Impact)					0.026 (0.027)	0.011 (0.027)	0.038 (0.025)	0.037** (0.021)	0.049*** (0.025)
M(Sales)					-0.261 (0.461)	-0.123 (0.454)	-0.106 (0.442)	1.084*** (0.567)	1.044*** (0.565)
N. observations	130	129	136	80	130	129	136	80	75

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

α	Random effectsα				RE-Mundlakα				
	Public Fundsα	Energy taxesα	Env. Taxesα	Stringencyα	Public Fundsα	Energy taxesα	Env. Taxesα	Stringencyα	TOTAL°
Subsidiesα	0.613*** (0.116)α	α	α	α	0.746*** (0.111)α	α	α	α	0.486*** (0.140)α
Energy Taxα	α	0.331 <sup>†</sup> (0.254)α	α	α	α	0.365 <sup>†</sup> (0.305)α	α	α	-0.382 <sup>†</sup> (0.272)α
Pollution Taxα	α	α	0.283*** (0.127)α	α	α	α	0.304* <sup>†</sup> (0.179)α	α	0.187*** (0.092)α
CO2α	α	α	α	0.396*** (0.145)α	α	α	α	0.393*** (0.142)α	0.221* <sup>†</sup> (0.132)α
CONTROLSα									
Constantα	5.583* <sup>†</sup> (2.974)α	3.579 <sup>†</sup> (4.183)α	11.19*** (3.314)α	3.331 <sup>†</sup> (3.624)α	4.555 <sup>†</sup> (2.973)α	5.731 <sup>†</sup> (4.673)α	11.26** (5.614)α	3.126 <sup>†</sup> (4.011)α	5.345*** (2.495)α
Log-salesα	0.032 <sup>†</sup> (0.151)α	0.285 <sup>†</sup> (0.216)α	0.034 <sup>†</sup> (0.187)α	0.336* <sup>†</sup> (0.196)α	0.516 <sup>†</sup> (0.377)α	0.498 <sup>†</sup> (0.357)α	0.031 <sup>†</sup> (0.422)α	0.525 <sup>†</sup> (0.353)α	0.224 <sup>†</sup> (0.531)α
Human RD-intensityα	-0.034 <sup>†</sup> (0.057)α	0.087 <sup>†</sup> (0.078)α	0.374*** (0.122)α	0.119* <sup>†</sup> (0.070)α	0.550*** (0.170)α	0.612*** (0.185)α	0.381 <sup>†</sup> (0.318)α	0.631*** (0.184)α	0.182 <sup>†</sup> (0.382)α
Foreign capitalα	0.084 <sup>†</sup> (1.470)α	-1.008 <sup>†</sup> (1.275)α	0.753 <sup>†</sup> (1.148)α	-0.729 <sup>†</sup> (1.213)α	2.036 <sup>†</sup> (1.609)α	0.116 <sup>†</sup> (1.317)α	0.608 <sup>†</sup> (1.264)α	0.234 <sup>†</sup> (1.299)α	1.071 <sup>†</sup> (1.700)α
Importance to reduce env. impactα	0.023*** (0.011)α	0.003 <sup>†</sup> (0.014)α	-0.006 <sup>†</sup> (0.011)α	-0.002 <sup>†</sup> (0.013)α	-0.016 <sup>†</sup> (0.015)α	-0.005 <sup>†</sup> (0.017)α	0.003 <sup>†</sup> (0.017)α	-0.004 <sup>†</sup> (0.017)α	0.009 <sup>†</sup> (0.022)α
M(Human RD)α	α	α	α	α	-0.628*** (0.181)α	-0.551*** (0.204)α	-0.003 <sup>†</sup> (0.355)α	-0.550*** (0.194)α	-0.031 <sup>†</sup> (0.380)α
M(Foreign)α	α	α	α	α	-4.316 <sup>†</sup> (3.238)α	-4.407 <sup>†</sup> (4.652)α	-0.040 <sup>†</sup> (5.371)α	-3.010 <sup>†</sup> (3.548)α	-0.624 <sup>†</sup> (2.371)α
M(Reduce env. impact)α	α	α	α	α	0.068*** (0.021)α	0.011 <sup>†</sup> (0.028)α	-0.016 <sup>†</sup> (0.032)α	-0.001 <sup>†</sup> (0.025)α	-0.002 <sup>†</sup> (0.025)α
M(Isales)α	α	α	α	α	-0.498 <sup>†</sup> (0.406)α	-0.174 <sup>†</sup> (0.443)α	0.010 <sup>†</sup> (0.508)α	-0.133 <sup>†</sup> (0.416)α	-0.036 <sup>†</sup> (0.537)α
N-observationsα	136α	89α	60α	89α	136α	89α	60α	89α	60α



**Table A. Robustness Diagnostics**

	IV	Hausman-Taylor	IV	Hausman-Taylor	Placebo-Test
Dependent Variable	Log-of-Environment-R&D-investments				Log-of-R&D-Investments
Investment in production process	0.473*** (0.124)	0.120 (0.096)			
Subsidies			1.072*** (0.139)	0.564*** (0.143)	0.892*** (0.090)
Energy Tax					-0.286*** (0.114)
Pollution Tax					0.014 (0.039)
CO2					0.081 (0.055)
CONTROLS					
Constant	4.615 (3.463)	11.206*** (4.720)	1.433 (2.593)	6.427*** (3.577)	0.152 (1.151)
Log Sales	0.083 (0.572)	0.279 (0.400)	0.547 (0.522)	0.479 (0.369)	-0.001 (0.223)
Human RD-intensity	0.379 (0.282)	0.531*** (0.183)	0.576*** (0.258)	0.538*** (0.167)	0.213 (0.161)
Foreign capital	-0.086 (2.043)	0.103 (1.671)	2.701 (1.896)	1.634 (1.587)	2.401*** (0.713)
Importance to reduce env. impact	-0.012 (0.020)	-0.006 (0.016)	-0.019 (0.018)	-0.014 (0.015)	-0.004 (0.009)
M(Human RD)	-0.251 (0.291)	-0.426*** (0.199)	-0.736*** (0.272)	-0.574*** (0.183)	-0.164 (0.159)
M(Foreign)	-2.797 (3.905)	1.110 (5.082)	-6.027*** (3.063)	-3.369 (3.708)	-0.575 (0.994)
M(Reduce env. impact)	0.025 (0.026)	0.028 (0.131)	0.075*** (0.022)	0.063*** (0.024)	0.016 (0.010)
M(Sales)	-0.094 (0.599)	-0.374 (0.472)	-0.474 (0.541)	-0.480 (0.410)	0.160 (0.225)
N observations	108	130	113	136	60
Instruments	Lprevec-1		Lfunds-1		
Rho	0.375	0.719	0.302	0.616	
$\Sigma u$	0.627	1.084	0.476	0.813	
$\sigma_u$	0.809	0.677	0.725	0.643	0.093

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# 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!!!**

