

# Environmental Regulations and Green Innovations: International and Irish Evidence

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# Disclaimer

Results are based on analysis of strictly controlled Research Microdata Files provided by Ireland's Central Statistics Office (CSO). The CSO does not take any responsibility for the views expressed or the outputs generated from this research.

# Research and Policy Context

## Two competing views in environmental economics

- **The pollution heaven hypothesis - McGuire (1982)**  
Stricter environmental regulations crowd out investment in innovation
- **The Porter hypothesis – Porter (1991) Porter and van der Linde (1995)**  
More stringent environmental regulations trigger greater investment in innovation – new clean technologies which over time may offset part of the compliance cost

# Research Questions

- Do environmental regulations incentivize firms to introduce innovations with environmental benefits?
- What other factors influence the propensity of firms to introduce innovations with environmental benefits?
- Is the innovation behavior different for firms with different characteristics?
  - Local vs foreign-owned
  - Manufacturing vs services

# Green Innovations

## **Innovations with environmental benefits within firm**

- reduced material or water use per unit of output
- reduced energy use or CO<sub>2</sub> footprint
- reduced air, water, noise or soil pollution
- recycled waste, water, or materials for own or sale

## **Innovations with environmental benefits for the end user**

- reduced energy use or CO<sub>2</sub> footprint
- reduced air, water, noise or soil pollution
- facilitated recycling of product after use

# International Evidence

## What factors drive firms' propensity to introduce green innovations?

- **Environmental regulations**

- + : DE - Horbach (2008); IT - Cainelli, Mazzanti, and Borghesi (2012); IR - Doran and Ryan (2012)
- - : IT - Borghesi, Cainelli, and Mazzanti (2015)
- No effect: DE - Rennings and Rammer(2011)

- **Innovation inputs**

- IT - Borghesi, Cainelli, and Mazzanti (2015); SP - Peñasco, del Río, and Romero-Jordán (2017); 19 EU countries - Horbach (2016)

- **Firm-specific factors**

- DE - Horbach, Rammer, and Rennings (2012); SP - De Marchi (2010); IT - Cainelli, and Mazzanti (2015)

- **Competition**

- DE - Horbach (2014) & Horbach and Rammer (2018)

- **Spillovers**

- IT - Antonioli and Mazzanti (2016)

- **Public Funding**

- IT - Cainelli, and Mazzanti (2013); KR - Castellacci and Lie (2017); DE - Rogge and Schleich (2018)

## Contribution and Novelties

- We analyse the effects of a comprehensive set of factors in an unified econometric framework
- We examine the role of spillovers - investigated only by a handful of studies in the context of green innovations
- We take into account for firm heterogeneity - important within a small open economy

# Key Findings

## Major drivers of Green Innovations (Green Innov) in Ireland

- **Environmental Regulations** → Pr(Green Innov) ↑ by **9-29%**
- **In-House R&D activity & acquisition of capital assets** → Pr(Green Innov) ↑, respectively, by **6% & 10%**
- **Larger firm** → Pr(Green Innov) ↑ by **3-5%**



# Empirical Methodology

A Probit model with sector ( $I_j$ ) and regional ( $R_r$ ) fixed effects

$$\text{Prob}(Y_i=1 | X_i) = F(X_i, I_j, R_r)$$

Where

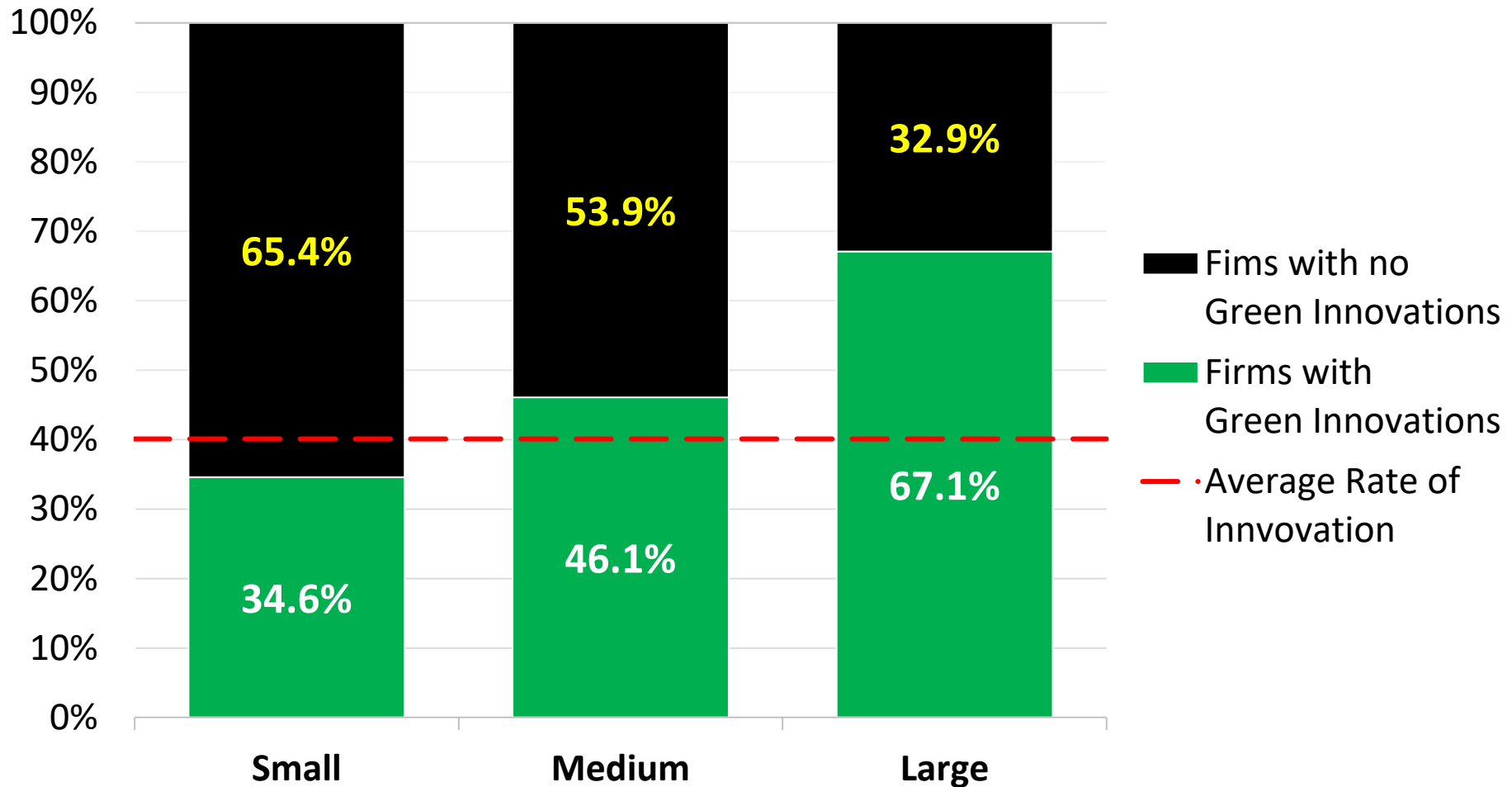
- $Y_i$  = a binary variable that takes the value 1 if firm  $i$  implemented any innovation with environmental benefits between 2012 and 2014.
- $X_i$  = a vector that includes explanatory variables, such as
  - Environmental regulations
  - Innovation inputs
  - Firm-specific factors
  - Spillovers
  - Public Funding

# Data

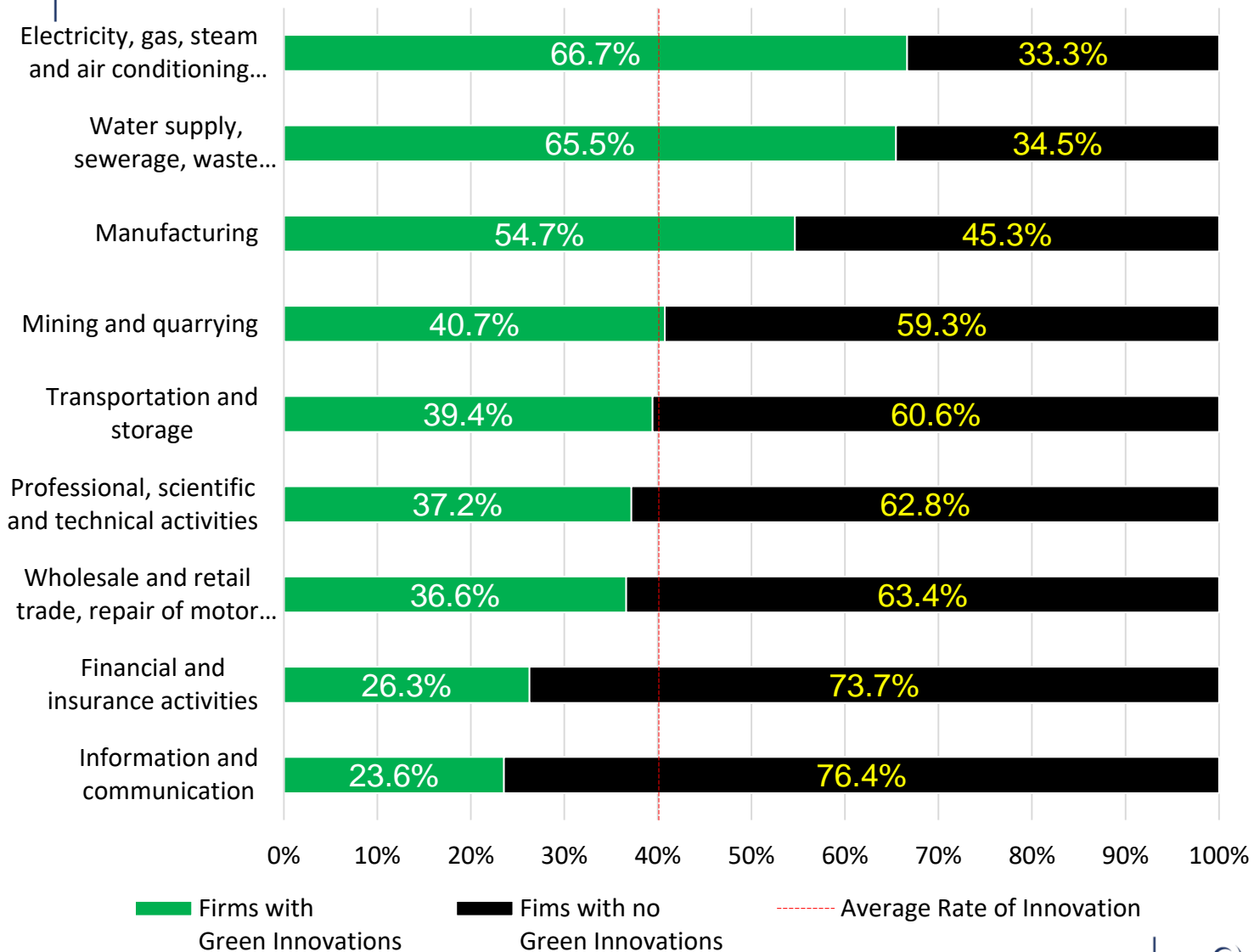
- Community Innovation Survey (CIS) 2014
  - Information on innovation activities of 3,036 firms, with 10 or more employees, over the period 2012-2014
  - Includes questions on Green Innovations
  - Covers manufacturing and services

# Descriptive Analysis

## Descriptive Analysis – Green Innovation Rate by Firm Size



# Descriptive Analysis – Green Innovation Rate by Sector



# Empirical Results

## Determinants of green innovations – all green innovations

Dep. Var.: Innovation with environmental benefits 2012 -2014	All firms	Manufacturing	Services	Indigenous	Foreign-owned
<b>Environmental regulations</b>					
Pre-2012	<b>0.092***</b>	0.012	<b>0.138***</b>	<b>0.089***</b>	<b>0.111***</b>
Post-2012	<b>0.256***</b>	<b>0.291***</b>	<b>0.242***</b>	<b>0.263***</b>	<b>0.236***</b>
<b>Innovation inputs</b>					
In-house R&D	<b>0.063***</b>	0.019	<b>0.069**</b>	<b>0.074***</b>	0.003
External R&D	0.000	0.044	-0.030	0.008	-0.014
Machinery, equipment, software & buildings	<b>0.106***</b>	<b>0.134***</b>	<b>0.096***</b>	<b>0.108***</b>	<b>0.090**</b>
Other external knowledge	<b>0.063**</b>	0.007	<b>0.095***</b>	<b>0.082***</b>	-0.0123
Other innovation activities	<b>0.060**</b>	<b>0.086*</b>	0.040	<b>0.075**</b>	0.040

Notes: The figures reported in the table are marginal effects. Robust standard errors are reported in parentheses. \*, \*\*, \*\*\* denote significance at 10%, 5% and 1% respectively.

## Determinants of green innovations – all green innovations - continued

Dep. Var.: Innovation with environmental benefits 2012-2014	All firms	Manufacturing	Services	Indigenous	Foreign-owned
<b>Co-operation With</b>					
Enterprise group	<b>0.075*</b>	0.079	0.071	0.020	<b>0.112*</b>
Suppliers	0.020	0.096	0.027	0.008	0.039
Private clients	0.071	<b>0.155*</b>	-0.012	0.090	0.057
Public clients	-0.017	-0.040	0.024	0.009	-0.041
Competitors	<b>0.121**</b>	0.021	<b>0.167**</b>	<b>0.134**</b>	0.123
Consultants, private R&D	-0.010	-0.114	0.032	-0.041	0.0617
Universities, HEI	-0.024	0.066	-0.101	-0.054	0.027
Government	-0.045	-0.048	-0.019	-0.049	0.057

Notes: The figures reported in the table are marginal effects. Robust standard errors are reported in parentheses. \*, \*\*, \*\*\* denote significance at 10%, 5% and 1% respectively.



## Determinants of green innovations – all green innovations - continued

Dep. Var.: Innovation with environmental benefits 2012 -2014	All firms	Manufacturing	Services	Indigenous	Foreign-owned
<b>Firm-specific factors</b>					
Productivity 2012	-0.002	-0.004	0.000	-0.002	0.001
Size (employment quartile)	<b>0.026***</b>	<b>0.048***</b>	0.011	<b>0.031***</b>	0.019
Exported to Europe	-0.015	-0.023	-0.010	-0.029	0.036
Exported to other destinations	-0.021	-0.045	-0.020	-0.022	-0.012
Irish owned	0.007	0.026	0.011		
USA owned					<b>-0.067*</b>
EU owned					0.010

Notes: The figures reported in the table are marginal effects. Robust standard errors are reported in parentheses. \*, \*\*, \*\*\* denote significance at 10%, 5% and 1% respectively.

## Determinants of green innovations – all green innovations - continued

Dep. Var.: Innovation with environmental benefits 2012-2014	All firms	Manufacturing	Services	Indigenous	Foreign-owned
<b>Spillovers (industry level)</b>	-0.123	-0.032	<b>0.610***</b>	-0.151	0.046
<b>Public funding</b>					
Local/Regional authorities	<b>0.084*</b>	0.035	<b>0.145**</b>	0.072	0.172
Central government	0.012	0.053	<b>-0.076*</b>	-0.003	0.084
European Union	0.011	0.074	-0.066	0.036	-0.121
Sector fixed effects	Yes	No	No	Yes	Yes
N	2763	854	1827	2137	624
Pseudo R <sup>2</sup>	0.220	0.267	0.167	0.212	0.274
Chi2	686.8	278.0	353.9	504.9	200.5

Notes: The figures reported in the table are marginal effects. Robust standard errors are reported in parentheses. \*, \*\*, \*\*\* denote significance at 10%, 5% and 1% respectively.

## Main Takeaways

- Environmental regulations incentivise firms to introduce green innovations
- Other factors associated with a greater propensity of firms to introduce green innovations include:
  - In-house R&D activity
  - Investment in tangible and intangible assets
  - Firm-size
  - Knowledge spillovers from other green innovators (in the case of services firms)

# Thank you!

# Determinants of green innovations: Firm-level evidence

Working Paper No. 643

<https://www.esri.ie/system/files/publications/WP643.pdf>

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