The European Commission's science and knowledge service

Joint Research Centre

Environmental Innovations: indicators, demand side, innovative public procurement

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Outline

Innovation Policies

- Difficult to identify level of resources market can invest for knowledge
  - Market can fail in providing adequate levels of R&D Investments;
  - Limited appropriability and intrinsic uncertainty of any innovation process;
  - sub-optimal supply of knowledge and social losses in the absence of proper technology and innovation policies (e.g. Laranja et al. 2008, Flanagan et al. 2011).

Demand pull and Innovation

- Crucial role of public (mainly governmental) **demand** in shaping direction and speed of technological change (Nelson, 1982)
  - Levin (1982): semi-conductors technologies at their early stage development;
  - Katz and Phillips (1982): computer industry;
- Recent turn to demand oriented innovation policies to stimulate innovation (OECD, 2011; Edler et al. 2012).
- **Public procurement** (PP) is an instrument of public demand policies: conceived as a tool useful to reduce the risks characterizing any innovation investment (Helpman and Trajtenberg, 1994) when:
  - Related demand is unknown;
  - Market size is too low;
  - Development is uncertain, making it too risky for the firm to sustain the costs.

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Public Procurement

- Support to innovative activities through PP as a driver for the uptake of crucial technologies:
  - as it happened in the case of general purpose technologies (Ruttan, 2006)
  - which in turn played the role of enabling technologies that fostered widespread technical progress
  - Steam engine, electric motor and semi-conductor - in turn enabling technologies leading to economic growth (Bresnahan and Trajtenberg, 1995).
- PP can be even more effective than alternative technology policy instruments (e.g. subsidies or grants or loans) in overcoming market or systemic failures and in stimulating private investments
- Geroski (1990) PP to be preferred over subsidies to stimulate industrial innovation as the latter are "unconscionably expensive" and may attract second best projects.

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Public Procurement

What is Public Procurement

"Every year, over 250 000 public authorities in the EU spend around 14 % of GDP on the purchase of services, works and supplies. In many sectors such as energy, transport, waste management, social protection and the provision of health or education services, public authorities are the principal buyers.
Public procurement refers to the process by which public authorities, such as government departments or local authorities, purchase work, goods or services from companies. Examples include the building of a state school, purchasing furniture for a public prosecutor's office and contracting cleaning services for a public university (EC, DG GROW)"

Public Procurement

- Public procurement is a significant tool of the European Single Market as it represents 19% of the EU Gross Domestic Product (GDP) spent by the public sector and utility service providers on public works, goods and services.
- "Given its huge economic weight, public procurement is a powerful instrument to pursue broader policy objectives and foster growth in the EU" (EC, DG GROW)
- "In the last decade, public procurement has also acquired a strategic role. Governments are shifting away from considering procurement a purely administrative function, and are increasingly using public tenders as a means for achieving policy goals, notably in the realms of innovation, sustainable and social development" (EC, DG GROW).

Strategic Public Procurement

EC has now moved its attention to **strategic public procurement**:

- Green public procurement;
  - "procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (COM (2008) 400)
- Socially responsible public procurement;
  - includes social aspects in the purchasing decision of the public body, e.g. employment opportunities, decent work, compliance with social and labour rights, social inclusion (including persons with disabilities), equal opportunities, accessibility;
- Public procurement of innovation; Innovative Public procurement.

Innovative Public Procurement

Innovative vs Regular PP

Innovative PP occurs when a public institutions does not limit to buy already existing products or services for which no R&D is involved, rather it refers to products or services which still have to be developed but could be within a reasonable time and aim at satisfying human needs or solve societal problems and thus promote innovation
(Edquist and Zabala-Iturriagagitia 2012).

- Evidence suggests that in contrast to the other two types of strategic public procurement, IPP is exclusively carried out on a voluntary basis by MS
- are more complex and less suitable to standardisation as it responds to specific needs of the contracting authority and therefore it is not applicable as a one size fits all policy (EC, DG GROW, 2015)

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Innovative Public Procurement

- Instrument of technology policy;
- Source of innovation:
  - it counteracts market and systemic innovation failures;
  - failures would contrarily lead to under-investments in innovative activities (Edlerand and Georghiou, 2007; Edquist and Zabala-Iturriagagoitia, 2012);
  - IPP has the potential to improve delivery of public policy and services, often generating improved innovative dynamics and benefits from the associated spillovers
  - but it has been neglected or downplayed for many years (Edler and Georghiou 2007: 949)
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Innovative Public Procurement

- Significant driver for innovation in empirical analysis (Aschoff and Sofka, 2009; Guerzoni and Raiteri, 2015).
- Aschhoff and Sofka (2009) focus on German firms and find that PP lead to heterogeneous effects on firms innovation performance: in particular it is effective for smaller firms, located in regional areas under economic stress thus suggesting it may be of particular relevance for firms facing limited resource constraints.
- Guerzoni and Raiteri (2015) provide original evidence on the interactions of demand and supply side technology policies for firms innovative activities, finding support that the interaction of R&D subsidies, R&D tax credits and IPP helps explaining innovation, but also that IPP is more effective than R&D subsidies in stimulating innovation.

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Research Paper

- "Demand-pull and environmental innovations: estimating the effects of innovative public procurement"
- under review
- link Public Procurement to Environmental innovations

Environmental Innovations EI

- Multiple definitions available (see Carrillo-Hermosilla et al. 2010)
- one of the most established one:
  "is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) which results, throughout its lifecycle, in a reduction of environmental ris, pollution and other negative impacts or resources use (including energy use) compared to relevant alternatives" (Kemp and Pearson, 2008).
- Growing research on the topic including determinants, economic effects, environmental effects.

Public Procurement & EI

- PP can be useful to favour the achievements of European 2020 goals in terms of:
  - Socio-economic sustainability;
  - Environmental sustainability.
- Environmental innovations (EI) require more systemic lens than "standard" innovations (Rennings, 2000);
- In principle the uptake of climate-friendly energy technologies (EI) is affected by public policies that support the demand as the transition requires (Mowery et al. 2010):
  - the invention, adoption and diffusion of radical and consequently riskier innovations;
  - high investment levels which are not likely to be sustained by the sole private sector.
- Crucial importance of EI to lead to win-win solutions whereby sustainability and competitiveness are combined (EEA, 2014).

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Research Hypothesis

- PP can create **niches** that allow the emergence of EI in their early stages:
  - Favour their early adoption;
  - More than it would have been in the absence of public support;
  - Reduce the associated risks of the investments due to the radicalness of the innovation combined with the uncertain demand;
  - Can create niches to be exploitable for EI and favor their early stage adoption, coherently with the lead market approach (Beise and Rennings, 2005; Edler and Georghiou, 2007; Horbach et al. 2014).

Formulation of RQ and RH

Main Question

Does innovative PP affect firms environmental strategies?

Main Hypothesis

Expectation of a positive effect exerted by PP on firms' EI

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Expectation of a positive effect exerted by PP on firms' EI

Originality

- Many academic contributions confirmed environmental regulation to be a driver for EI (Barbieri et al., 2016, for a review; Horbach et al. 2012; Rennings, 2000);
- Neglected the role of PP as effective policy instrument for EI;
- The absence of adequate policy instruments and mixes can be lead to technological lock-ins and path dependency in dirty and more established technologies (Oltra and Saint Jean, 2009);
- First empirical analysis aimed at empirically investigating the role of PP as a policy instrument to drive EI.

Dataset

- Empirical analysis on Innobarometer (2015) dataset (EC, 2015):
  - Flash Eurobarometer 415 - The Innovation Trends at EU Enterprises ;
  - TNS Political and Social and commissioned by the DG for Internal Market, Industry, Entrepreneurship and SMEs;
  - December 2015
  - It covers any business with one or more employee in manufacturing and service sector (NACE C to M and R);
  - in EU28, Switzerland and the USA;
  - Respondents were general managers, financial directors or owners;
- The full sample amounts to 14.118 businesses, 13.117 of which in EU28;
- Q on the role of PP and on the EI were only meant for manufacturing firms (3018, 3001 after cleaning for missing values)

Variables Description

Table: Main variables

VAR	Descr
EI	The company has adopted or plans to adopt in the coming 12 months sustainable manufacturing technologies (i.e.which use energy and materials more efficiently and reduce emissions)
FINbar	The company perceived the lack of financial resources
GROUP	The company is part of a group
INNO	Processor product innovator
Lsize	Natural logarithm of the full-time equivalent employees
IPP	The company submitted at least one tender for a PP contract and included an innovation as part of such contract
PP	The company submitted at least one tender for a PP contract
RD	The company invested in R/&D activities
YOUNG	The company has been established after January 2014

Empirical Strategy 1

1. Model probability of introducing EI on a set of covariates as in relevant EI literature by IPP as a regulatory variable

$$EI_i = \alpha + \beta_1 IPP_i + \beta_2 RD_i + \beta_3 GROUP_i + \beta_4 Lsize + \beta_5 YOUNG_i + \beta_6 INNOPD_i + \beta_7 INNOPC_i + \gamma Sec_i + \gamma Country_i + \epsilon_i \quad (1)$$

Results

Table: Main Results STEP 1

	(1)	(2)	(EU15)
IPP	0.4739***	0.3851***	0.6196***
	(0.1306)	(0.1318)	(0.1817)
RD	0.5623***	0.4146***	0.4561***
	(0.0861)	(0.0890)	(0.1315)
GROUP	0.1668*	0.1246	0.2730*
	(0.1000)	(0.1015)	(0.1434)
Lsize	0.1606***	0.1503***	0.1476***
	(0.0284)	(0.0296)	(0.0426)
INNOPD		0.4256***	0.4616***
		(0.0934)	(0.1305)
INNOPC		0.5008***	0.5645***
		(0.0884)	(0.1287)
YOUNG		0.0751	0.2072
		(0.1648)	(0.2516)
Cons	-2.5647***	-2.5697***	-2.3638***
	(0.3486)	(0.3514)	(0.3744)
N	3001	3001	1475
pR2	0.0701	0.088	0.1103

Selection bias?

- Need to rule out problems of simultaneity and selection bias in the funding process (David et al. 2000);
- The assignment of IPP to firms may be non randomized:
  1. Firms submitting IPP proposal can be self-selected on certain observable characteristics;
  2. public agencies can try to maximise the effects by imposing selection criteria ("picking the winner" or "aiding the poor")
- Potential selection bias in simple probit or logit: the difference in eco-innovators is not the consequence of the technology policy;
- Quasi-experimental through non-parametric matching methods as in Almus and Czarnitzki (2003);
- Compare the eco-innovative behaviour of a firm that has benefited of PP with the hypothetical scenario in which the same firm that has not gained from this treatment.

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Statistics by group

Variable	Description	Min	Max	Mean			
				Full sample n=3001	Treated (PP=1)	Control (PP=0)	T test on mean differences (#)
EI	The company has adopted or plans in the next 12 months to adopt sustainable manufacturing technologies	0	1	0.381	0.497	0.368	*
FIN bar	The company perceives a lack of financial resources	0	1	0.251	0.221	0.255	NS
GROUP	The company is part of a group	0	1	0.313	0.351	0.308	NS
Lsize	Natural logarithm of full-time equivalent employees	0	10.08	3.478	3.84	3.44	*
IPP	The company won at least one PP contract and included an innovation as part of this contract	0	1	0.103	-	-	-
RD	The company invests in R&D activities	0	1	0.528	0.660	0.513	*
Size	Measured by full-time equivalent employees	1	23764	162.78	289.16	148.33	*
YOUNG	The company was established after January 2014	0	1	0.0746	0.045	0.778	*

(#) *: variable mean differences in the two groups are statistically different from zero (t-test p value < 0.05) ; NS: the difference in the groups is not statistically different

ATT

- ATT = average treatment effect on the treated
- PP = the treatment (D=1)
- Y(1)= Outcome when firm receives PP
- Y(0)= Outcome when firm receives no PP

$$ATT = E[Y(1) - Y(0) \mid D = 1]$$
$$E[Y(1) \mid D = 1] - E[Y(0) \mid D = 1] \quad (2)$$

- For the treated firms it is not observed EI that would have been adopted in the absence of PP;
  - a counter-factual needs to be built;
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PSM

- The propensity score matching estimation of ATT is used (Rosenbaum and Robin, 1983)
- PS = models the probability of being treated;
- M= based on matching treated firms with "similar" untreated ones;
- Difference in EI is due only to the treatment - and not on unbservable divergences;

Conditional Independence Assumption

Once we control for all observable variables, the potential outcomes are independent of treatment assignment: no unobserved factor that influences both PP and EI.

Common support condition

The vector of those covariates should not perfectly predict the outcome.

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PSM

- **teffects psmatch** - STATA 13 estimates standard errors adjusted for the first step estimation (Abadie and Imbens, 2016)
  - 1st step: estimate the probability of receiving PP (propensity scores) according to selected covariates (FIN bar, GROUP, Lsize, RD, YOUNG and sector dummies)
  - 2nd step: Use PS to match treated and control firms by different matching algorithms

PSM Matching algorithms

1. Balance the bias-efficiency trade-off (Caliendo and Kopeinig, 2008)
2. one - by - one matching **NNM** (single nearest matching algorithm)
3. **3NNM**: 3 matches per observation taken from the non treated group
4. 3NNM and set a **caliper** to impose a minimum degree of quality of the matching by setting a maximum distance at which two observations are matched.
   - as suggested by Rosenbaum and Rubin (1985) equal to 0.25 ps*sd **0.0114**
5. 5NNM
6. Kernel (bootsrap s.e.)

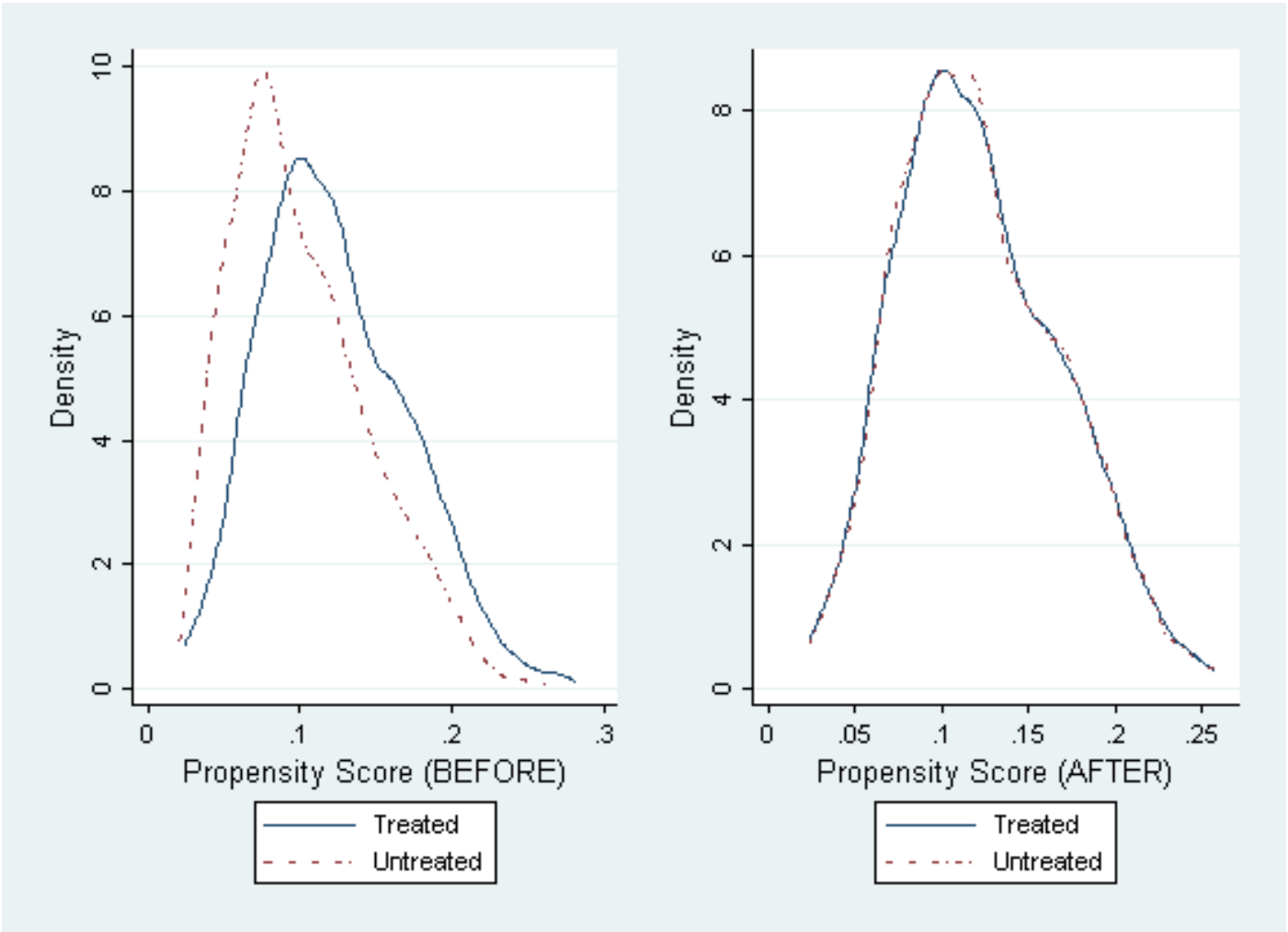
PSM Robustness

1. Full sample
2. **Reduced sample**: a more restrictive control group construction, which increases the homogeneity of firms in the two groups
   - by excluding firms that declared never having submitted a IPP tender or explored the possibility of doing so;
3. Different innovative outcome **INNO**, equal to 1 if firms are either product or process innovators, is used as an outcome variable in the estimates of ATT of IPP treatment.

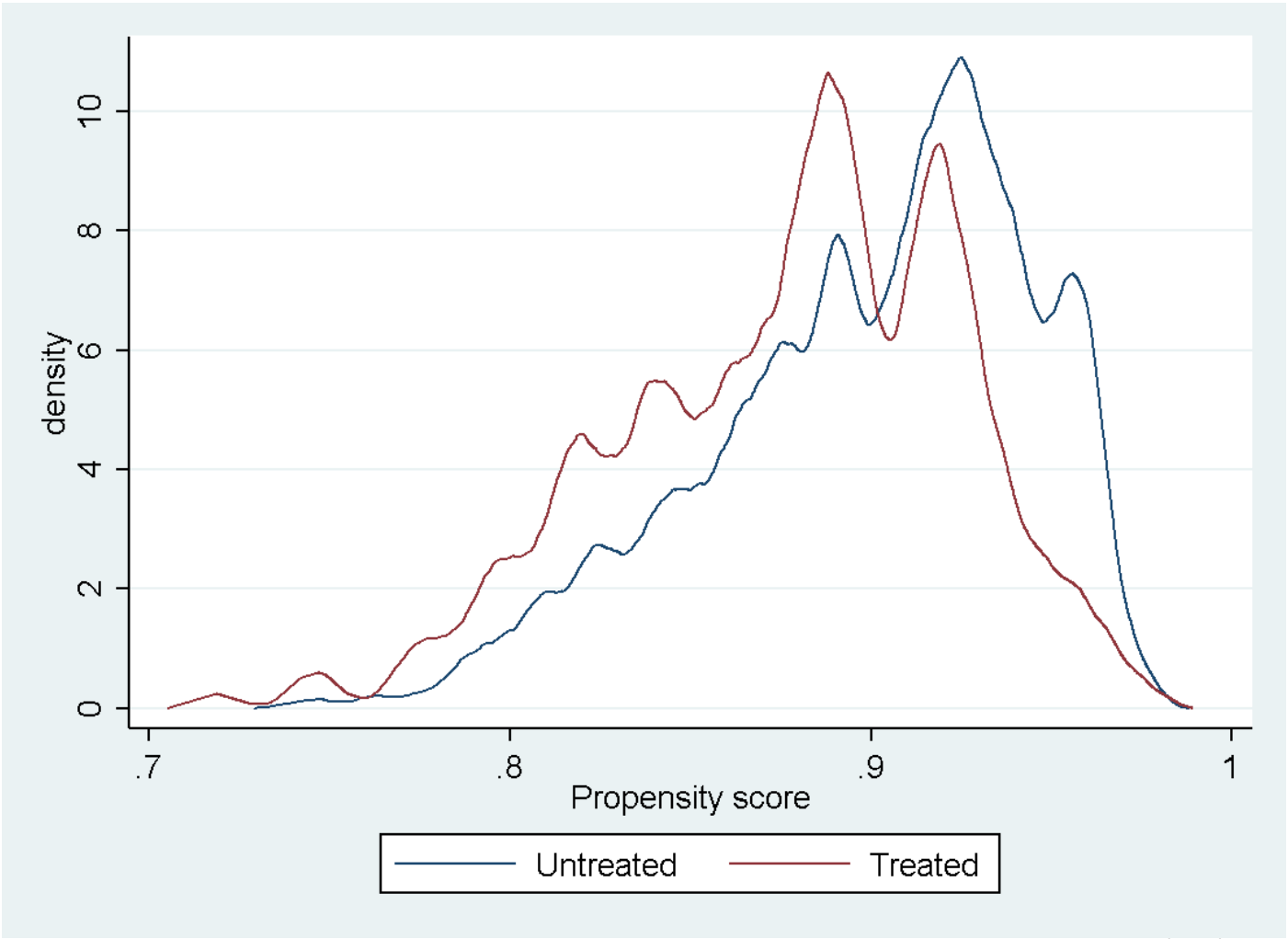
Quality of the matching

- Regression t-test on differences in covariates means: **OK**
  - all p values in the test fall below 5 percent
- log-likelihood ratio test: **OK**
  - it is rejected before matching and not after the matching
- Pseudo R2 test: **OK**
  - Pseudo R2 in matched is lower than in the unmatched
- Standardized bias test: **OK**
  - Mean std bias below 5 percent

Quality of matching



Overlap



Results

	(1) ATT	(2) ATT reduced sample	(3) ATT outcome INNO
3NNM	**0.111*** **	0.112***	0.066***
	(0.033)	(0.037)	(0.025)
NNM	0122***	0.101***	0.067**
	(0.038)	(0.041)	(0.028)
3NNM caliper (°)	0.098***	0.150***	0.064**
	(0.034)	(0.037)	(0.025)
5NNM	0.107***	0.116***	0.060**
	(0.032)	(0.036)	(0.024)
Kernel (°°)	0.121***	0.126***	0.077***
	(0.029)	(0.032)	(0.024)

SE in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

(°)Caliper = 0.25 times PS' SE. It equals 0.0114 in the whole and 0.0198 in the reduced sample

(°°)Bootstrapped SE, 1000 repetitions

Environmental Regulation

- Environmental Regulation as driver for EI

OECD EPS

The **OECD** Environmental Policy Stringency ranges from 0 to 6 and it grants comparability across country.
It is based on the degree of stringency of 14 environmental policy instruments, primarily related to climate and air pollution.

- n.a. for: Luxembourg, Croatia, Cyprus, Estonia, Latvia, Lithuania, Malta, Slovenia, Bulgaria, Romania
  - n falls to 2238, 235 of which are treated and 2003 are not last available year 2012
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Conclusion

- Innovative PP confirmed to be a significant driver for EI:
  - the difference in outcome averages between the treated and control groups after pairing, is positive and significant for the alternative matching algorithm adopted;
  - The number of firms that are environmentally innovative after treatment by IPP is **11.1** percentage points higher in the treated compared to the control group;
- The effect on more standard innovative outcomes remains significant and positive but it is half that for EIs
  - the number of firms in the treated group is only **6.6** percentage points higher compared to the control group.

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Conclusion

- This result is robust to:
  - a more restrictive control group construction, which increases the homogeneity of firms in the two groups;
  - alternative matching algorithms;

Implications

- As the full social costs of pollution are not (yet) reflected in market prices
- As early versions of most alternative energy technologies would be handicapped when compared to dirtier technologies by prospective adopters (Fisher and Newell, 2008; Newell, 2010)
- EI may require policy support for early adopters.
- As IPP helps to reduce the risks of innovation investments facing unknown demand, low expected market size;
- As EI may suffer of technological lock-ins at the advange of dirtier technologies
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Limitation

- Diversity in the nature of EIs calls for the need to be cautios as one-size-fits-all model of IPP is unlikely to work;
- IPP moel does not work in all procurement contexts and for all types of goods and services (Uyarra and Flanagan, 2010);
- Current data do not allow to highlight the design of PP instrument:
  - which affects the degree of success of the instrumnent (Geroski, 1990);
  - bad design can eventually lead to policy failures (Georghiou et al. 2014).
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Thanks for your attention

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1st step

	PS	PS reduced sample
Lsize	0.1156***	0.1090**
	(0.0425)	(0.0455)
GROUP	-0.1518	-0.1690
	(0.1529)	(0.1633)
YOUNG	-0.4084	-0.3905
	(0.2856)	(0.3055)
RD	0.4835***	0.4171***
	(0.1323)	(0.1410)
FIN_bar	-0.0546	-0.2112
	(0.1495)	(0.1618)
Cons	-2.4237***	-1.5670***
	(0.2088)	(0.2289)
N	3001	1253
pseudo R^2	0.0336	0.0307

SE in parentheses $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$
Seven Sector dummies included

OECD EPS index