Innovation Performance and Signal Effect: Quasi-experimental Evidence from European Program

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Motivation.

Public support to productivity growth popular among OECD and emerging countries:

- **Objectives**: Stimulate private expenditure on R&D through a reduction cost
- Address market failures: **knowledge spillovers** and **financing constraints**

But do government intervention really work?

- Do R&D grants have a positive effect on innovation output?
- How more likely credit constrained firms respond?
- Is it economically efficient to subsidized private innovation?

Despite widespread positive argument of R&D tax incentives:

- Evidence of causal impacts of R&D subsidies on innovation output are scarce
- Causality identification are not convincing (endogeneity bias)
- Cost-benefit analysis important due to budget constraints

This paper:

- Exploits grant assignment and controlling for endogeneity bias
- treatment randomization after conditioning on observable characteristics plus diff-in-diff to control for time-invariant unobserved firm characteristics
- Evaluates European policy on firm patenting and use of external capital

Related Literature.

Bronzini and Piselli, 2016

- uses the score-based fund assignment of the **Northern Italian** program to control for selection bias
- exploit exogenous variation at a particular threshold $\rightarrow$ **local effect**
- finds firms increase patent application and probability to file a patent

Howell, 2017

- evaluate impact of Energy US SBIR program
- Firms increase cite-weighted patents and VC in response to R&D grants
- Stronger response for youngest firms and emerging sectors

This study differs in:

- captures the differential change for the treatment group relative to the control group to estimate ATT
- studies European SMEs' patent and debt financing policy response

Key Findings.

Program Effects

Subsidized proof of concept effectively spur innovation performance

- At the intensive and extensive margins (ATT)
- Stronger effect for more financially constrained firms (i.e., young firms)

No evidence on innovation performance for commercialization grants

Mechanism of the Impact

- R&D grants increase subsequent debt outstanding
- Signal effect on external investors

SME Instrument: Policy Background.

Selective program for SMEs managed by the EIC (Horizon 2020) that supports for breakthrough innovation projects with a market-creating potential

SMEs apply with a business plan. Evaluation process assigns overall score and selects the best project based on a competitive evaluation and ranking. R&D grants cover **70%** of investment project costs

Analog to **SBIR** program in the US (launched in 1984) but with lowest amounts of R&D grants

R&D Grant supports

Phase 1: Proof of concept phase

- Lump sum of €50,000 per project
- Project duration: 6 month

Phase 2: Innovation and commercialization phase

- €500,000 to €2.5 million per project
- Project duration: around 1 to 2 years

In 2014:

- 33 involved countries
- 8,182 applicants
- €250 million allocated to 825 projects

Data.

- **EASME**: Administrative base on SMEI program winners (treatment), information on firm identifier, address, grant amount awarded and timing of funding
- **Amadeus**: Balance sheet information on treated and control group recorded at the firm level.
- **PATSTAT**: Information on worldwide patent. **EPO**, **WO** and **USPTO** patent applications from 2008 to 2017
- **Crunchbase, Dealroom**: Information on other European-based programs participation

Balanced panel from matched samples for the period 2008-2017 for 10 European countries.

Outcome and Control Variables.

Measures of intensive and extensive margins innovation

- Intensive margin: Patent applications at EPO, WO and USPTO
- Extensive margin: dummy for positive patent applications ($P > 1$)

Firm Characteristics

- Age (incumbents inertia)
- Size: total assets
- Intangible Assets
- Tangible Assets
- Patent Stock (innovative capacity)

Control

- Country location
- Sector classification

Summary Statistics.

	Treated Group			Control Group			
Variables	Mean	Max	Std.	Mean	Max	Std.	Diff
Outcome variables:							
Patent	0.223	39	1.552	0.121	365	1.659	***
Appl	0.079	1	0.270	0.061	1	0.240	***
Control variables:							
Age	9.758	73	10.714	17.480	1121	18.502	***
Size (log)	13.835	18.784	2.301	13.644	22.712	1.905	***
Intangible Assets (log)	6.666	17.217	6.215	4.854	19.722	5.199	***
Tangible Assets (log)	11.441	17.403	2.577	11.474	20.636	2.308	–
Patent Stock	0.436	56	2.328	0.130	776	2.284	***

Quasi-experimental Design.

Threat to identification: Treatment Endogeneity

- R&D grants are not randomly assigned
- Recipient might differ conditional to unobserved characteristics
- Public agency *"Picking-the-winners"* associated with higher performance

→ Selection on pre-treatment observable covariates: **One-to-one propensity score matching** without replacement

▸ Matching

DID specification

$$Y_{it} = F[\alpha + \beta_1 D_{it_k} + \beta_2 D_{it_k} \times Post_t + \eta_i + \delta_t] \quad (1)$$

$\rightarrow$ Control estimates from unobserved time-invariant heterogeneity

- Y_{it}: outcomes at firm level *i* in calendar year *t*
- $D_{it_k} \times Post_t$: key policy variable of interest turn to one for recipient firms in **post treatment period**
- Assumptions: CDID valid if treated and control groups would have followed a **parallel trends**
  - Parallel Trend Tests indicate no differences $\beta_{-6} = ... = \beta_{-1}$

▸ Pre-Trends

Effect of the SMEI program.

	OLS		Poisson	Logit
Dependent variable:	**(1)** *Log Patent*	**(2)** *Appl*	**(3)** *Patent*	**(4)** *Appl*
	Panel A. Phase 1			
Recipient*Post-Grant	0.031*	0.036**	0.529*	0.504*
	(0.018)	(0.017)	(0.291)	(0.293)
Obs.	5,680	5,680	1,890	1,870
Clusters (firms)	568	568	189	187
log-likelihood	–	–	-1,221.1	-684.0
	Panel B. Phase 2			
Recipient*Post-Grant	0.033	0.039	0.124	0.595
	(0.071)	(0.045)	(0.573)	(0.731)
Obs.	1,520	1,520	1,520	1,520
Clusters (firms)	152	152	55	52
log-likelihood	–	–	-774.6	-195.1

Treatment Heterogeneity by Firm Age and Size Phase 1

	OLS		Poisson	Logit
Dependent variable:	**(1)** *Log Patent*	**(2)** *Appl*	**(3)** *Patent*	**(4)** *Appl*
Recipient*Post-Grant				
×Age	0.070**	0.063**	0.887***	0.874**
	(0.028)	(0.028)	(0.297)	(0.413)
×Size	-0.022	-0.034	-0.068	-0.467
	(0.025)	(0.026)	(0.299)	(0.388)

Positive effect of R&D grant in proof of concept Phase

- Increases firm's patenting on intensive and extensive margins.
- Strongest respond for **younger** and **larger** SMEs
- Zero evidence for **older** and **smaller** firms

No effect of Phase 2 on innovation performance
$\rightarrow$ Seems to reflect innovation development and commercialization

Robust to alternative specifications

- IPW
- Permutation tests
- Anticipation Effect

Robustness

Mechanism of the Impact

Phase 1 grant effect on external capital

Dependent variable:	*Log Loan*			*Log Debt*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Recipient*Post-Grant	0.692*	-0.006	0.386	0.557	0.073	0.086
	(0.410)	(0.489)	(0.503)	(0.421)	(0.451)	(0.446)
×Age		2.163***			1.626***	
		(0.647)			(0.628)	
×Size			0.654			1.315***
			(0.556)			(0.500)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	3,726	3,726	3,726	3,490	3,490	3,490
Clusters (firms)	474	474	474	481	481	481

Significant effect on probability of short and long term debt financing for youngest SMEs $\rightarrow$ **Signal project's quality**

Conclusions

Evaluation of SMEs' financial support for innovation using quasi-experimental R&D grant assignment for 10 EU countries

- **Positive effect** on patent applications and probability of patenting in Phase 1
- **No effect** on innovation performance for Phase 2 participants
- **Positive effect** on most financially constrained firms, but... **larger** SMEs benefit from the subsidy

Proof of concept grants **signal project's quality** of youngest firms to investors.

R&D grant is important for the subsequent development of young firms.

Thank you.

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For Further Reading

Balancing Tests

	Phase 1			Phase 2		
	Recipient Firms	**Non-recipient Firms**		**Recipient Firms**	**Non-recipient Firms**	
Covariates	Mean	Mean	Diff	Mean	Mean	Diff
Age	11.980	12.415	0.434	13.039	13.934	0.874
	(0.627)	(0.582)	(0.082)	(1.298)	(1.109)	(1.708)
Size	13.972	13.933	-0.039	14.733	14.913	0.179
	(0.108)	(0.092)	(0.142)	(0.180)	(0.166)	(0.245)
Intangible Assets	8.196	8.371	0.174	9.131	9.201	0.069
	(0.345)	(0.312)	(0.465)	(0.667)	(0.655)	(0.935)
Tangible Assets	11.026	11.103	0.076	11.692	11.977	0.285
	(0.166)	(0.163)	(0.233)	(0.269)	(0.362)	(0.452)
Patent Stock	0.193	0.193	0	0.644	1.026	0.381
	(0.040)	(0.052)	(0.066)	(0.187)	(0.537)	(0.569)
Obs.	2840	2840		760	760	

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Parallel Trends

	Phase 1		Phase 2	
Dependent variable:	**(1)** *Patent*	**(2)** *Appl*	**(3)** *Patent*	**(4)** *Appl*
Recipient*Year-2009	0.005	-0.003	0.0004	0.026
	(0.020)	(0.022)	(0.051)	(0.039)
Recipient*Year-2010	0.006	0.010	0.045	0.078*
	(0.022)	(0.023)	(0.058)	(0.043)
Recipient*Year-2011	0.017	0.021	0.064	0.039
	(0.026)	(0.028)	(0.084)	(0.059)
Recipient*Year-2012	0.018	0.035	-0.063	0.013
	(0.025)	(0.028)	(0.073)	(0.053)
Recipient*Year-2013	0	0	0	0
Firm FEs	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes
Obs.	5,680	5,680	1,520	1,520
F-test	0.16	0.43	1.26	0.79
p-value	0.976	0.830	0.291	0.559

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Robustness Test: IPW

	OLS		Poisson	Logit
Dependent variable:	**(1)** *Log Patent*	**(2)** *Appl*	**(3)** *Patent*	**(4)** *Appl*
	Panel A. Phase 1			
Recipient*Post-Grant	0.033*	0.047**	0.343*	0.796***
	(0.017)	(0.018)	(0.176)	(0.299)
Obs.	405,121	405,121	112,123	111,593
Clusters (firms)	40,524	40,524	11,216	11,163
log-likelihood	–	–	-63,506.7	-38,090.7
	Panel B. Phase 2			
Recipient*Post-Grant	-0.032	-0.055	1.232*	-0.439
	(0.076)	(0.081)	(0.736)	(1.214)
Obs.	297,387	297,387	106,155	105,645
Clusters (firms)	37,290	37,290	10,619	10,568
log-likelihood	–	–	-73,817.5	-36,443.7
Firm FEs	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes

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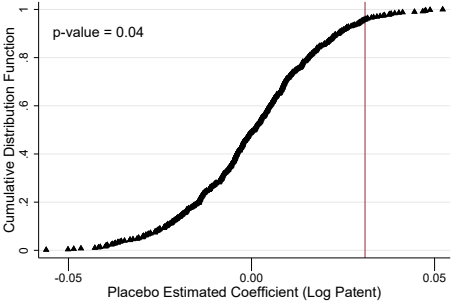
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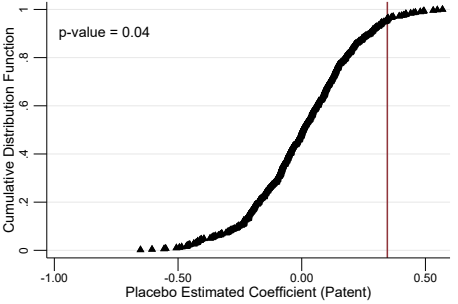
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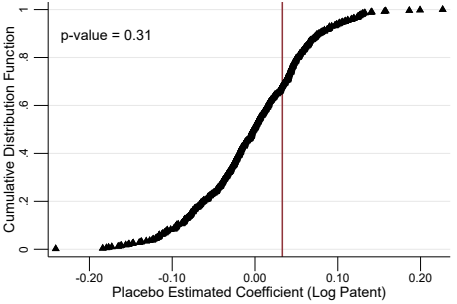
Placebo Estimated Coefficient (Patent)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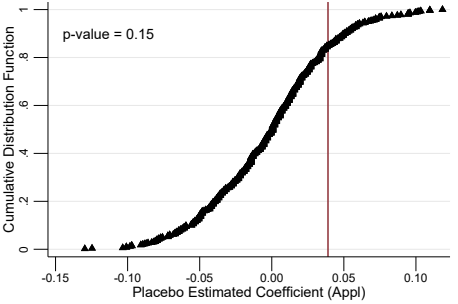
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Placebo Estimated Coefficient (Appl)