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Direct and Cross-scheme effects in a Research and Development Subsidy Program

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Motivation

- Impact of R&D on productivity is substantial, at the micro as well as at the macro level (see e.g. Griliches, 1980; Hall et al. 2010; Aghion and Howitt, 2005; Jones, 2005)
- Firms play a crucial role, for the discovery as well as the diffusion of new knowledge and technologies.
- BUT: R&D is subject to market failure (Arrow, 1962)
  - Incomplete appropriability of returns (weak or non-excludability) → knowledge spillover
  - Capital market imperfection
- HENCE: left to themselves, firms may underinvest in R&D and innovation from a social welfare point of view

Innovation Policy

- From a society's point of view: sub-optimal investment in innovation
  → especially with high social return and high levels of risk

- Justification for government intervention:
  - Patent systems (see e.g. Jaffe, 1986; Levin et al., 1987)
  - Publicly funded research at Universities and PROs (see e.g. Jaffe, 1989, Aghion et al., 2008)
  - Public venture capital (see Hall and Lerner, 2010, for a survey)
  - Tax credits (see e.g. Hall and Van Reenen, 2000)
  - **Direct subsidies**

Why direct subsidies ?

- Endogenous growth theory has singled out public subsidies to R&D as one of the main policy tools (Aghion and Howitt 1998; Howitt 1999; Segerstrom 2000)
- R&D subsidies are one of the largest and fastest-growing forms of industrial aid in developed countries (Nevo 1998; Pretschker 1998)
- EU exempts R&D subsidies from its state aid rules

What do we know so far?

- Ample literature analyzes the impact of public support on
  - Input additionality
    - See e.g. Wallsten (2000), Hall & Maffioli (2008), Czarnitzki & Lopes-Bento (2012, 2013), Takalo, Tanayama & Toivanen (2013)
  - Output additionality
    - See e.g. Branstetter & Sakakibara (2002), Hussinger (2008), Czarnitzki & Lopes-Bento (2014) Hottenrott & Lopes-Bento(2014)

This study...

...adds to the literature on the efficacy of R&D subsidies

- At which stage of the R&D process is it most effective?
- Is a policy with differentiated schemes for Research and Development more effective than a general one?

Why does it matter?

‘R’esearch

- Uncertainty of project outcome
- Higher probability of no returns at all (Karlsson et al., 2004)
- Far from market
- Knowledge creation often tacit (e.g. Arrow, 1962; Usher, 1964)
- Usually no tangible assets (e.g. Hall, 2002)
- Higher financing constraints (Kamien and Schwartz,1978)
- Higher externalities likely
- …

‘D’evelopment

- Based on previous success in ‘R’ (e.g. Mansfield, 1971; Rosenberg, 1990; Fleming & Sorenson, 2004)
- Higher probability of returns
- Closer to market (Cassiman, Veugelers, 2002)
- Patentable results, hence more tangible
- Yielding returns sooner
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→ Higher market failure and higher social to private return for R than for D

What we do

For a sample of Flemish firms (2000-2011), we

- Analyze impact of direct subsidies for R&D on private R&D investments
  - Distinguishing between R and D subsidies
    - Direct effects (within scheme)
    - Cross-scheme effects

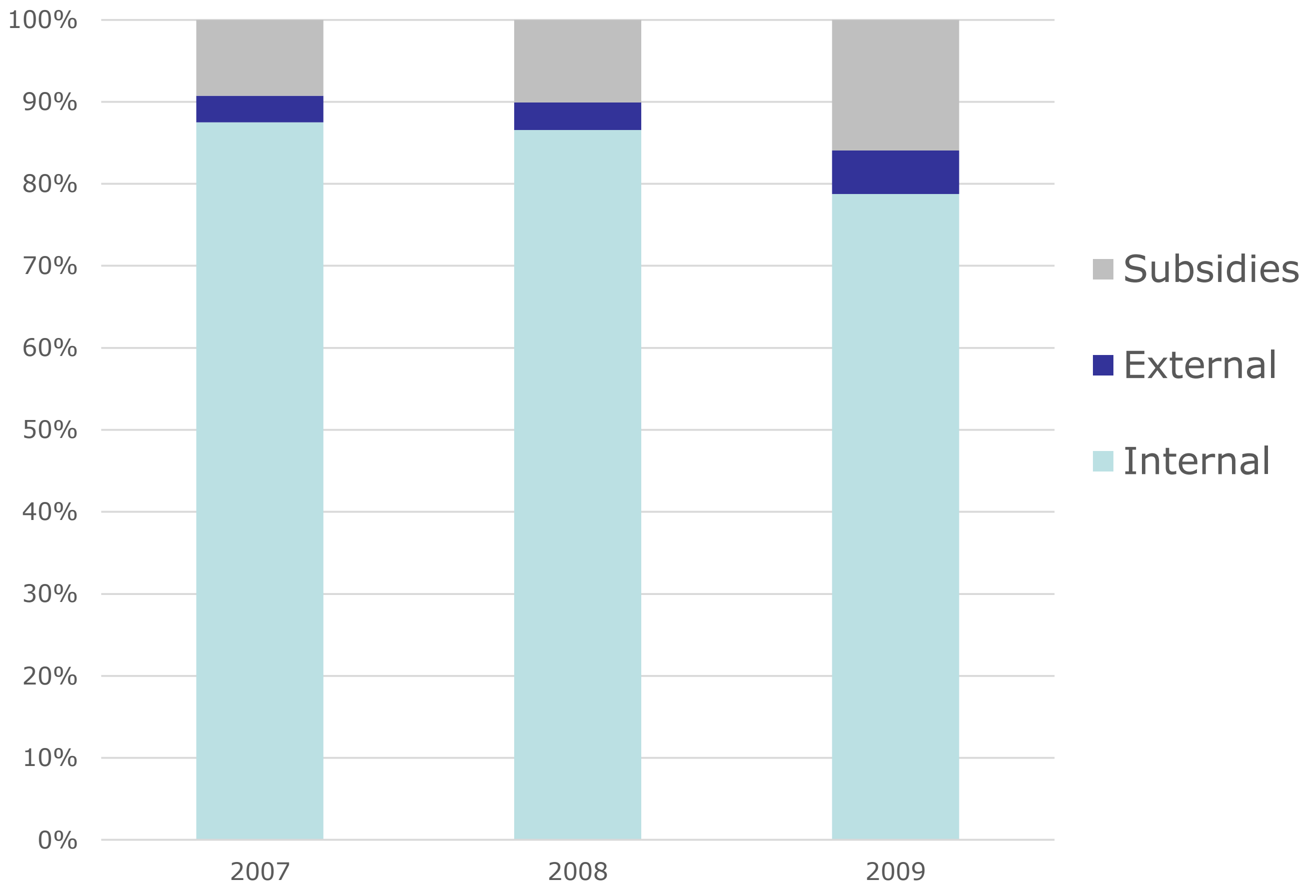
  → Measuring own and cross additionality

- Estimate elasticity of private R and D to grant size

Research setting

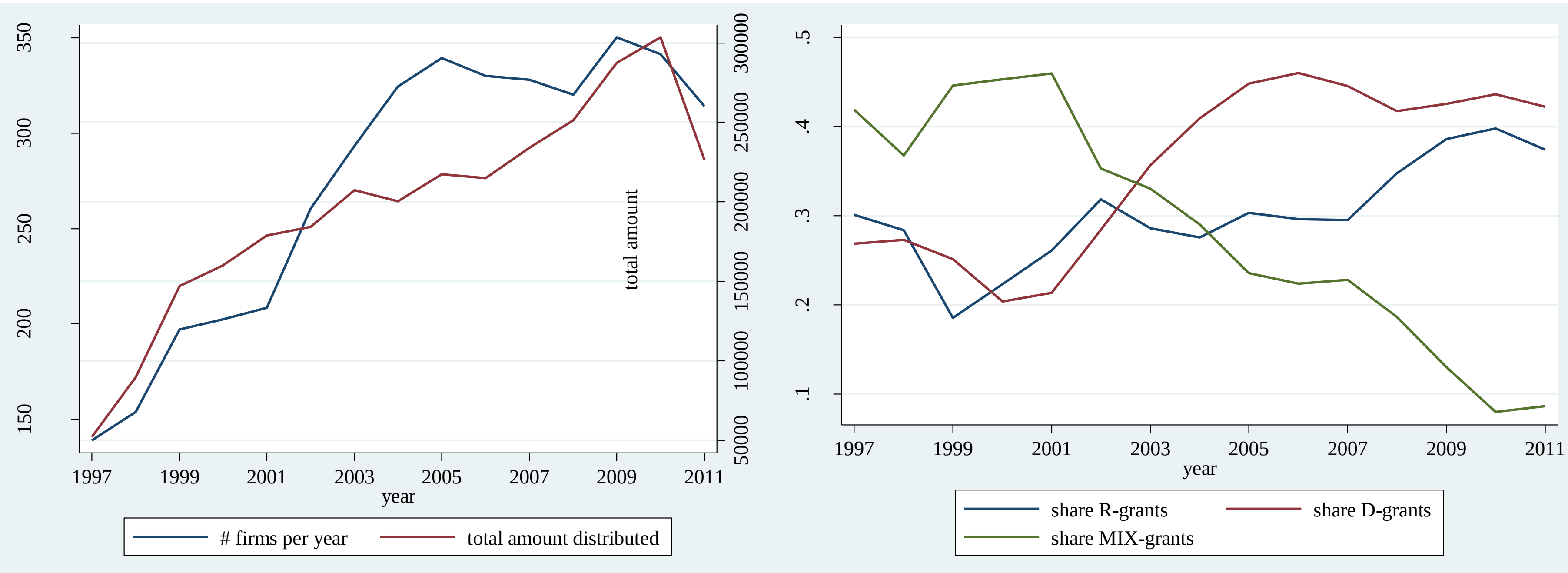
- Flanders: Regional Innovation Agency IWT distributes most R&D subsidies
- Different subsidy programs for R and D that differ wrt the share in total project costs to be borne
- About 40% for R, 15-25% for D
- Also mixed projects
- From 1997 to end 2011, the Flemish government granted a total number of 4,115 projects in 2,187 different firms
- Annual R&D spending and control variables from the OECD R&D survey, accounting data from Belfirst (BvD), patents from EPO data base (period under review: 2000-2009)

Financing Mix



Source: OECD R&D survey, Flanders, own calculations

Subsidy landscape in Flanders



Source: IWT (own calculations)

Empirical Evaluation

- Treatment effect analysis

- Dose response model (see e.g. Hirano and Imbens, 2004)

Treatment effects estimation

- Average treatment effect on the treated (ATT)
  - "**Nearest neighbor propensity score matching**" : we compare a firm with the most similar firm in our sample which serves as control observation
  - **Conditional Independence Assumption** (CIA, Rubin 1977)
    - Treatment and outcome variables are statistically independent from one another

The matching protocol & ATT

- Firm age, size, collaboration status, patent stock, past receipt of a subsidy (distinguishing between R scheme, D scheme and mixed scheme, EU and federal), qualifying as SME, being part of a group with a foreign parent, capital intensity, year, industry

- Estimate conditional propensity score for S based on X

$$\alpha^{TT} = \frac{1}{N^T} \sum_{i=1}^{N^T} (Y_i^T - \hat{Y}_i^C)$$

Y_i^T : outcome of treated
$\hat{Y}_i^C$: outcome of the counterfactual situation
N^T: Number of treated

Within sample grant characteristics

Variable	Median	Mean	Std. Dev.	Min	Max
Grant types in % of all firms					
R-grant	0	0.055	0.228	0	1
D-grant	0	0.090	0.286	0	1
MIX-grant	0	0.071	0.256	0	1
Grant amounts* of subsidy recipients					
R-grant	0	37.218	161.927	0	1940.826
D-grant	0	54.040	133.591	0	1558.176
MIX-grant	0	91.350	282.03	0	3626.761

*amounts in thousands of Euros (annual). Total grant size distributed over grant duration.

Descriptives BEFORE the matching

	I		II		I vs. II
	Non-subsidized firms, N=10,642		***Subsidized firms, any type[§], N=1,909***		
Variables	Mean	Std.Dev.	Mean	Std.Dev.	
	Outcome variables				
R&D_intensity_net	0.061	0.162	0.140	0.241	p<0.000
Develop._intensity_net	0.034	0.107	0.061	0.140	p<0.000
Research_intensity_net	0.027	0.100	0.078	0.173	p<0.000
	Control variables				
R&D cooperation	.081	0.273	0.364	0.481	p<0.000
Patent stock per employee	.014	0.097	0.048	0.138	p<0.000
Labour productivity	586.530	730.09.945	341.296	228.427	p=0.022
Past research grants	0.022	0.146	0.168	0.373	p<0.000
Past development grants	0.033	0.178	0.185	0.389	p<0.000
Past mixed grants	0.016	0.127	0.221	0.415	p<0.000
Foreign group	0.198	0.399	0.229	0.420	p=0.003
SME	0.854	0.353	0.746	0.435	p<0.000
Ln(Employees)	3.875	1.488	4.288	1.835	p<0.000
Ln(Capital intensity)	3.102	1.251	3.040	1.128	p=0.031
Ln(Age)	3.150	0.635	2.971	0.762	p<0.000

Matching results

	Outcome variables		
	Net R&D intensity	***Net Research intensity***	***Net Development intensity***
Treatment			
Any subsidy (N=1386)	0.054***	0.038***	0.016***
Research subsidy (N=334)	0.068***	0.031**	0.037***
Development subsidy (N=627)	0.052***	0.045***	0.006
Mixed subsidy (N=468)	0.037**	0.044***	-0.008

NOTE: All covariates are well balanced after the matching.
The only remaining differences are in the outcome variables.
Results in logs are similar to the intensities.

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Treatment effects over time

- $\alpha_i^{TT} = (Y_i - \hat{Y}_i^C)$

Treatment	*Any grant*			
Dependent variable	**α_i (net research intensity)**	**α_i (net dev. intensity)**	**α_i (net research intensity)**	**α_i (net dev. intensity)**
# of projects	0.600***	0.752***	0.558***	0.727***
Year trend	0.145***	0.022		
Year 2001			0.400	1.310***
Year 2002			0.297	0.610
Year 2003			0.366	0.061
Year 2004			0.473	0.320
Year 2005			0.436	0.545
Year 2006			1.866***	0.790*
Year 2007			1.382***	1.299***
Year 2008			1.421***	1.191**
Year 2009			1.243***	-0.160
Year 2010			0.990**	0.676
Year 2011			2.000**	0.879

Dose Response Function

- Based on the Generalized Propensity Score (Hirano and Imbens, 2004)

$$GPS_i = r(Ti, Xi)$$

The conditional expectation of Y_i given T_i and GPS_i can then be estimated:

$$E[Y_i/T_i, R_i] = \alpha_0 + \alpha_1 T_i + \alpha_2 T_i^2 + \alpha_3 GPS_i + \alpha_4 GPS_i^2 + \alpha_5 T_i * GPSi$$

- Takes into account that treatment is continuous (grant size)
- Grant size varies, but with a cap at 3 million euros
- log-log model → estimation of elasticities

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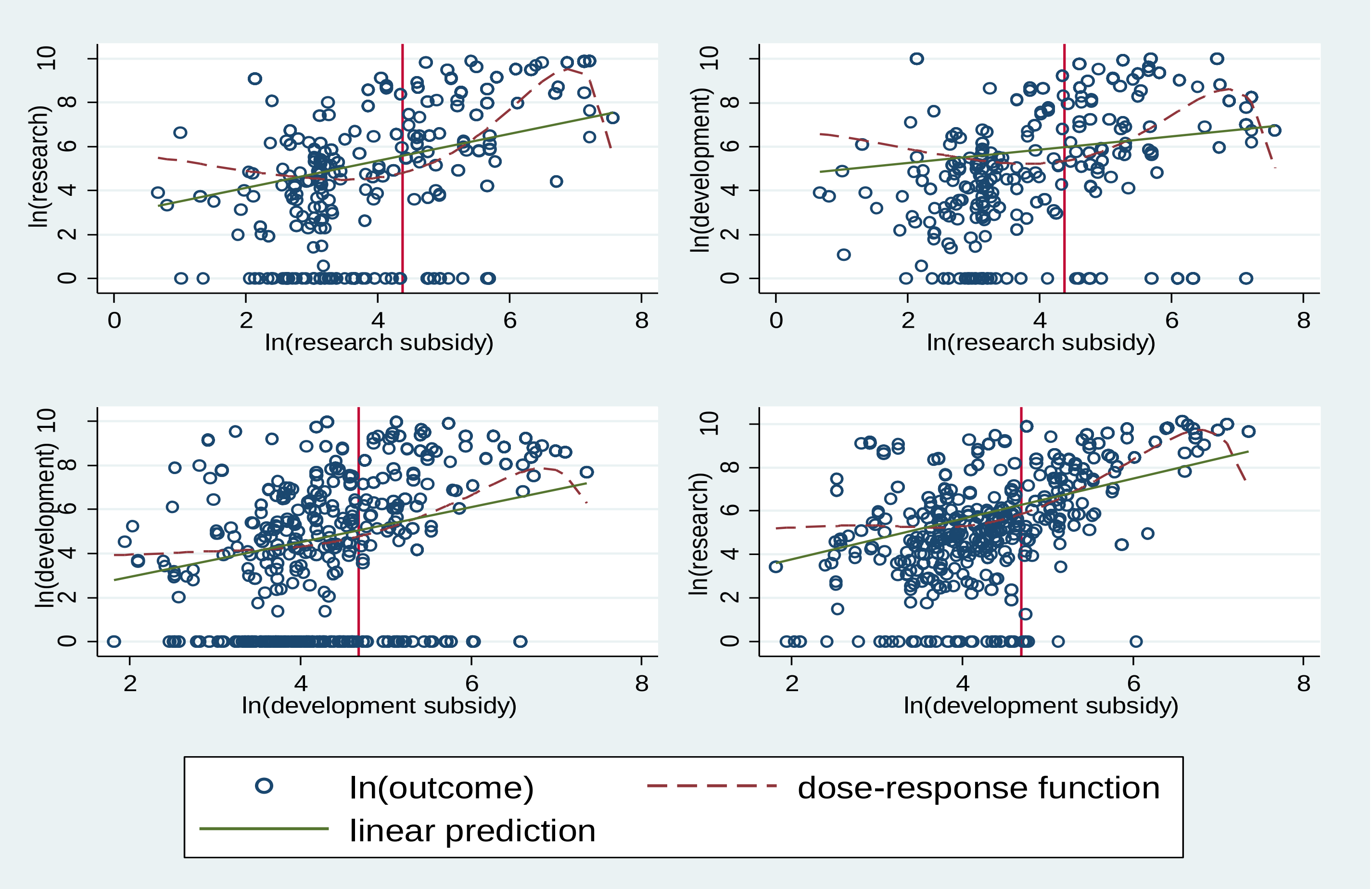
Impact of grant size



Concluding remarks

- Additionality on *NET* investment: neither total nor partial crowding out
- Disentangling R and D matters:
  - Own effects: R grants > D grants (additionality)
  - Cross effects:
    - R similar effects on both components
    - D only impact on R
- Higher effects with targeted schemes
- Minimum efficiency size

Policy Implications

- Targeted schemes increase overall R&D in the economy
- Support needed at the earlier stages of R&D activities, i.e. where market failures are highest

What is left to be discovered

- Estimating cost of providing targeted schemes vs overall subsidy scheme
- Model complementarity between R and D
- Estimate the impact of such policy on unsupported firms
  - within and across industries
  - role of spillovers and/or contractual market transactions

Strategy Implications

- Significantly higher impact of research grant than for development grant
  - ‘R’ can have multiple applications
  - ‘R’ renders ‘D’ more efficient
  - Yet, more firms apply for ‘D’

- Minimum efficient size
  - Apply for one or few larger projects than several smaller projects

What is left to be discovered

- How does firm organization matter ?
  - Team composition?
  - Centralization of R&D activities?
  - Internal mobility of employees

- What's the impact of the different schemes on innovation performance
  - Do the (different) types of grants impact outcome, or do firms only spend more money ?

- Incorporate access to external funding in the analysis

  → dynamics between subsidies and external funding

Thank you!
Any questions or suggestion?