Crowding in or Crowding Out? Evidence from Discontinuity in the Assignment of Business R&D Subsidies

Matěj Bajgar (Charles University and CERGE-EI)
Martin Srholec (CERGE-EI)

Introduction

- Private funding of business R&D short of what is socially desirable (Arrow, 1962; Klette et al., 2000)
- Government subsidies in OECD countries = USD 100 billion / year
- About a half of this in the form of direct subsidies

Research questions:

1. Do the subsidies crowd out private funds or crowd in additional private expenditure?
   - Both options theoretically possible (Takalo et al., 2013):
     a) Subsidised projects would take place even w/o the subsidies ➔ crowding out
     b) Subsidised projects additional and involve private co-financing ➔ crowding in
2. Do the subsidies persistently change firm behaviour after they expire?
3. Does the additional R&D spending translate in improved economic performance?

Literature

Crowding in/out effects of R&D subsides

- Effects of R&D subsidies studied by a large literature
  - See reviews by Zuniga-Vicente et al. (2014), Becker (2015), Cunningham et al. (2016)
- But no consensus reached (although more studies find evidence of crowding-in)
- More importantly, a vast majority of studies assume selection on observables: unlikely to hold as better (unobservable) R&D ideas correlated with both applying and being selected (Kauto, 1996).

Effects of R&D subsidies on other outcomes

- Recent quasi-experimental studies documented effects of R&D subsidies on other outcomes
  - Patenting - Bronzini and Piselli (2016), Howell (2017) and Wang et al. (2017)
  - Investment – Bronzini and Iachini (2014), Santoleri et al. (2022)
  - Survival - Howell (2017) and Wang et al. (2017);
  - Revenues – Howell (2017), Santoleri et al. (2022)
  - VC financing- Want et al. (2017)
- But no information on R&D expenditure (and often focus on startups)

Effects over time: studies above largely limited to studying short-term effects

This paper

WHAT WE DO

- Analyse a flagship Czech business R&D subsidy programme
- Leverage rich project and firm data (incl. firm R&D expenditure)
- Estimate causal effects of the programme in a regression discontinuity design
- The first RD study to estimate the effect of business R&D (direct) subsidies on R&D expenditure

PREVIEW OF RESULS

- **SMEs:**
  - Strong evidence of crowding in
  - 1 unit of subsidy ➔ 2.5 units of R&D
  - Effects persists after end of subsidies
  - Additional R&D translates in patents and economic effects
- **Large firms**: no effects
  - Evidence suggesting the differential effects related to credit constraints

The ALFA programme

- 1st programme of the Technology Agency of the Czech Republic
- R&D subsidies to (mostly) private firms
- Typical project duration 3-4 years
- Average subsidy per project and firm = EUR 200,000
- Programme budget: EUR 340,000,000
- 3 subprogrammes, analyse Subprogramme 1

The ALFA programme – project evaluation

- Each project evaluated by 2 or 3 external reviewers and 1 rapporteur
- Projects evaluated in 2 steps
    1. Ineligible projects eliminated based on several binary criteria
    2. Each evaluator assigned score 0-100 and projects ranked according to average
- Final cutoff for determined by available funds

The ALFA programme

Table 1: **Number of project proposals by calls**

	Call 1 2010	Call 2 2011	Call 3 2012	Call 4 2013	Total 2010-2013
Total					
Supported	114	107	101	102	424
Unsupported	211	297	496	447	1451
Binary criteria affirmatory					
Supported	114	107	101	102	424
Unsupported	54	113	278	297	742
Bandwith of 5.5 points around cutoff					
Supported	20	57	75	88	240
Unsupported	38	52	130	128	348

Data

- Multiple firm-level datasets linked by unique firm identifiers
  - Admin data on project proposals (successful + unsuccessful)
  - R&D survey (population of R&D-performing firms)
  - Administrative data on R&D tax relief
  - Structural Business Statistics survey data
  - Patent records
  - Business Census demographic data
  - Financial statements from MagnusWeb
- Exclude
  - Universities and research institutes
  - State-own enterprises
  - Legal forms not corresponding to private firms
- Resulting data:
  - 1,183 firm-project combinations
  - Years 2007-2021 (4+ years before and 8+ after each project

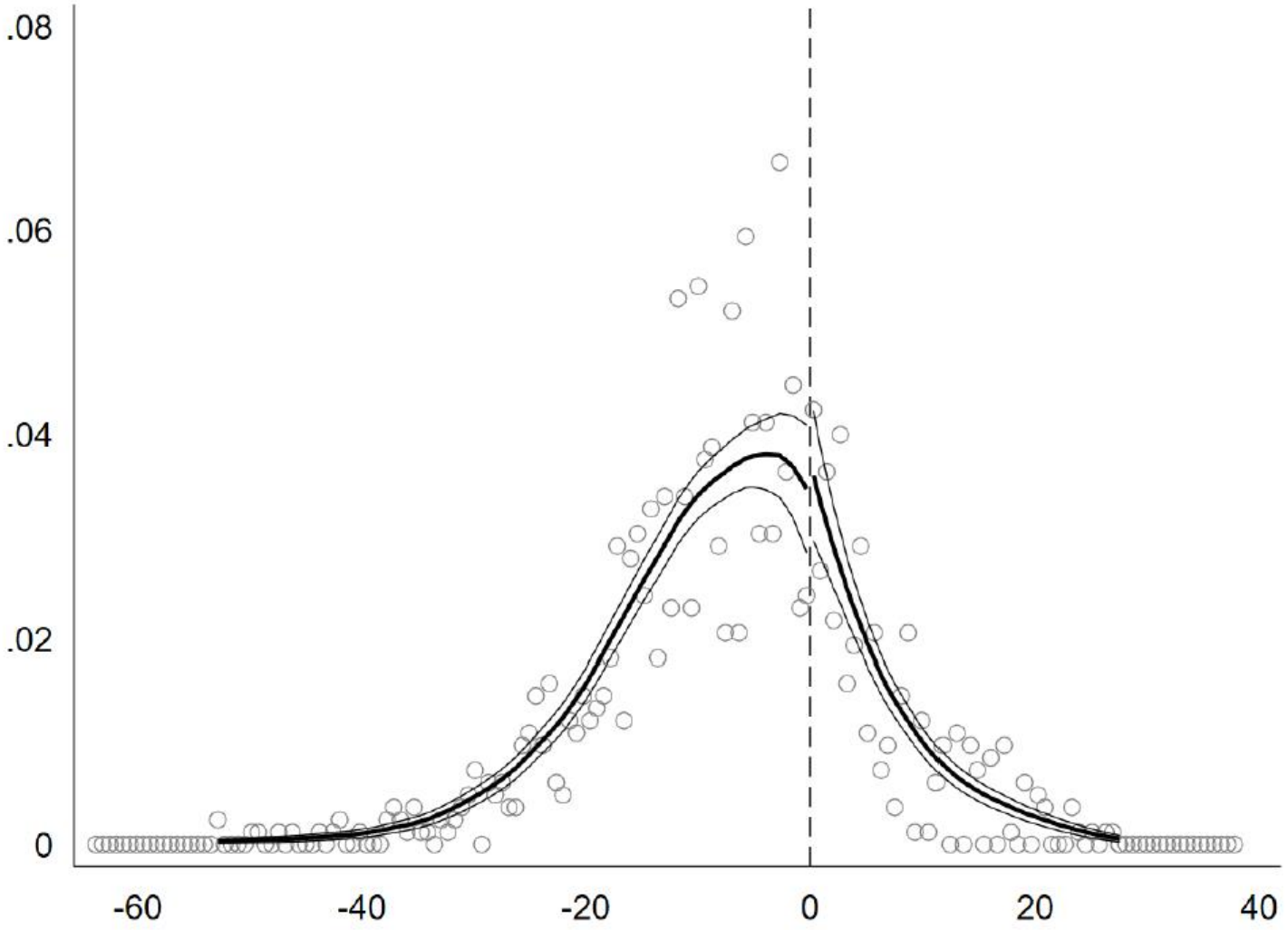
RD design

- An RD estimator comparing firms around the cutoff score
- Estimate the following stacked RD regression:

$$Y_{ipt} = \beta T_p + \gamma_-(1 - T_p)X_p + \gamma_+ T_p X_p + \sum_{j=1}^{J} \delta_j Z^j_{ipt_0} + \theta_c + \theta_t + \epsilon_{ipt}.$$

  - Y_{ipt} = outcome in year t for firm i participating in project p submitted to call c
    - e.g. log R&D expenditure, log number of patents, log sales
  - T_p = a dummy variable marking whether project p received a subsidy
  - X_p = project score
  - Z_{ipt0} = pre-treatment control variables
  - θ_c = call fixed effects
  - θ_t = year fixed effects
- Estimated using weighted least squares (weights given by triangular kernel)
- Bias-corrected RD estimates and robust standard errors clustered at firm level (Calonico et al., 2014).
- Baseline bandwidht 5.5 points suggested by Calonico et al. (2019) procedure but also report results for bandwidth of 4, 10 and infinite number of points.

Density of project proposals around cutoff



Placebo tests

	Before the subsidy							
Band.	Infinite	Wide	Baseline	Narrow	Infinite	Wide	Baseline	Narrow
	Log total R&D expenditure				Log privately funded R&D expenditure			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.12	-0.11	0.04	0.09	-0.13	-0.06	0.02	0.04
	(0.23)	(0.25)	(0.30)	(0.33)	(0.24)	(0.26)	(0.32)	(0.36)
N (left)	1742	1254	762	595	1742	1254	762	595
N (right)	1082	862	622	497	1082	862	622	497
	Log direct public funding from TACR				Log direct public funding from other sources			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.02	0.04	0.15	0.19	-0.07	-0.01	0.07	0.03
	(0.11)	(0.13)	(0.16)	(0.17)	(0.21)	(0.23)	(0.27)	(0.29)
N (left)	1742	1254	762	595	1742	1254	762	595
N (right)	1082	862	622	497	1082	862	622	497
	Log R&D tax relief				Log current R&D expenditure			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.25	-0.52*	-0.43	-0.43	-0.10	-0.11	-0.01	0.01
	(0.28)	(0.31)	(0.38)	(0.41)	(0.20)	(0.20)	(0.24)	(0.27)
N (left)	1742	1254	762	595	1742	1254	762	595
N (right)	1082	862	622	497	1082	862	622	497
	Log capital R&D expenditure				Log patent applications			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.12	-0.15	-0.19	-0.31	-0.05	-0.03	0.01	-0.00
	(0.22)	(0.24)	(0.30)	(0.34)	(0.07)	(0.08)	(0.09)	(0.10)
N (left)	1742	1254	762	595	1742	1254	762	595
N (right)	1082	862	622	497	1082	862	622	497
	Log employment				Log sales			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.06	-0.04	0.01	0.04	-0.29	-0.22	-0.23	-0.22
	(0.32)	(0.34)	(0.41)	(0.44)	(0.37)	(0.40)	(0.48)	(0.52)
N (left)	1619	1180	726	575	1683	1217	742	583
N (right)	1029	816	585	471	1043	833	598	480

Results

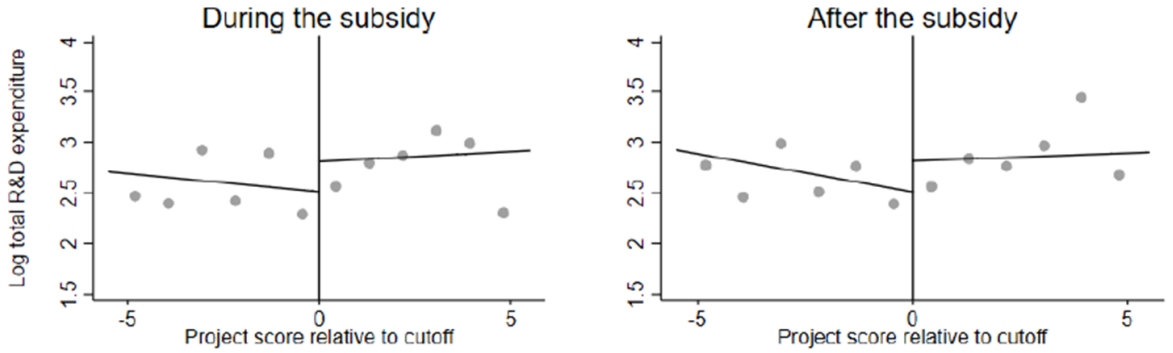
Effects on R&D expenditure

Full sample: Positive effects on total R&D expenditure

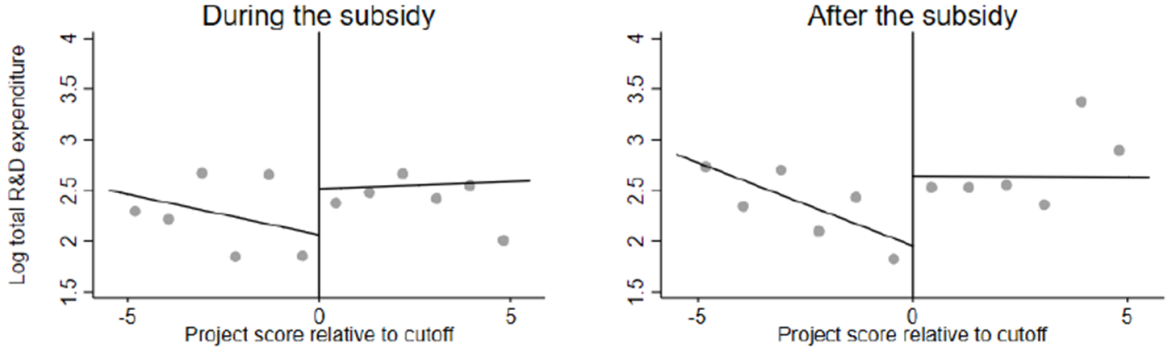
SMEs: Strong effects on R&D expenditure

Large firms: No effects on R&D expenditure

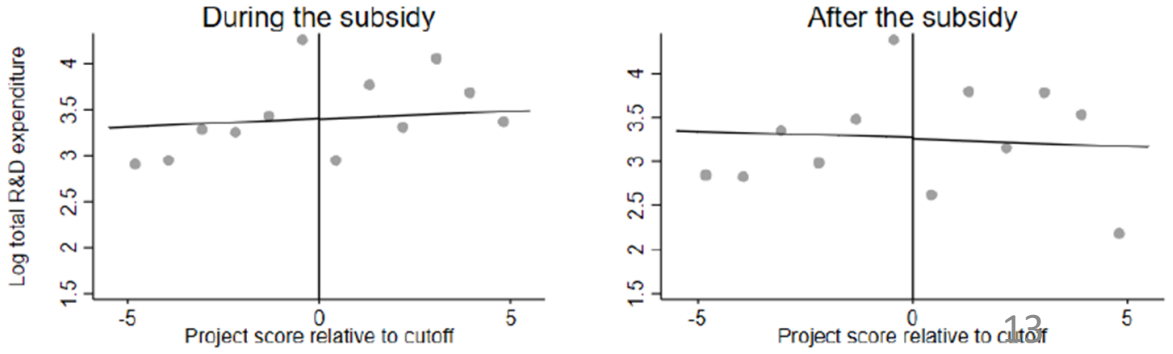
(a) All firms



(b) SMEs



(c) Large firms



Effects on R&D expenditure – full sample

	During the subsidy				After the subsidy			
Band.	Infinite	Wide	Baseline	Narrow	Infinite	Wide	Baseline	Narrow
				(a) All firms				
				Outcome: Log total R&D expenditure				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.25***	0.31***	0.30**	0.21	0.08	0.25	0.35*	0.30
	(0.09)	(0.10)	(0.15)	(0.16)	(0.15)	(0.16)	(0.21)	(0.22)
N (left)	1459	1072	669	526	1280	943	601	477
N (right)	925	756	545	449	860	691	499	419
				Outcome: Log privately funded R&D expenditure				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.17	0.25*	0.41*	0.34	0.17	0.37*	0.59*	0.58*
	(0.12)	(0.14)	(0.23)	(0.25)	(0.18)	(0.21)	(0.32)	(0.35)
N (left)	1459	1072	669	526	1280	943	601	477
N (right)	925	756	545	449	860	691	499	419

Effects on R&D expenditure – SMEs

	During the subsidy				After the subsidy			
Band.	Infinite	Wide	Baseline	Narrow	Infinite	Wide	Baseline	Narrow
				(b) SMEs				
				Outcome: Log total R&D expenditure				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.32***	0.39***	0.49***	0.42**	0.28	0.48**	0.80***	0.77***
	(0.12)	(0.13)	(0.17)	(0.19)	(0.20)	(0.20)	(0.25)	(0.27)
N (left)	1035	752	451	348	894	647	389	303
N (right)	681	548	371	301	616	485	327	273
				Outcome: Log privately funded R&D expenditure				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.30**	0.43**	0.81***	0.76***	0.38	0.66**	1.09***	1.10**
	(0.13)	(0.17)	(0.27)	(0.29)	(0.25)	(0.28)	(0.41)	(0.44)
N (left)	1035	752	451	348	894	647	389	303
N (right)	681	548	371	301	616	485	327	273

“Bang for the buck” (SMEs)

- How much additional R&D is generated by a unit of subsidy?

$$BFTB = \frac{dR}{dG} = \frac{\Delta R}{\frac{dG}{R}} = \frac{63\%}{25\%} = 2.5$$

Effects on R&D expenditure – large firms

	During the subsidy				After the subsidy			
Band.	Infinite	Wide	Baseline	Narrow	Infinite	Wide	Baseline	Narrow
				(c) Large firms				
				Outcome: Log total R&D expenditure				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.03	0.04	-0.09	-0.20	-0.14	-0.10	-0.04	-0.06
	(0.15)	(0.14)	(0.16)	(0.17)	(0.19)	(0.21)	(0.30)	(0.32)
N (left)	424	320	218	178	386	296	212	174
N (right)	244	208	174	148	244	206	172	146
				Outcome: Log privately funded R&D expenditure				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.15	-0.17	-0.21	-0.21	-0.18	-0.12	-0.00	0.07
	(0.20)	(0.17)	(0.19)	(0.19)	(0.20)	(0.20)	(0.28)	(0.29)
N (left)	424	320	218	178	386	296	212	174
N (right)	244	208	174	148	244	206	172	146

Why different effects for SMEs vs. large firms?

1) Subsidies quantitatively more important for SMEs

➔ We indeed find somewhat larger effects when subsidies represent a larger share of (pre-treatment) R&D budget

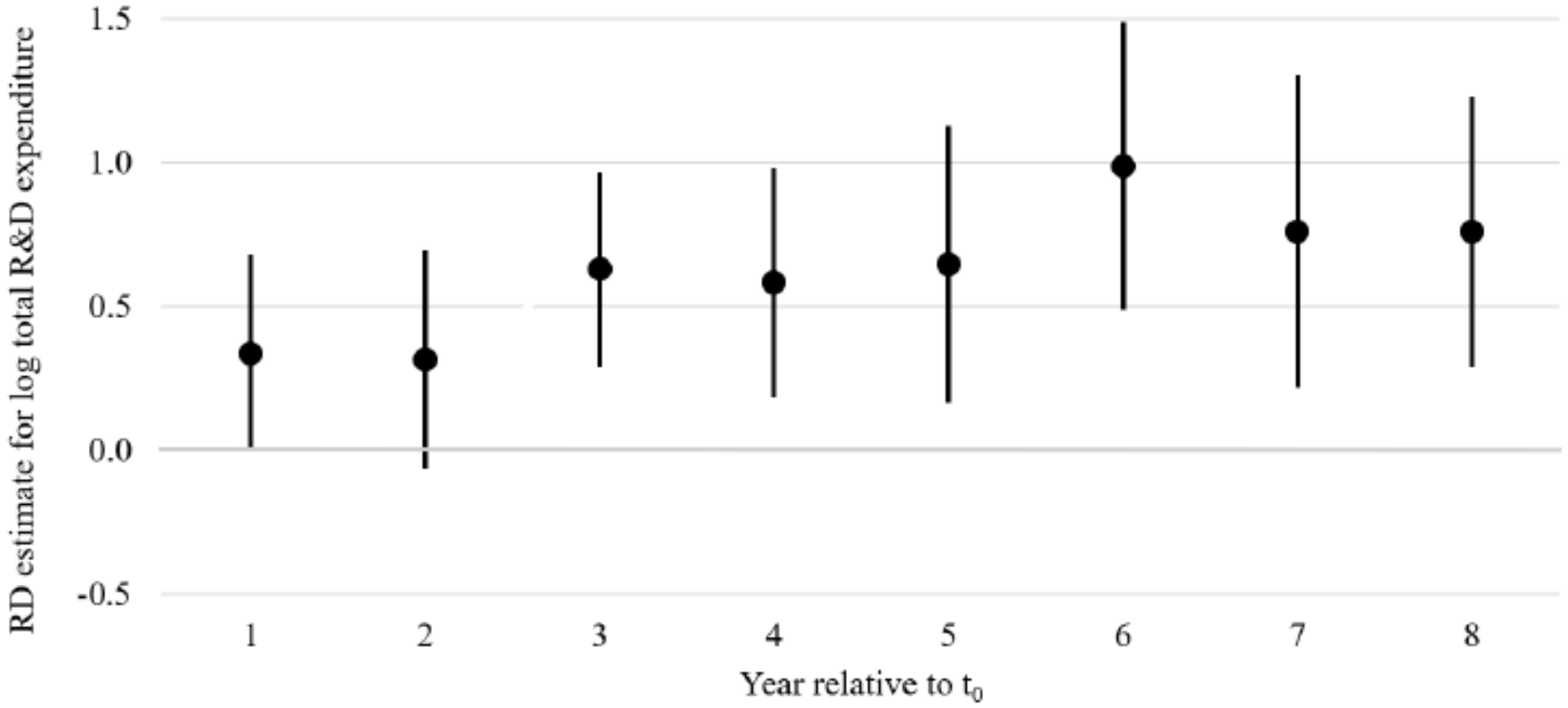
2) Subsidies more effective for financial constrained firms

- Studies indicate stronger effects of R&D subsidies for financially constrained firms
  - Howell (2017), Bronzini and Iachini (2014) and Santoleri et al. (2022)
- SMEs more likely to be financially constrained (Hall and Lerner, 2010)

➔ No evidence of stronger effects for younger firms (but few young firms in the sample)

➔ But stronger effects for firms in financial distress (using Altman Z-score)

Short-tearm vs. long-term effects



➔ The increased R&D persists years after the end of the subsidies

Short-term vs. long-term effects

Outcome: Log direct public R&D funding from TA CR								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.86***	1.04***	1.15***	1.04***	0.28	0.56***	0.89***	0.93***
	(0.15)	(0.15)	(0.18)	(0.20)	(0.20)	(0.20)	(0.25)	(0.27)
N (left)	1035	752	451	348	894	647	389	303
N (right)	681	548	371	301	616	485	327	273
Outcome: Log direct public R&D funding from other sources								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.03	-0.08	-0.33*	-0.30	0.12	0.16	0.03	0.18
	(0.13)	(0.14)	(0.19)	(0.21)	(0.17)	(0.19)	(0.24)	(0.25)
N (left)	1035	752	451	348	894	647	389	303
N (right)	681	548	371	301	616	485	327	273
Outcome: Log R&D tax relief								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	-0.12	-0.13	-0.32	-0.46	-0.33	-0.35	-0.38	-0.61
	(0.22)	(0.26)	(0.38)	(0.40)	(0.24)	(0.29)	(0.44)	(0.47)
N (left)	1035	752	451	348	894	647	389	303
N (right)	681	548	371	301	616	485	327	273

Effects on patenting and economic performance

- No patenting or economic effects detected on the full sample of SMEs
- But subsidy-to-sales ratio very small for many firms (median 1.3%)

  ➔ Detecting significant economic effects would require unrealistically high returns

  ➔ Look at SMEs with above-median subsidy-to-sales ratio

Effects on patenting and economic performance

	During the subsidy				After the subsidy			
Band.	Infinite	Wide	Baseline	Narrow	Infinite	Wide	Baseline	Narrow
			Outcome: Log patent applications					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.10	0.20***	0.21**	0.17*	0.11*	0.17**	0.09	0.00
	(0.07)	(0.08)	(0.10)	(0.10)	(0.07)	(0.07)	(0.09)	(0.09)
N (left)	1035	752	451	348	894	647	389	303
N (right)	259	203	122	104	227	181	112	97
			Outcome: Log sales					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.07	0.17*	0.22**	0.24**	0.03	0.21	0.26*	0.20
	(0.09)	(0.09)	(0.10)	(0.10)	(0.14)	(0.14)	(0.15)	(0.14)
N (left)	1019	742	445	342	850	614	373	293
N (right)	247	197	117	99	202	163	97	82
			Outcome: Log employment					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimate	0.10***	0.12***	0.10*	0.10**	0.06	0.16**	0.20**	0.14
	(0.04)	(0.04)	(0.05)	(0.05)	(0.07)	(0.07)	(0.08)	(0.09)
N (left)	992	735	442	339	720	523	320	251
N (right)	227	183	107	95	160	136	75	68

- Implies private rate of return to R&D around 22%, consistent with the literature (Hall et al., 2010)

Summary

- Analyse a flagship R&D business subsidy scheme in the Czech Republic
- RD design compares firms around the cutoff for receiving support
- **SMEs:**
  - Strong evidence of crowding in
  - 1 unit of subsidy ➔ 2.5 units of R&D
  - Effects persists after end of subsidies
  - Additional R&D translates in patents and economic effects
- **Large firms**: no effects
- Evidence suggesting the differential effects related to credit constraints