The Causal Effects of Climate Investment Subsidies: Regression Discontinuity Evidence from Swedish Firms

Shon Ferguson[1] Johanna Nolgren[1]

[1]Department of Economics, Swedish University of Agricultural Sciences (SLU)

25 November 2024

Introduction

- Subsidies to reduce emissions less common than carbon pricing
- Open question whether abatement subsidies are an effective climate policy tool
- Potential lack of “additionality”
- Few rigorous studies

Research question

- We evaluate the causal effects of a Swedish subsidy scheme: *Klimatklivet*
  - Swedish for "the climate leap"
  - One of Sweden's major policies targeting GHG emissions
- We exploit discontinuities in the assignment mechanism in the program during 2016 and 2017
- Estimate impact on investment and firm growth

Related Literature

- Firm-level investment additionality in GHG context
    - Calel et al. (2024), Marino et al. (2021)
- Individual- and household-level studies
    - EV subsidies, home energy efficiency programs
- Additionality of R&D investment grants
    - Santoleri et al. (2022), Howell (2017)

Studies of Klimatklivet

- Consultant reports - descriptive
  - Isberg et al. (2017), Pädam et al. (2021)
- National Audit Office (RiR 2019:1) - cost-ineffective
- Ferguson and Nolgren (2024) - self-selection

Preview of results

- RD design is valid
- Significant effects on investment, turnover, number of employees
- Back-of-the-envelope calcs: Ex-post firm investment $>$ subsidy

Sweden's climate investment subsidy scheme

- Awarded SEK 14.8 billion in grants 2015–2023
- Subsidized 41 percent of total investment costs
- Goal: Fund investment products with highest CO2e emission reductions per invested SEK
- Firms and other organizations eligible
- 2–4 application rounds per year

Klimatklivets project criteria

- Cannot be profitable in less than five years
- Cannot qualify for certificate system for renewable electricity production
- Cannot commence before being granted funding
- Cannot be covered by EU ETS
- CO_2e reduction per invested SEK must exceed minimum threshold

Threshold levels and timing of application rounds, 2015–2017

Application round	Threshold, kg CO2e/SEK	Application period
2015:1	1.00	Jun 29 – Sep 15
2015:2	1.00	Nov – Dec 17
2016:1	**0.75**	**Feb 15 –Mar 14**
2016:2	**1.00**	**May 16 – Jun 13**
2016:3	1.00	Aug 29 – Sep 26
2017:1	1.00	Jan 9 – Jan 31
2017:2	**0.75**	**Mar 10** – **Apr 3**
2017:3	0.75	Aug 7 – Sep 11
2017:4	0.75	Oct 9 – Nov 9

Regression Discontinuity Methodology

- Idea: compare observations just above vs. just below threshold
- Tradeoff between comparability and N
- ± 0.249 bandwidth doesn't overlap with previous round's threshold

$$y_i = \beta_0 + \beta_1 granted_i + f(CO2perSEK_i) + \beta_2 y_i^{pre} + \lambda_{round} + \lambda_{category} + \lambda_{ind} + \epsilon_i \quad (1)$$

Data

- Application data (KlivIT)
  - Source: Swedish EPA
  - Detailed data for granted and rejected applications
- Firm-level balance sheet register data (LISA)
  - Source: Statistics Sweden
  - Annual longitudinal data
  - Covers all firms in Sweden
  - investment, turnover, employees, etc.

Data

- Restrict sample to granted applications and applications rejected solely on CO2e/SEK metric
- Firms with at least one employee one year before and after application
- After merge with firm-level data: 406 applications
  - 198 granted
  - 208 rejected

Application descriptive statistics

Variables	Obs.	Mean	SD	p10	Median	p90
Requested subsidy, SEK thousands						
Granted	198	1235	2739	26	300	2970
Rejected	208	1562	3233	70	291	4100
Total	406	1403	3003	40	300	4100
Total cost of investment, SEK thousands						
Granted	198	2405	6090	53	562	5940
Rejected	208	2934	6903	120	568	6100
Total	406	2676	6517	80	568	6100
Subsidy fraction of investment in percent						
Granted	198	55	18	40	50	92
Rejected	208	57	21	37	50	100
Total	406	56	19	40	50	100
kg CO2e reductions per invested SEK						
Granted	198	4.96	10.46	0.72	1.25	14.11
Rejected	208	0.34	0.23	0.00	0.29	0.65
Total	406	2.59	7.65	0.11	0.65	3.47

Number of rejected and granted applications by project category

Category description	Rejected	Granted	Total
Charging stations	120	103	223
Energy conversion	21	61	82
Energy efficiency	25	3	28
Transport	1	25	26
Vehicles	7	0	7
Information	6	0	6
Gas emissions	1	3	4
Biogas production	2	2	4
Infrastructure	2	1	3
Other	23	0	23
Total	208	198	406

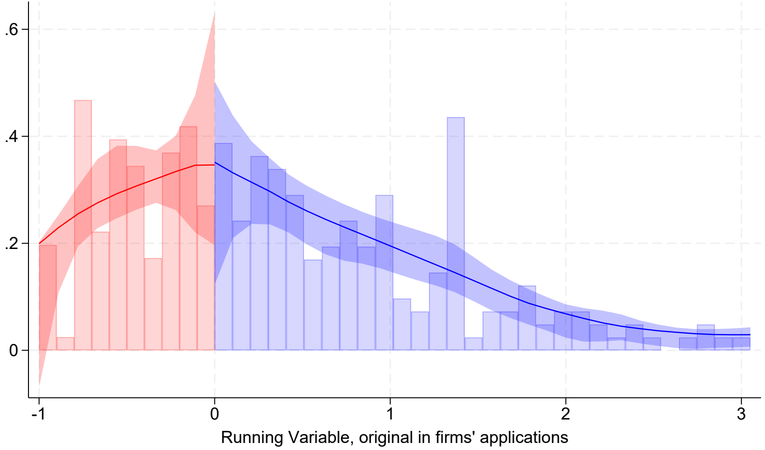
Number of applications by project length, in calendar years

Project length (years)	Number of applications
0	130
1	143
2	111
3	18
4	3
5	1
Total	406

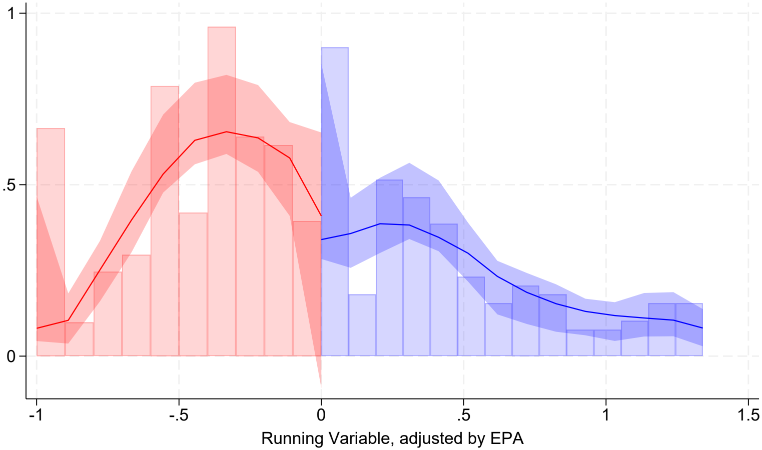
Firm descriptive statistics

Variables	Granted		Rejected		T-test, equal means	
(SEK millions unless noted)	Mean	Median	Mean	Median	Difference	p-value
Total Investment	66.9	17.5	62.5	11.4	-4.40	0.781
Machinery Investment	31.0	6.6	31.1	4.4	0.06	0.992
Employees	198.7	40.0	224.8	40.0	26.10	0.571
Turnover	1035.9	239.9	1286.4	155.8	250.46	0.247
Profit	76	16	138	13	61.93	0.060
Fixed Assets	1235.0	129.0	1788.2	36.9	553.25	0.297
Age	18.4	21.0	15.8	17.0	-2.67**	0.001
Observations	198		208		406	

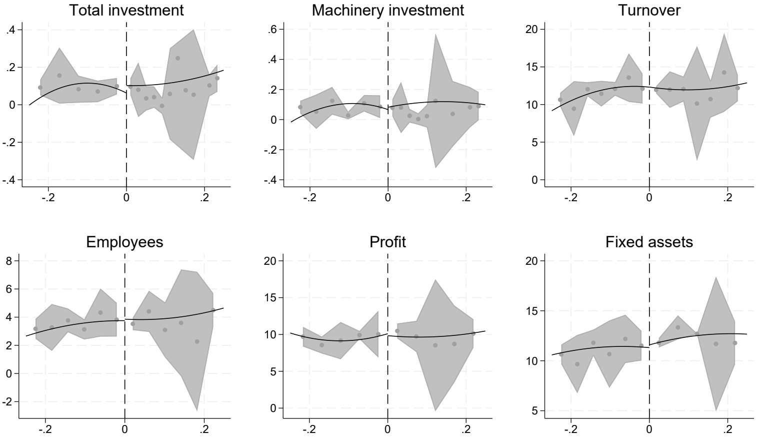
Histogram of running variable and manipulation test based on original applications to Swedish EPA



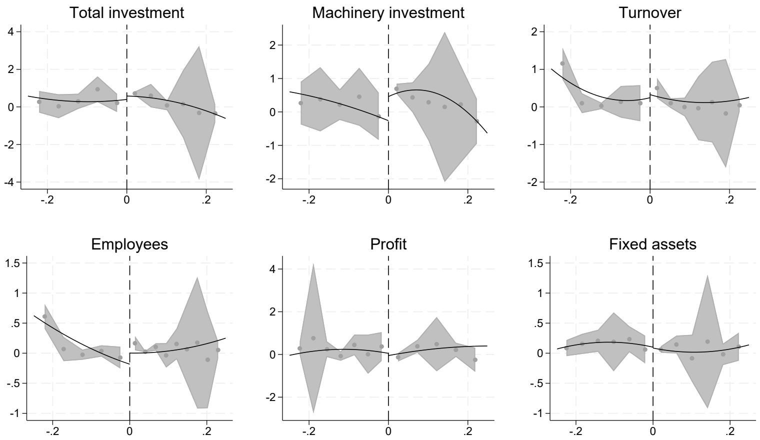
Histogram of running variable and manipulation, adjusted by Swedish EPA



RD plots for outcomes, pre-grant



RD plots for outcomes, pre vs. post changes



Effects on Total Investment

Panel A: All observations

	Log growth, $t-1$ vs $t+1$		As share of fixed assets	
	(1)	(2)	(3)	(4)
RD_Estimate	-0.06	0.15	0.05	0.07
	(0.13)	(0.17)	(0.07)	(0.07)
Polynomial	Linear	Quadratic	Linear	Quadratic
Observations	295	295	316	316

Panel B: ± 0.249 bandwidth

	Log growth, $t-1$ vs $t+1$		As share of fixed assets	
	(1)	(2)	(3)	(4)
RD_Estimate	0.35***	0.49***	0.11*	0.14**
	(0.12)	(0.16)	(0.06)	(0.07)
Polynomial	Linear	Quadratic	Linear	Quadratic
Observations	82	82	86	86

Effects on Machinery Investment

Panel A: All observations

	Log growth, $t-1$ vs $t+1$		As share of fixed assets	
	(1)	(2)	(3)	(4)
RD_Estimate	0.11	0.26	0.05	0.08
	(0.15)	(0.21)	(0.07)	(0.06)
Polynomial	Linear	Quadratic	Linear	Quadratic
Observations	283	283	308	308

Panel B: ± 0.249 bandwidth

	Log growth, $t-1$ vs $t+1$		As share of fixed assets	
	(1)	(2)	(3)	(4)
RD_Estimate	0.66***	0.57***	0.11*	0.16**
	(0.11)	(0.11)	(0.06)	(0.08)
Polynomial	Linear	Quadratic	Linear	Quadratic
Observations	78	78	85	85

Firm-level Investment Additionality: Crowding in or crowding out?

- Total net investment: 12–15 percent increase
- Machinery net investment: 12–17 percent increase
- Pre-grant mean machinery investment: SEK 31 million
- Implies that investment increased by between SEK 3.7–4.7 million
- Compare with mean investment size: SEK 2.4 million

Further Results

- Positive effects on turnover and the number of employees - firm expansion
- No detectable effects on fixed assets - puzzling
  - Stock of fixed assets relatively large compared to annual total investment (SEK 1.24 billion versus SEK 67 million)
- Lack of an effect on firm profits - not surprising since profitable projects not eligible

Effects on the Number of Employees

Panel A: All observations

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log employees at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	0.12	0.05	0.08	0.06	0.10	0.10
	(0.15)	(0.09)	(0.13)	(0.08)	(0.13)	(0.09)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	406	406	403	403	403	403

Panel B: ± 0.249 bandwidth

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log employees at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	0.45***	0.43***	0.43***	0.42***	0.45***	0.47***
	(0.15)	(0.16)	(0.13)	(0.14)	(0.15)	(0.16)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	115	115	115	115	115	115

Effects on Turnover

Panel A: All observations

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log turnover at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	0.12	0.15	0.13	0.18	0.16	0.20
	(0.12)	(0.12)	(0.11)	(0.12)	(0.11)	(0.12)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	404	404	403	403	403	403

Panel B: ± 0.249 bandwidth

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log turnover at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	0.40***	0.50***	0.43***	0.53***	0.50***	0.68***
	(0.11)	(0.12)	(0.11)	(0.12)	(0.13)	(0.13)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	115	115	115	115	115	115

Effects on Profits

Panel A: All observations

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log profit at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	-0.03	-0.04	0.05	-0.04	0.00	-0.08
	(0.08)	(0.11)	(0.06)	(0.08)	(0.07)	(0.10)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	328	328	325	325	325	325

Panel B: ± 0.249 bandwidth

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log profit at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	-0.15	-0.09	0.12	0.14	0.13	0.15
	(0.11)	(0.11)	(0.09)	(0.11)	(0.09)	(0.11)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	82	82	82	82	82	82

Effects on Fixed Assets

Panel A: All observations

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log fixed assets at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	-0.02	-0.02	0.03	0.09	0.08	0.14*
	(0.05)	(0.05)	(0.07)	(0.06)	(0.08)	(0.09)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	375	375	375	375	375	375

Panel B: ± 0.249 bandwidth

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log fixed assets at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
RD_Estimate	-0.03	0.00	-0.15	-0.17	-0.17	-0.19
	(0.06)	(0.07)	(0.11)	(0.14)	(0.12)	(0.14)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
Observations	111	111	112	112	112	112

Placebo Tests

Panel A: Total investment

	Log growth, $t-1$ vs $t+1$		As share of fixed assets	
	(1)	(2)	(3)	(4)
runningvar-0.05	0.16	0.25	-0.05	0.03
	(0.31)	(0.36)	(0.07)	(0.09)
runningvar$+0.05$	-0.14	-0.63***	0.05	-0.08
	(0.14)	(0.19)	(0.08)	(0.13)
Polynomial	Linear	Quadratic	Linear	Quadratic

Panel B: Machinery investment

	Log growth, $t-1$ vs $t+1$		As share of fixed assets	
	(1)	(2)	(3)	(4)
runningvar-0.05	0.17	-1.10**	-0.02	0.09
	(0.37)	(0.46)	(0.07)	(0.10)
runningvar$+0.05$	-0.22	-0.12	-0.02	-0.06
	(0.13)	(0.27)	(0.10)	(0.15)
Polynomial	Linear	Quadratic	Linear	Quadratic

Panel A: Employment

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log employees at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
runningvar-0.05	0.12	0.28	0.03	0.12	0.05	0.16
	(0.16)	(0.20)	(0.14)	(0.18)	(0.15)	(0.20)
runningvar$+0.05$	0.06	-0.14	0.07	-0.07	0.05	-0.09
	(0.22)	(0.21)	(0.19)	(0.19)	(0.21)	(0.20)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic

Panel B: Turnover

	Log growth, $t-1$ vs $t+1$		Log growth, $t-1$ vs project end		Log employees at project end	
	(1)	(2)	(3)	(4)	(5)	(6)
runningvar-0.05	0.04	0.33	-0.10	0.05	-0.10	0.11
	(0.14)	(0.23)	(0.13)	(0.20)	(0.15)	(0.25)
runningvar$+0.05$	-0.01	-0.02	0.05	0.09	-0.01	0.04
	(0.17)	(0.19)	(0.16)	(0.17)	(0.18)	(0.20)
Polynomial	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic

Conclusion

- Evaluate a Swedish grant scheme for local climate investments
- Identify causal effects of receiving a grant
- Evidence of investment additionality, particularly machinery investments

Comments welcome!

shon.ferguson@slu.se