Making Subsidies Work: Rules versus Discretion

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Present by George Chou
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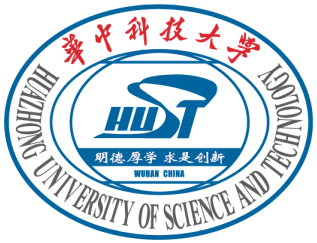

Outline

Authors

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  - Ph.D. in Economics, Universitat Pompeu Fabra, *2000-2005*.
  - M.Sc. in Economics, Universitat Pompeu Fabra, *1996-1998*.
  - B.A. in Economics, University of Venice "Ca' Foscari", *1992-1996*.
- Research Interests
  - Productivity and Growth, Regulation and Industrial Policy, Labor Economics, Political Economy, Applied Economics

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- Education
  - Ph.D. in Economics, Princeton University, *2020-2026(expected)*.
  - M.Sc. in Economic and Social Sciences, Bocconi University, *2016-2019*.
  - B.Sc. in Economics and Management, University of Padua, *2013-2016*.
- Research Interests
  - Econometrics, Causal Inference, Labor Economics, Program Evaluation

Filippo Palomba

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  - Professor, Bocconi University, *2011-present*.
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- Education
  - Ph.D. in Economics, Universitat Pompeu Fabra, *2004-2009*.
  - M.A. in Economics, University of Chicago, *2003-2004*.
  - M.A. in Economics, Universitat Pompeu Fabra, *2002-2003*.
  - B.A. in Economics, Bocconi University, *1997-2001*.
- Research Interests
  - Social Phenomena (such as immigration, discrimination, crime, and mass media.)

Paolo Pinotti

Recent Paper

Authors

- Employment
  - Professor, University of Padua, *2020-present*.
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- Education
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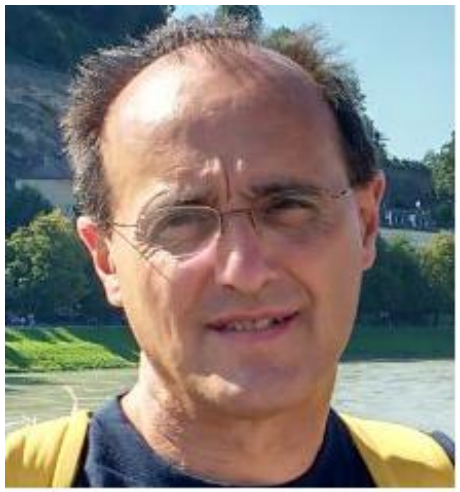
  - M.A. in Statistics and Economics, University of Padua, *1982-1984*.
- Research Interests
  - Econometrics of Program Evaluation, Methodology of the Regression Discontinuity and Case Studies



Enrico Rettore

Motivation

- **Public subsidies to firms** represent a substantial and growing portion of public expenditures worldwide. The increase in industry subsidies budgets has sparked renewed interest in understanding their impact.
- However, there remains significant uncertainty regarding the specific effects of subsidies on different types of recipients:
  - Small or emerging firms tend to derive the highest benefits from public capital, which aids them in overcoming liquidity constraints.
  - Market frictions may cause larger, more established producers to miss out on potential investment opportunities.
  - Some other perspectives...
- What determines the recipients of subsidies?
- Does the subsidies work efficiently?

Rules v.s. Discretion Dilemma

- The discretionary power by (local) bureaucrats and politicians:
  - Potentially enhances rigid policy rules by incorporating additional information about the quality of firms and projects into subsidy allocation;
  - Increases the risk that subsidies serve private benefits rather than the public interest, as exemplified by cases involving political connections.
- Hayek (1945): *We need decentralization because only thus can we ensure that the knowledge of the particular circumstances of time and place will be promptly used.*
- Migué and Bélanger (1974) and Niskanen (1975): The utility of a bureaucrat may be a function of discretionary budget (total budget minus the minimum cost of producing the expected output) and output (total budget).

What This Paper Do

This paper

- Examines the relevance of firm characteristics and allocation criteria.
- Assesses the effectiveness of public subsidies provided to private firms.
- Specifically, it investigates the impact of Italian Law 488/92, which stands as the largest program of investment subsidies ever implemented in Italy, between 1996 and 2007, through 35 open calls with a total budget of nearly €26 billion.

Challenges in Policy Evaluation

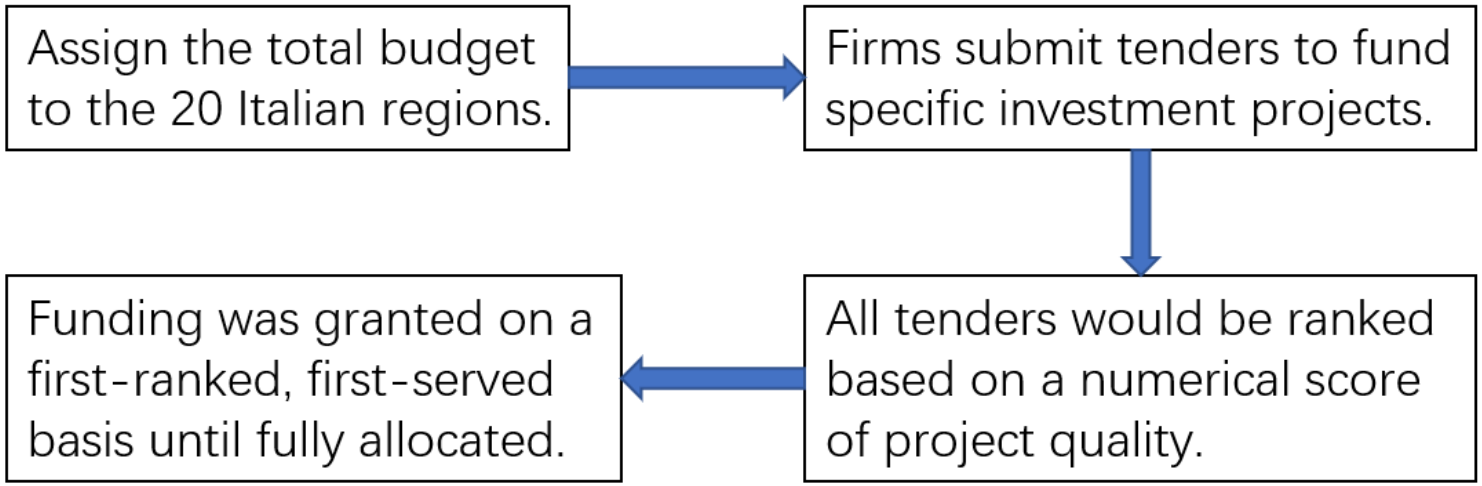
1. To ensure **internal validity**, this paper must compare subsidized and non-subsidized firms that are similar in all aspects, except for the subsidy receipt.
2. The effect of the subsidy may be **heterogeneous** across firms.
3. It is difficult to interpret the **external validity** of estimates in different contexts or when different allocation criteria are considered.

Challenges in Policy Evaluation

- A possible strategy: only estimate the ATE among a subset of compliers group. But it cannot explain the heterogeneous effect, and may limit the external validity.
- To address these limitations, this paper leverages the method of Angrist and Rokkanen (2015), which provide testable restrictions under which one can extrapolate estimated treatment effects to different subpopulations of inframarginal units away from the RD cutoff.

The Procedure of Fund Allocation

- The numerical score was determined by two main components:
  1. Rules: objective criteria.
  2. Discretion: regional priorities indicated by local politicians.



Main Results

- Using ML methods, this paper shows that the discretionary component of the overall score tends to favor projects submitted by:
  - Smaller applicant firms;
  - Demand larger subsidies;
  - Are located in relatively disadvantaged areas.

Main Results

- Using a RD design, this paper finds:
  - Investment $\uparrow 43\%$, and employment $\uparrow 11\%$ during the 3-year subsidy period.
  - Employment $\uparrow 17\%$ consistently in 6 years after being awarded the subsidy (a net increase), and firm survival $\uparrow 3\%$ over the same horizon.

Overall Effectiveness

- The estimated cost-per-new-job over a time horizon of six years stands at €178,000.
  - €68,000 in the North but €241,000 in the South, the economically underdeveloped area.
- The cost of investment shows a similar gradient.
  - Multiplier: 3 in the North but only 1 in the South.

Counterfactual Policies

- The allocation by only the "rules" component:
  - The cost per new job $\downarrow 11\%$, and the cost of new investment $\downarrow 13\%$.
- The allocation by only the "discretion" component:
  - The cost per new job $\uparrow 42\%$, and the cost of new investment $\uparrow 22\%$.
- The optimal allocation:
  - It would result in reducing the cost per new job by more than half.

Contributions

This paper

- Contributes to a vast body of literature that examines the causal impact of public subsidies on investment, employment, and overall economic activity.
- Provides the empirical evidence by firm-level data, and shows the heterogeneous effect, specifically considering the trade-off between rules and discretion.
- Contributes to the growing literature on the impact of discretion on the effectiveness of public policies.

Regional Disparities

- Significant economic gap: in 2001, the median value-added per capita in the northern regions was double that of the southern regions.
- Low mobility in labor market: by 2005, the one-year mobility rate in Italy was only one-third of that in the United States, ranking as one of the lowest among countries.

Fund Distribution

	All Italy	North	Center	South
Total Funds	25.98	2.34	1.68	21.95
Allocation across economic sectors				
Industry	21.89	1.97	1.37	18.55
Tourism	2.68	0.21	0.19	2.28
Trade	0.73	0.06	0.06	0.61
Special	0.45	0.09	0.05	0.31
Craftwork	0.23	0.02	0.01	0.20
Source of funds				
National	19.77	1.95	1.52	16.30
EU	6.21	0.39	0.17	5.65

Stage 1: Objective Rules

- During the initial calls for projects in 1996 and 1997, three primary quality indicators were established:
  1. **I1**: ratio of applicant's investment to the requested funds.
  2. **I2**: the number of jobs the project would generate.
  3. **I3**: proportion of requested funds compared to a benchmark set by the EU Commission.
- Standardized score:

$$S_{ir} = \sum_{j=1}^{3} \frac{I_{ir}^{j} - \mu_{r}^{j}}{\sigma_{r}^{j}}$$

where I_{ir}^{j} is the value of the jth indicator for project i in call-region r.

Stage 2: Additional Indicators

- Starting from the third call for projects in 1998, two additional indicators were introduced:
  1. **I4**: regional government-assigned points based on priorities.
  2. **I5**: adherence to environmental management systems.
- Adjusted standardized score:

$$S_{ir} = \sum_{j=1}^{4} \frac{I_{ir}^{j} \times I_{ir}^{5} - \mu_{r}^{j}}{\sigma_{r}^{j}}$$

where $I_{ir}^{5} = 1.05$ if the applicant i is compliant with environmental certification, and $I_{ir}^{5} = 1$ otherwise.

Ranking and Funding of Projects

- This ranking was conducted region-wise and was influenced by additional rules that prioritized certain applicant and project categories. Specifically, there were three main rules:
  1. Within each region, a minimum of 50% of the budget was set aside for small-medium enterprises.
  2. Up to 5% of the regional budget was allocated to service sector firms.
  3. Projects that qualified for supplemental co-funding from EU structural funds were prioritized over those projects that only qualified for national funding.

Data Source

- The analysis capitalizes on a unique data set, merging administrative records, firm registry data, and a proprietary balance sheet database:
  - Comprehensive information on all applications to 26 calls for L488/92 funds from 1996 to 2007, by the Italian Ministry of Economic Development.
  - Firm archives which records present monthly employment statistics and document business start and closure dates, by the Italian Social Security Institute.
  - Balance sheet data from Cerved—a proprietary database covering all limited liability companies incorporated in Italy.

Descriptive Statistics

	Average	p_{10}	p_{25}	p_{50}	p_{75}	p_{90}	Obs
Panel A: Administrative data on L488/92							
Funds requested (ths. €)	685	61	130	303	697	1448	40,366
Score ≥ cutoff (%)	46	0	0	0	100	100	40,366
Score ≥ cutoff & funded (%)	80	0	100	100	100	100	40,366
Panel B: Social security data (INPS)							
Firm age	11	0	3	8	17	26	40,366
Firm size (n. employees, $t-1$)	36	1	4	12	30	74	40,366
Industrial (%)	72	0	0	100	100	100	40,366
South (%)	67	0	0	100	100	100	40,366
Employment cumulative growth (pp, $t+6$)	0.28	−0.60	−0.10	0.21	0.66	1.37	35,156
Survive (%, $t+6$)	87	0	100	100	100	100	40,366
Panel C: Balance sheet data (CERVED)							
Total assets (ths. €)	13,153	394	1044	2921	8434	24,173	27,856
Total revenues (ths. €)	12,784	311	925	2780	8377	24,545	27,384
Investment rate (pp)	0.08	0.00	0.00	0.02	0.10	0.22	27,856
Revenues cumulative growth (pp, $t+6$)	0.46	−0.36	0.09	0.44	0.85	1.41	18,516

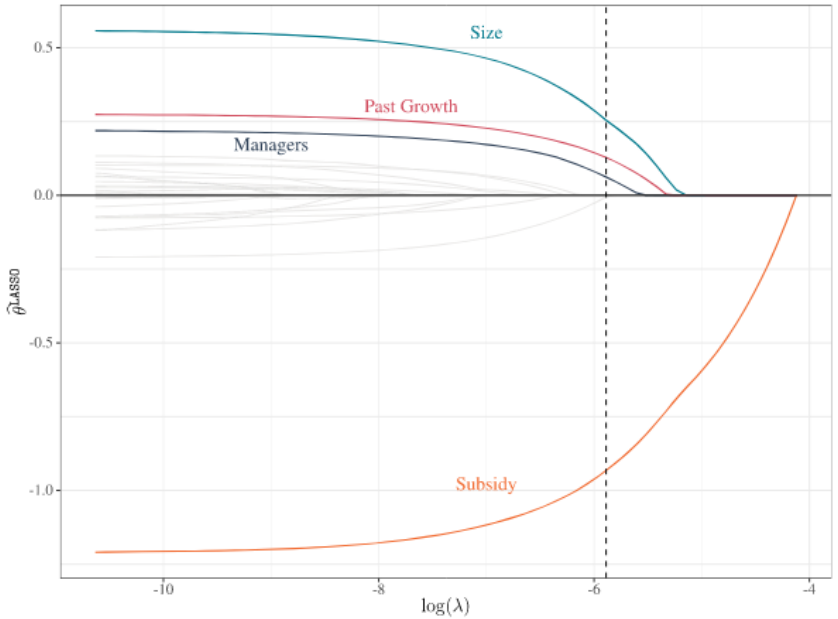
Implications of Discretion

- How about the implications of political discretion for their allocation across firms?
- This paper investigates the factors influencing the objective and discretionary sub-scores—denoted as SR and SD, respectively.
- The LASSO estimator:

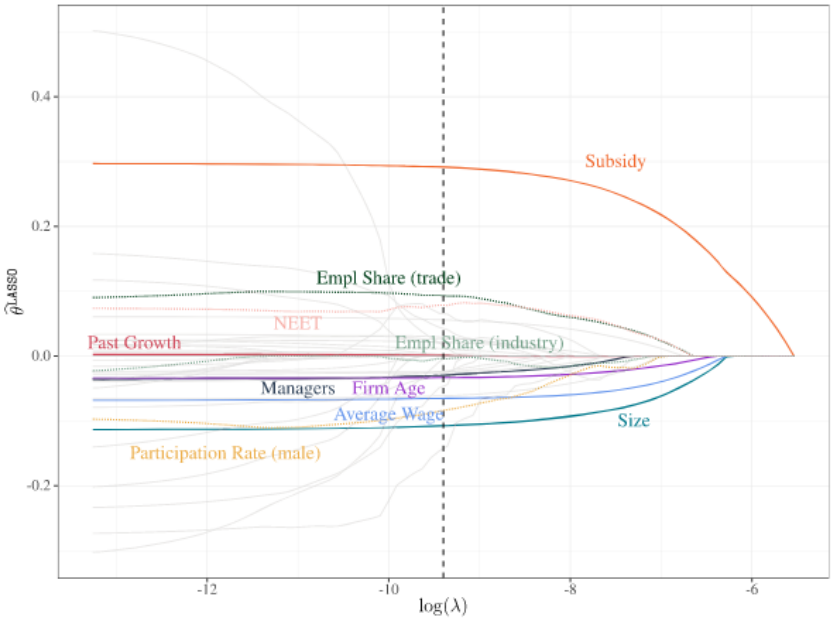
$$\hat{\theta}^{LASSO} := \arg\min_{\theta \in \mathbb{R}^k} \left\{ \sum_{i=1}^{n} (Y_i - Z_i'\theta)^2 + \lambda \sum_{j=1}^{k} |\theta_j| \right\}$$

while the optimal λ is determined by the one-standard-deviation rule.

Implications of Discretion

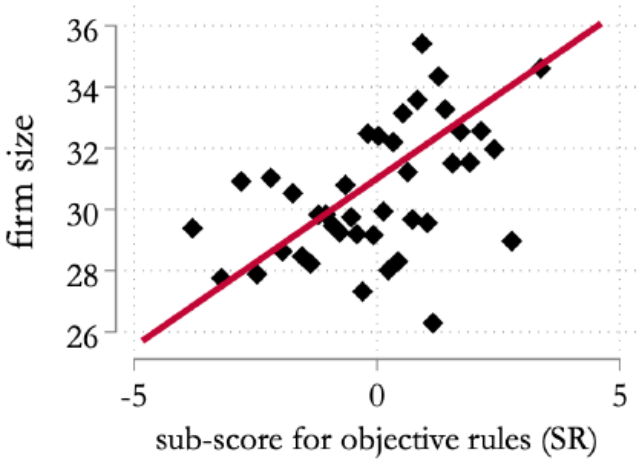


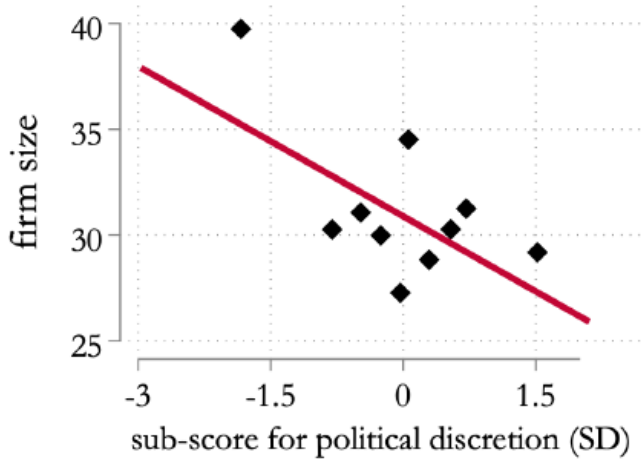
(i) *SR, main predictors*

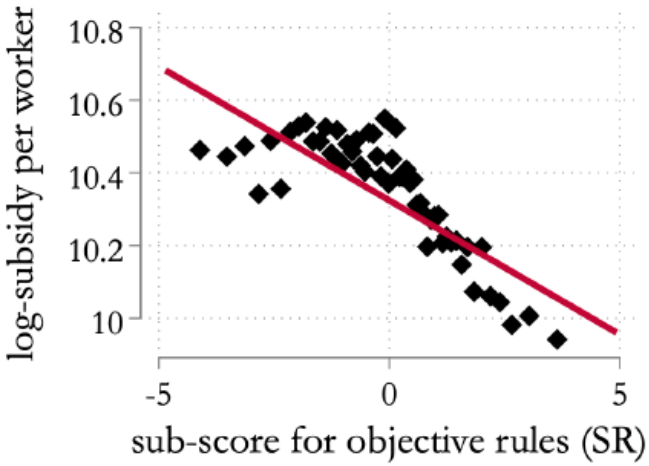


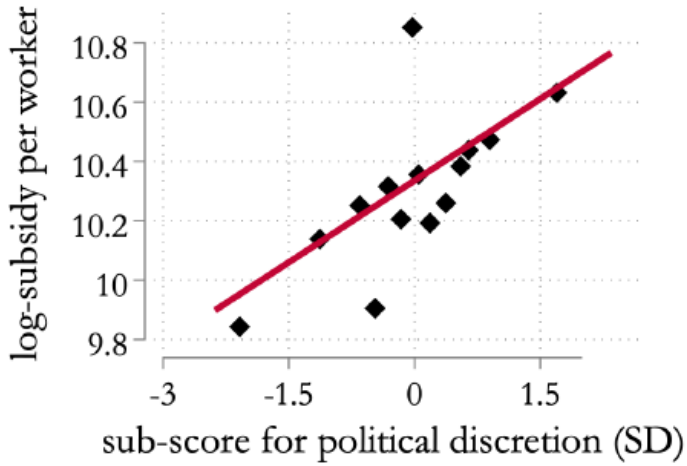
(ii) *SD, main predictors*

Implications of Discretion

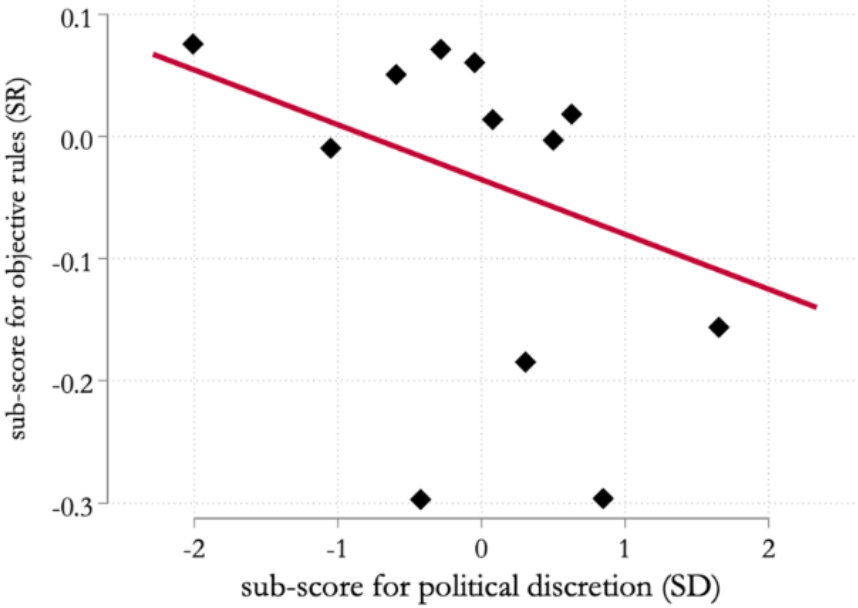


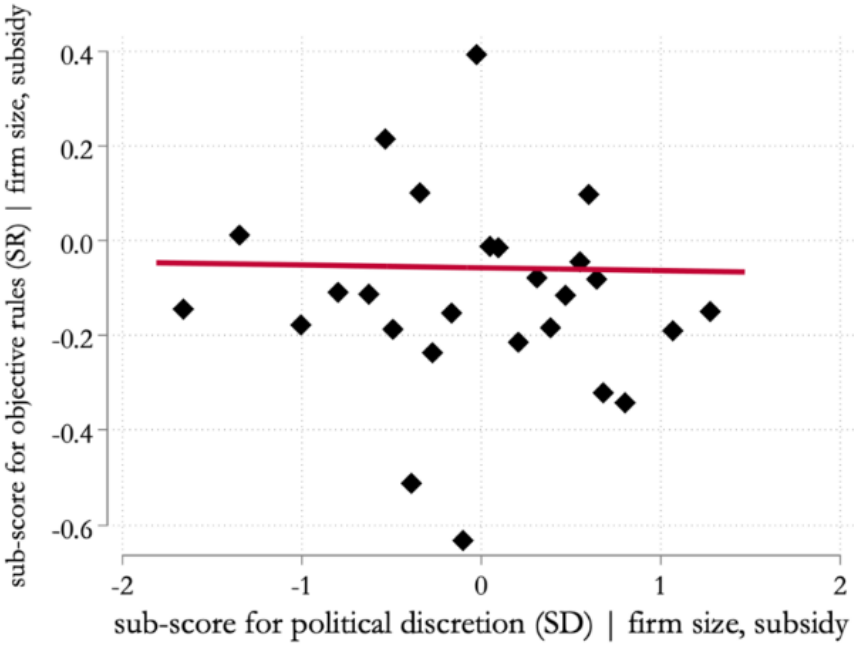






Implications of Discretion





Definitions

- $Y_{ic}(d)$, $d = \{0, 1\}$, the potential outcomes of applicant firm i competing in cell c.
- $\tilde{S}_{ic}$, the score received by firm i; and $\bar{S}_c$, the cutoff score required for obtaining the subsidy in cell c. So $S_{ic} = \tilde{S}_{ic} - \bar{S}_c$ is the normalized score for each firm.
- D_{ic}, the treatment assignment variable, equal to 1 whenever $S_{ic} \geq 0$, and equal to 0 otherwise.

Benchmark RD Design

- The ITT effect:

$$\tau = \lim_{s \to 0^+} \mathbb{E}[Y|S = s] - \lim_{s \to 0^-} \mathbb{E}[Y|S = s]$$

- RD estimation:

$$Y = \tau D + \sum_{l=1}^{p} \gamma_l S^l + \sum_{l=1}^{p} \delta_l D \cdot S^l + FE_c + \varepsilon$$

with the bandwidth $S \in [-5, 5]$ (82% of the sample), the polynomial order $p \in \{1, 2\}$ and triangular kernels.

Global Effect Estimation

- Angrist and Rokkanen (2015) shows that, if there exists a set of covariates X that satisfies the two assumptions below, we can extrapolate estimated treatment effects to different subpopulations of inframarginal units away from the RD cutoff.
- **A1**: The conditional (mean) independence assumption:

$$\mathbb{E}[Y(d)|S, X] = \mathbb{E}[Y(d)|X] \quad d \in \{0, 1\} \tag{1}$$

- **A2**: The overlap / common support assumption:

$$0 < \mathbb{P}(D = 1|X) < 1 \tag{2}$$

Global Effect Estimation

- If the CIA holds,

$$\mathbb{E}[Y(d)|SR, SD, X] = \mathbb{E}[Y(d)|X] \quad d \in \{0, 1\} \tag{3}$$

we can estimate conditional average treatment effects as

$$\begin{aligned} &\mathbb{E}[Y(1) - Y(0)|SR = sr', SD = sd'] \\ &= (\beta_1 - \beta_0)' \mathbb{E}[X|SR = sr', SD = sd'] \end{aligned} \tag{4}$$

and this equation will allow us to assess the contribution of objective rules and political discretion, respectively, to the effectiveness of public subsidies. More Details

Counterfactual Evaluation

- Let F_Z^a and F_Z^c be the distributions of the pool of applicants with respect to the characteristics Z relevant for the outcome under, respectively, the actual and the counterfactual assignment rule.
- And let $SR^a(i)$ and $SR^c(i)$ be the objective sub-score obtained by the ith project under, respectively, the actual and the counterfactual assignment rule.
- The policy invariance condition:

$$F_Z^a \sim F_Z^c \quad \text{and} \quad SR^a(i) = SR^c(i) \quad \forall i \tag{5}$$

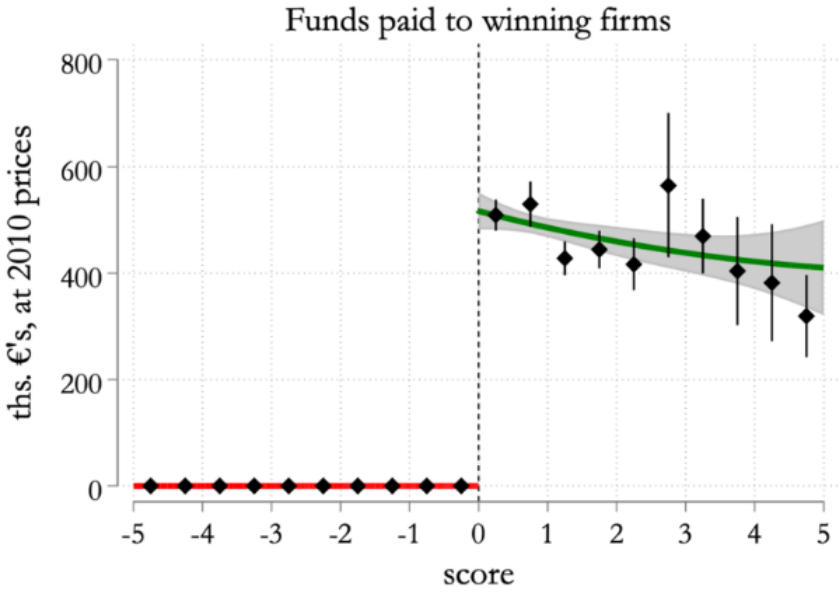
Counterfactual Evaluation

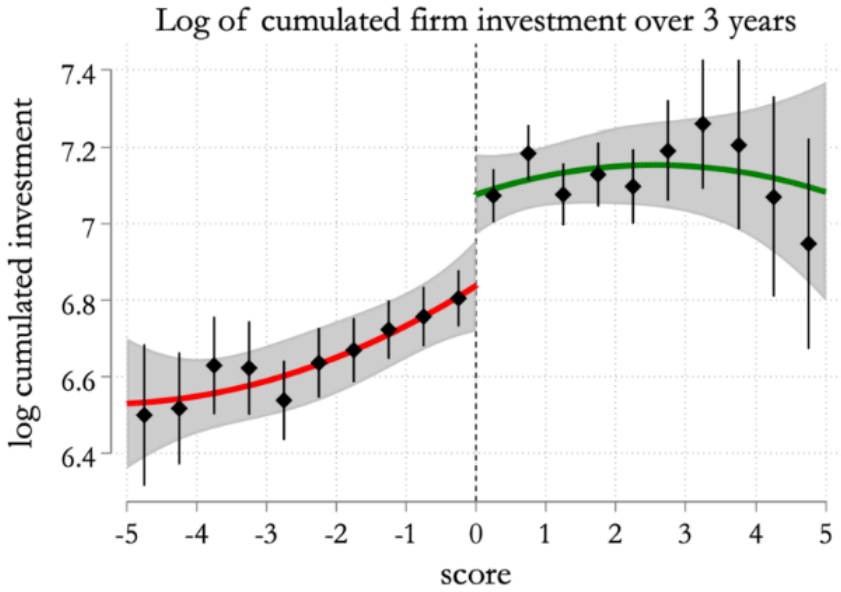
- Holding condition (5), we shall use the CIA condition (3) to assess how the average impact of subsidies would change under alternative assignment rules.
- Under an assignment rule based only on the sub-score for objective rules:

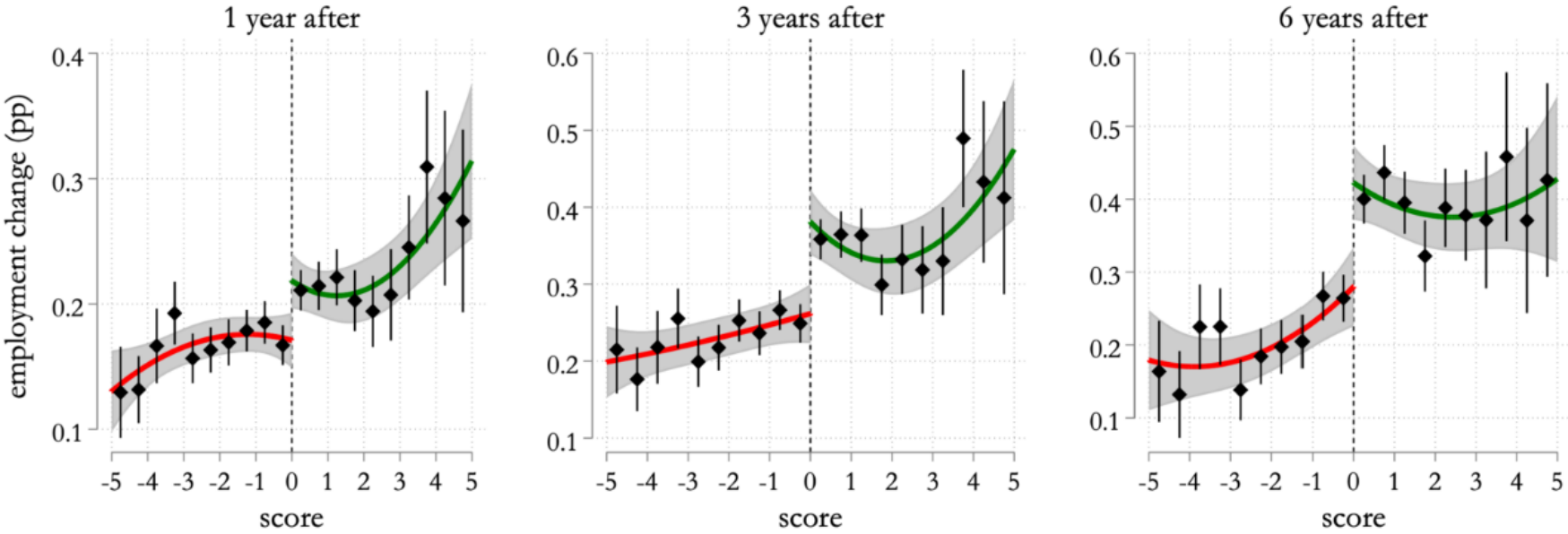
$$\mathbb{E}[Y(1) - Y(0)|SR = sr'] = (\beta_1 - \beta_0)'\mathbb{E}[X|SR = sr']$$

- Under an assignment rule based only on the sub-score for political discretion:

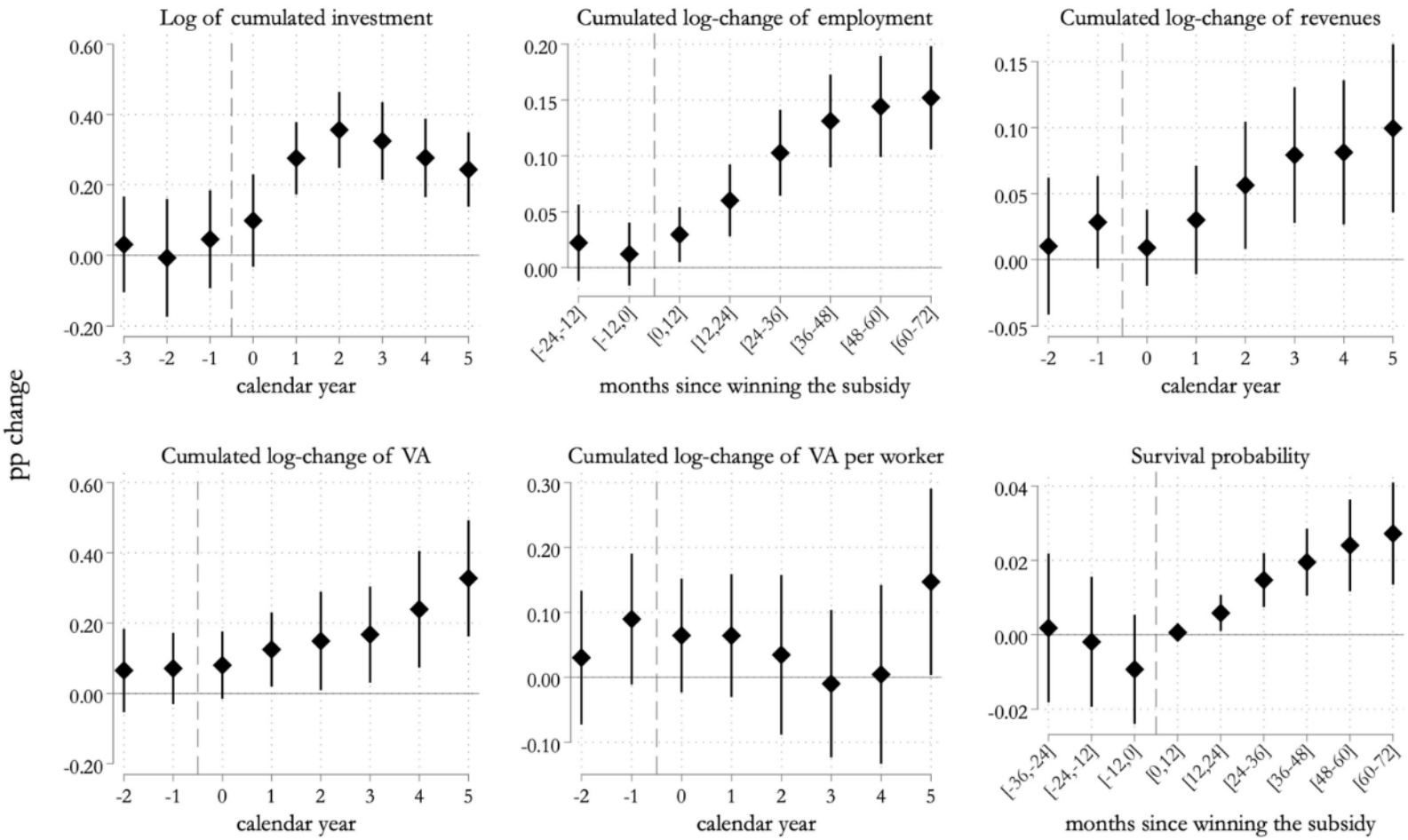
$$\mathbb{E}[Y(1) - Y(0)|SD = sd'] = (\beta_1 - \beta_0)'\mathbb{E}[X|SD = sd']$$


Funds paid to winning firms
ths. €'s, at 2010 prices
800
600
400
200
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
score


Log of cumulated firm investment over 3 years
log cumulated investment
7.4
7.2
7
6.8
6.6
6.4
-5
-4
-3
-2
-1
0
1
2
3
4
5
score

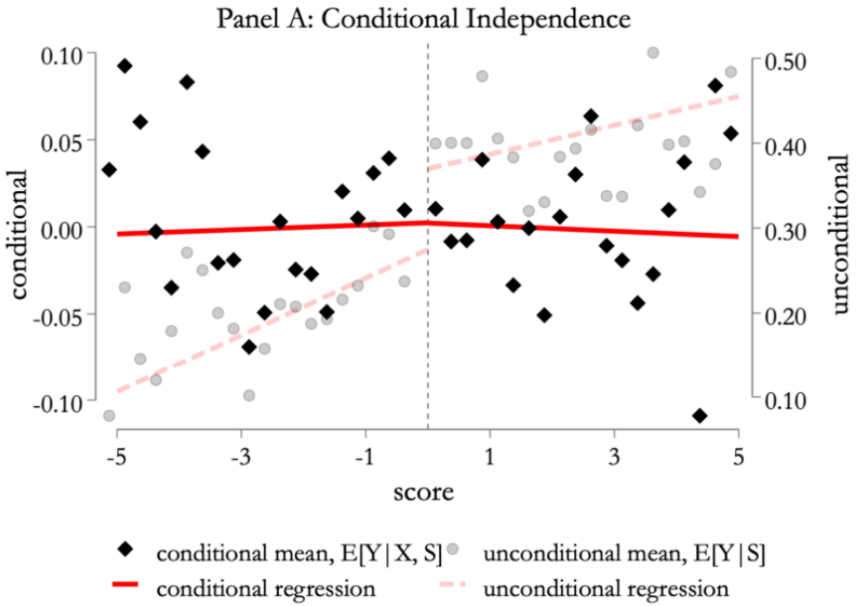

1 year after
3 years after
6 years after
employment change (pp)
0.4
0.3
0.2
0.1
0.6
0.5
0.4
0.3
0.2
0.1
-5 -4 -3 -2 -1 0 1 2 3 4 5
score

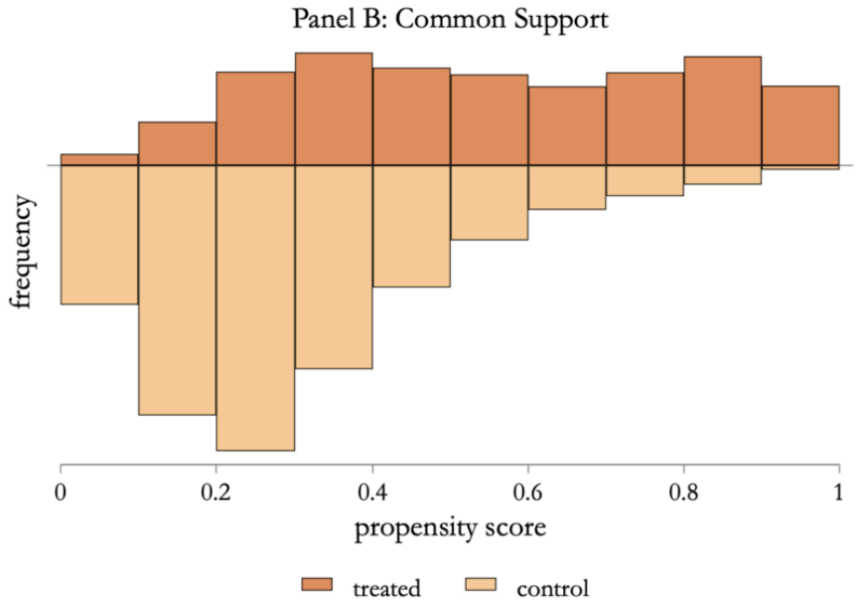
Specification:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Linear				Quadratic			
Kernel:	Uniform		Triangular		Uniform		Triangular	
Group Fixed Effects:	✗	✓	✗	✓	✗	✓	✗	✓
Panel A: Log of cumulated investment over 3 years								
Subsidy	0.300	0.360	0.277	0.321	0.240	0.278	0.255	0.277
	[0.060]	[0.055]	[0.060]	[0.058]	[0.077]	[0.073]	[0.077]	[0.073]
		43%						
Obs	17,425	17,425	17,425	17,425	17,425	17,425	17,425	17,425
Adj. R^2	0.016	0.229	0.014	0.230	0.016	0.229	0.014	0.230
Panel B: Log-change in employment over 3 years								
Subsidy	0.088	0.104	0.101	0.104	0.120	0.107	0.114	0.105
	[0.019]	[0.020]	[0.020]	[0.020]	[0.026]	[0.025]	[0.028]	[0.026]
		11%						
Obs	31,681	31,681	31,681	31,681	31,681	31,681	31,681	31,681
Adj. R^2	0.004	0.059	0.004	0.063	0.004	0.059	0.004	0.063
Panel C: Log-change in employment over 6 years								
Subsidy	0.147	0.153	0.145	0.139	0.142	0.124	0.131	0.119
	[0.023]	[0.024]	[0.023]	[0.023]	[0.030]	[0.029]	[0.032]	[0.030]
		17%						
Obs	28,759	28,759	28,759	28,759	28,759	28,759	28,759	28,759
Adj. R^2	0.007	0.066	0.007	0.067	0.007	0.066	0.007	0.067

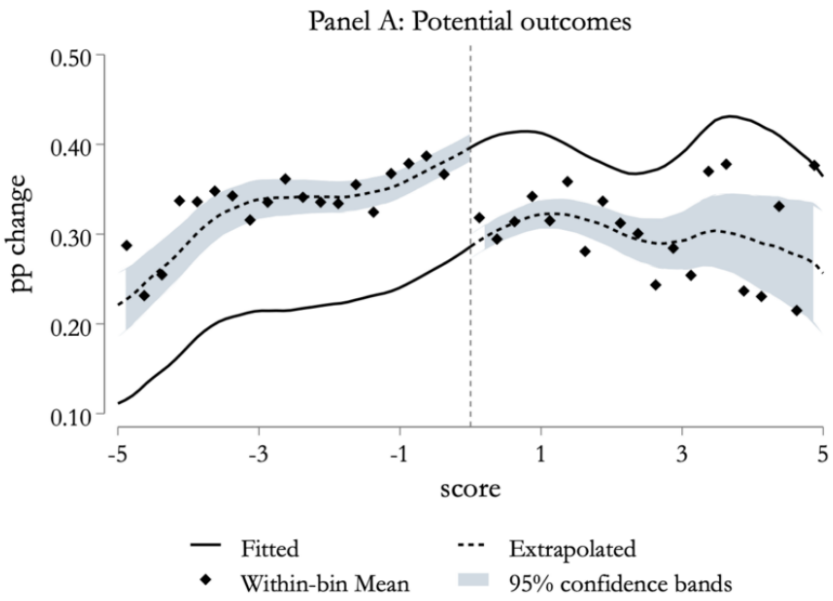

pp change
Log of cumulated investment
0.60
0.40
0.20
0.00
-0.20
-3 -2 -1 0 1 2 3 4 5
calendar year
Cumulated log-change of employment
0.20
0.15
0.10
0.05
0.00
[-24,-12] [-12,0] [0,12] [12,24] [24-36] [36-48] [48-60] [60-72]
months since winning the subsidy
Cumulated log-change of revenues
0.15
0.10
0.05
0.00
-0.05
-2 -1 0 1 2 3 4 5
calendar year
Cumulated log-change of VA
0.60
0.40
0.20
0.00
-0.20
-2 -1 0 1 2 3 4 5
calendar year
Cumulated log-change of VA per worker
0.30
0.20
0.10
0.00
-0.10
-2 -1 0 1 2 3 4 5
calendar year
Survival probability
0.04
0.02
0.00
-0.02
[-36,-24] [-24,-12] [-12,0] [0,12] [12,24] [24-36] [36-48] [48-60] [60-72]
months since winning the subsidy

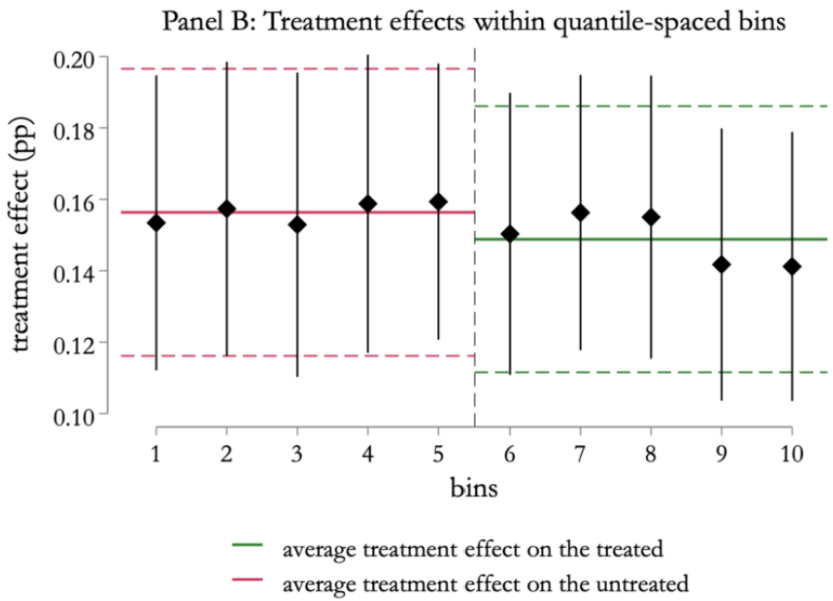
Covariates

- This paper experiments with alternative predictors of firm growth, and achieves CIA and common support for a vector X^* that includes the following covariates:
  - firm age;
  - lagged realizations of a firm's growth and 3-year forward growth of firms in the same market, as defined by the LLM and 3-digit sector;
  - pre-treatment workers' skills, as measured by the average wage of white-collar workers and indicators for having managers or apprentices in the payroll;
  - a measure of the size of the investment project, scaled by initial employment along with cell fixed effects.

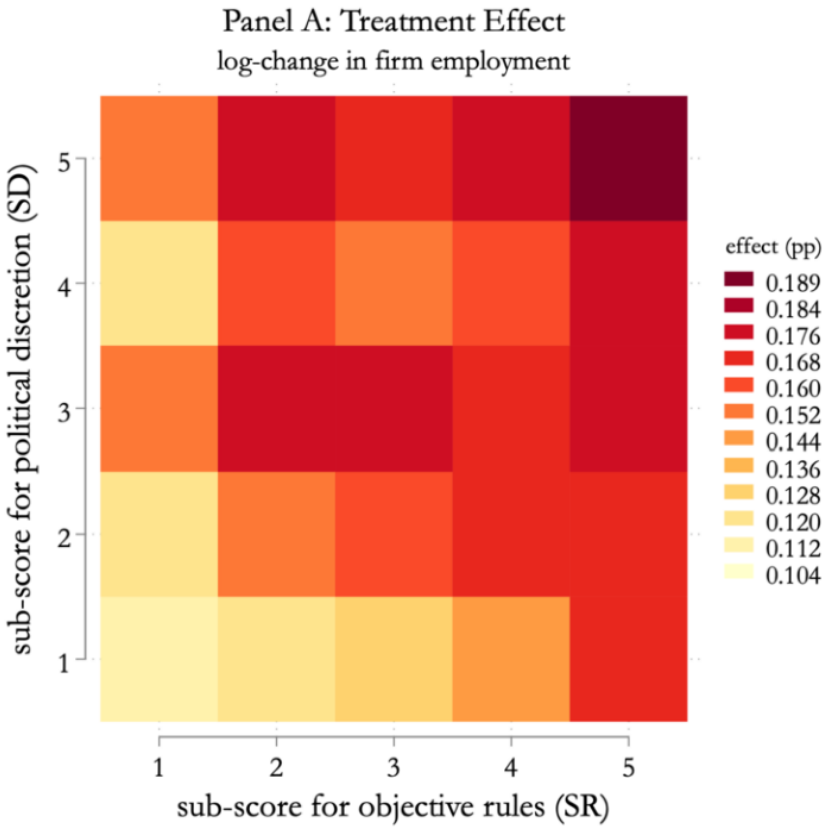

Panel A: Conditional Independence
conditional
unconditional
0.10
0.05
0.00
-0.05
-0.10
0.50
0.40
0.30
0.20
0.10
-5
-3
-1
1
3
5
score
conditional mean, E[Y | X, S]
unconditional mean, E[Y | S]
conditional regression
unconditional regression

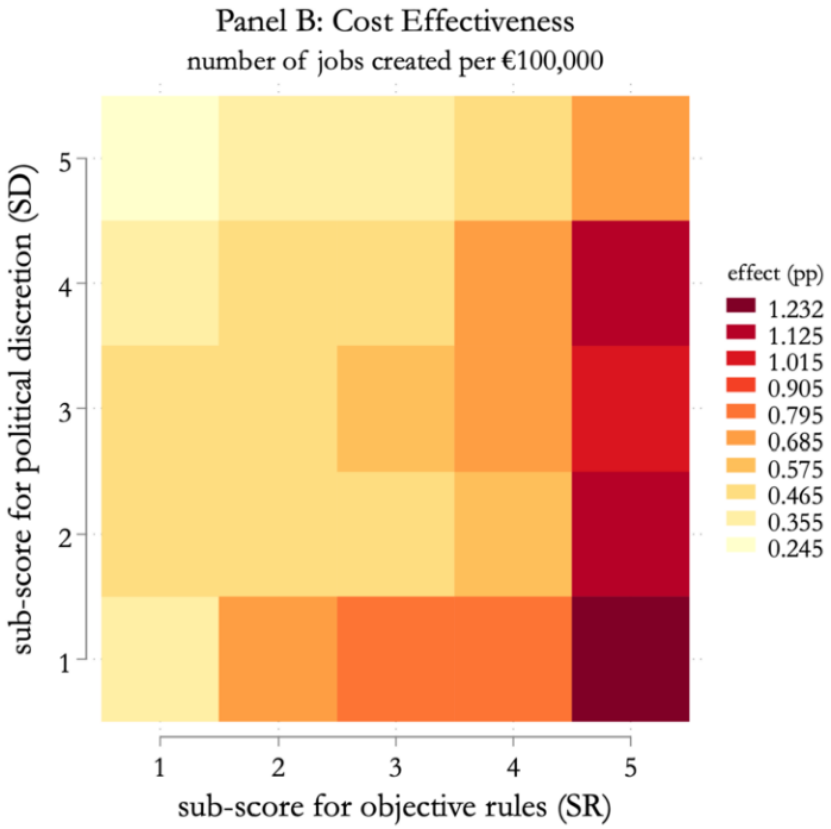

Panel B: Common Support
frequency
0
0.2
0.4
0.6
0.8
1
propensity score
treated
control


Panel A: Potential outcomes
pp change
0.50
0.40
0.30
0.20
0.10
-5
-3
-1
1
3
5
score
Fitted
Within-bin Mean
Extrapolated
95% confidence bands


Panel B: Treatment effects within quantile-spaced bins
treatment effect (pp)
0.20
0.18
0.16
0.14
0.12
0.10
1
2
3
4
5
6
7
8
9
10
bins
average treatment effect on the treated
average treatment effect on the untreated

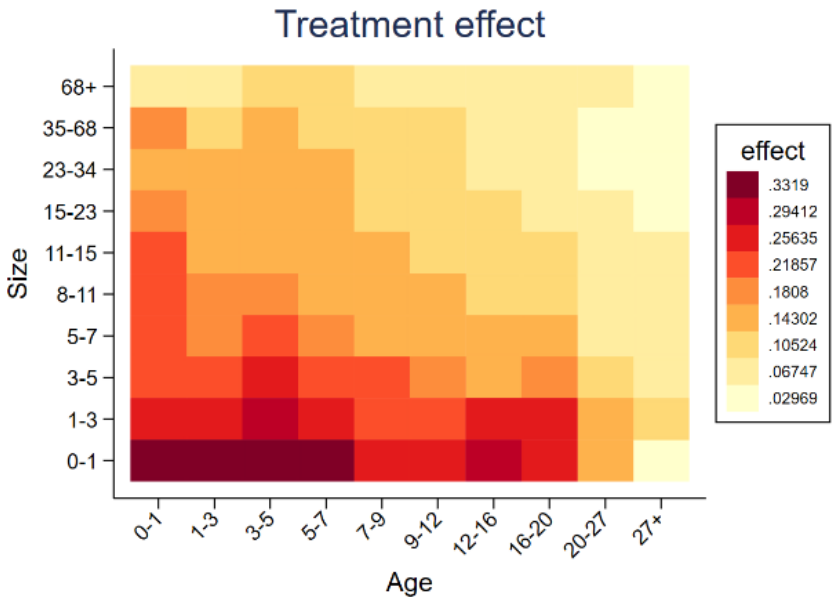
Cost measure:	(1) Cost per New Job (Thousands of €'s)	(2)	(3) Cost per Worker-Year (Thousands of €'s)	(4)	(5) Cost of New Investment (Cost per €1 of Investment)	(6)
$X^{\star}$:	Manual	Data-Driven	Manual	Data-Driven	Manual	Data-Driven
all regions	178	159	54	56	0.81	0.63
	[133; 299]	[118; 260]	[47; 62]	[51; 62]	[0.59; 1.25]	[0.48; 0.87]
south	241	201	77	72	1.05	0.87
	[195; 332]	[163; 270]	[70; 88]	[67; 79]	[0.79; 1.51]	[0.67; 1.17]
north-center	68	70	19	25	0.35	0.25
	[41; 211]	[44; 214]	[17; 24]	[22; 29]	[0.24; 0.59]	[0.18; 0.34]

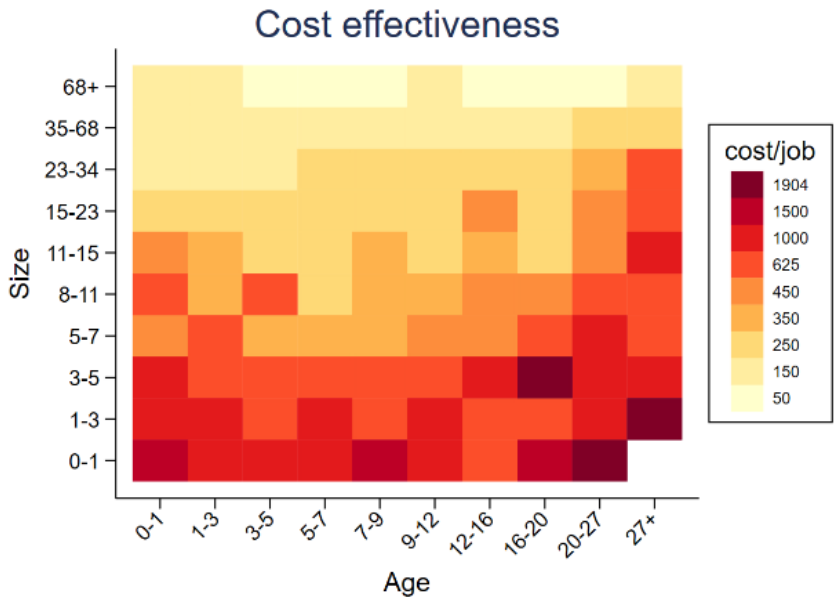

Panel A: Treatment Effect
log-change in firm employment
sub-score for political discretion (SD)
1
2
3
4
5
sub-score for objective rules (SR)
1
2
3
4
5
effect (pp)
0.189
0.184
0.176
0.168
0.160
0.152
0.144
0.136
0.128
0.120
0.112
0.104


Panel B: Cost Effectiveness
number of jobs created per €100,000
sub-score for political discretion (SD)
1
2
3
4
5
sub-score for objective rules (SR)
1
2
3
4
5
effect (pp)
1.232
1.125
1.015
0.905
0.795
0.685
0.575
0.465
0.355
0.245

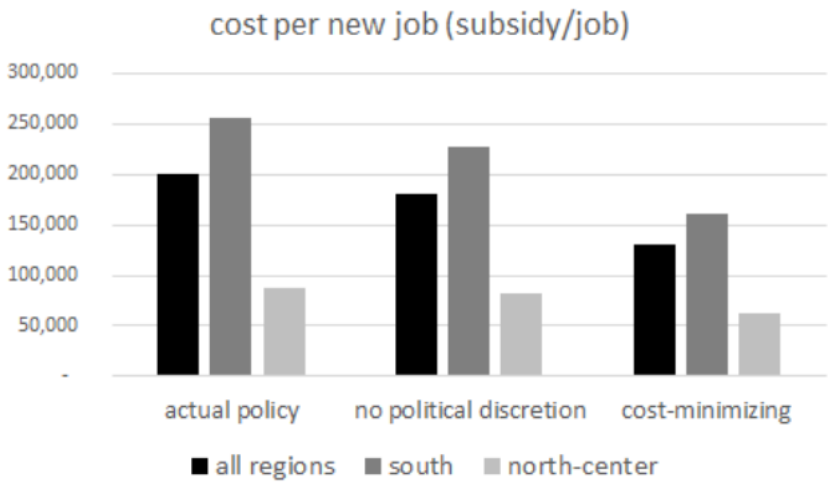
COST OF NEW JOBS AND INVESTMENT GENERATED BY L488 SUBSIDIES

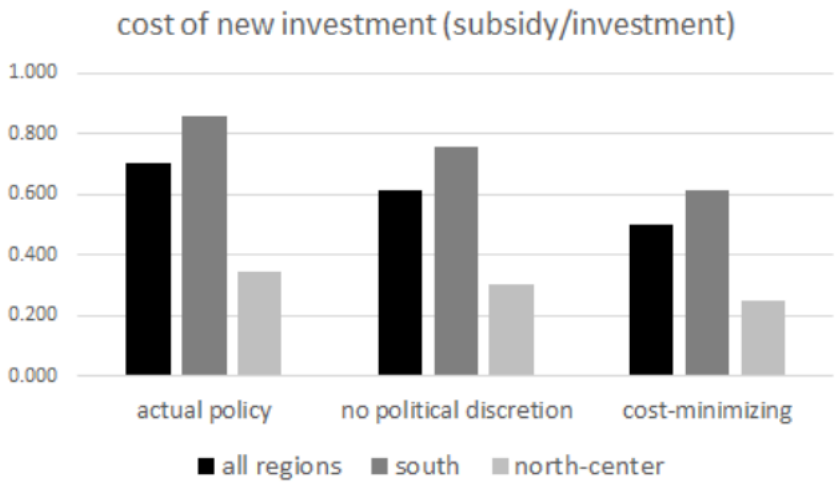
	(1)	(2)	(3)	(4)	(5)	(6)
Cost Measure	cost per new job (thousand of €'s)		cost per worker-year (thousand of €'s)		cost of new investment (thousand of €'s)	
$X^\star$	manual	data-driven	manual	data-driven	manual	data-driven
all firms	178	159	54	56	0.81	0.63
	[133; 299]	[118; 260]	[47; 62]	[51; 62]	[0.59; 1.25]	[0.48; 0.87]
large	78	78	24	29	0.4	0.29
	[47; 222]	[52; 174]	[19; 30]	[25; 35]	[0.27; 0.74]	[0.21; 0.41]
small	253	209	80	74	1.08	0.87
	[203; 349]	[162; 296]	[73; 90]	[68; 81]	[0.83; 1.49]	[0.68; 1.15]


Treatment effect
Size
68+
35-68
23-34
15-23
11-15
8-11
5-7
3-5
1-3
0-1
0-1
1-3
3-5
5-7
7-9
9-12
12-16
16-20
20-27
27+
Age
effect
.3319
.29412
.25635
.21857
.1808
.14302
.10524
.06747
.02969


Cost effectiveness
Size
68+
35-68
23-34
15-23
11-15
8-11
5-7
3-5
1-3
0-1
0-1
1-3
3-5
5-7
7-9
9-12
12-16
16-20
20-27
27+
Age
cost/job
1904
1500
1000
625
450
350
250
150
50

	(1) Actual Policy	(2) Counterfactual Policies		(3) Counterfactual Policies		(4) Counterfactual Policies	
		No Discretion		Only Discretion		Cost Minimizing	
	Cost	Cost	%Δ	Cost	%Δ	Cost	%Δ
Panel A: Cost per new job (thousands)							
all regions	179	159	−11.13 [−14.76; −8.04]	253	41.68 [17.67; 64.30]	83	−53.73 [−60.25; −52.41]
south	225	198	−12.14 [−16.03; −8.49]	310	37.83 [23.52; 54.57]	97	−57.07 [−61.36; −54.55]
north-center	83	76	−8.68 [−14.92; −3.66]	115	37.67 [−32.96; 47.69]	45	−45.62 [−62.45; −43.47]
Panel B: Cost per 1€ of investment							
all regions	0.76	0.67	−12.8 [−16.89; −9.25]	0.93	22.45 [12.01; 32.75]	0.33	−56.19 [−59.94; −53.37]
south	0.94	0.82	−12.38 [−17.00; −8.54]	1.12	19.98 [12.02; 30.90]	0.38	−59.21 [−63.35; −55.56]
north-center	0.39	0.33	−13.8 [−21.58; −6.43]	0.47	22.64 [1.25; 27.33]	0.2	−48.87 [−55.69; −44.49]


cost per new job (subsidy/job)
300,000
250,000
200,000
150,000
100,000
50,000
-
actual policy
no political discretion
cost-minimizing
all regions
south
north-center


cost of new investment (subsidy/investment)
1.000
0.800
0.600
0.400
0.200
0.000
actual policy
no political discretion
cost-minimizing
all regions
south
north-center

Conclusions

- Both firms ranking high on objective criteria and firms preferred by local politicians generate larger employment growth on average, but the latter do so at a higher cost per job.
- For the case of this specific policy, eliminating political discretion—thus relying only on ex ante, objective criteria—would improve cost-effectiveness by 11%, while relying only on political discretion would increase the cost by as much as 42%.

Questions are welcome.

Recent Paper of Prof. Pinotti

- "Rules, Discretion, and Corruption in Procurement: Evidence from Italian Government Contracting" (2025 JPE: Micro):
  - The benefits of bureaucratic discretion depend on its use for public benefit versus private gain. Using data on Italian firms and procurement officials investigated for corruption, we show that discretionary auctions (awarded on the basis of negotiation rather than open bidding) are linked to corruption only when competition is restricted. Corrupt officials favor these negotiated auctions, though they are used less often in administrations where at least one official is under investigation. This suggests that discretion enhances efficiency but also enables theft, leading monitors to limit discretion in high-corruption settings. Overall, competition helps authorities to harness discretion's benefits while limiting its abuse. Back

Angrist and Rokkanen (2015)

- The ATE at $S = s'$ when two assumptions hold:

$$\begin{aligned} &\mathbb{E}[Y(1) - Y(0)|S = s'] \\ &= \mathbb{E}[\mathbb{E}[Y|X, D = 1] - \mathbb{E}[Y|X, D = 0]|S = s'] \end{aligned} \tag{6}$$

- Using the linear reweighting estimator by Kline (2011):

$$\mathbb{E}[Y|S, X, D = 1] = \sum_k \alpha_{k,1} S_1^k + X'\beta_1 \tag{7}$$

$$\mathbb{E}[Y|S, X, D = 0] = \sum_k \alpha_{k,0} S_0^k + X'\beta_0 \tag{8}$$

- By CIA, we failure to reject the restrictions $\forall k$, $\alpha_{k,1} = \alpha_{k,0} = 0$, so equation (7) and (8) becomes

$$\mathbb{E}[Y|S, X, D = 1] = \mathbb{E}[X, D = 1] = X'\beta_1 \tag{9}$$

$$\mathbb{E}[Y|S, X, D = 0] = \mathbb{E}[X, D = 0] = X'\beta_0 \tag{10}$$

Angrist and Rokkanen (2015)

- Substitute equation (9) and (10) into (6), we obtain

$$\begin{aligned}
&\mathbb{E}[Y(1) - Y(0)|S = s'] \\
&= \mathbb{E}[X'\beta_1 - X'\beta_0|S = s'] \\
&= (\beta_1 - \beta_0)'\mathbb{E}[X|S = s'] \qquad (11)
\end{aligned}$$

- Also, the condition $S = s'$ can be changed. Back