Regression Discontinuity Designs Based on Population Thresholds: Cautionary Tales from France, Germany, and Italy

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May 13, 2014

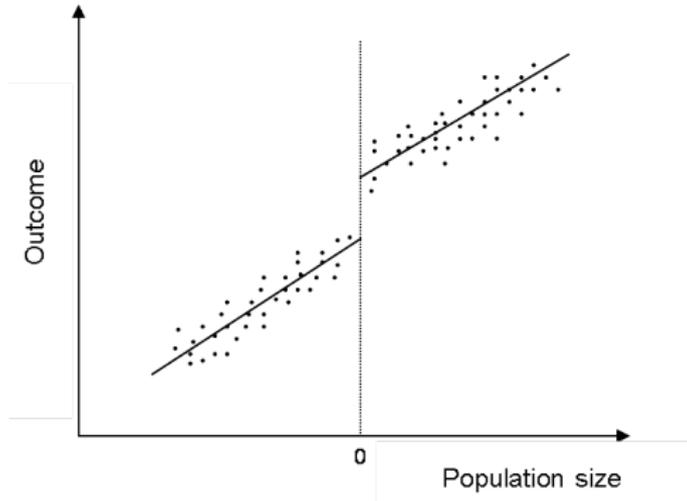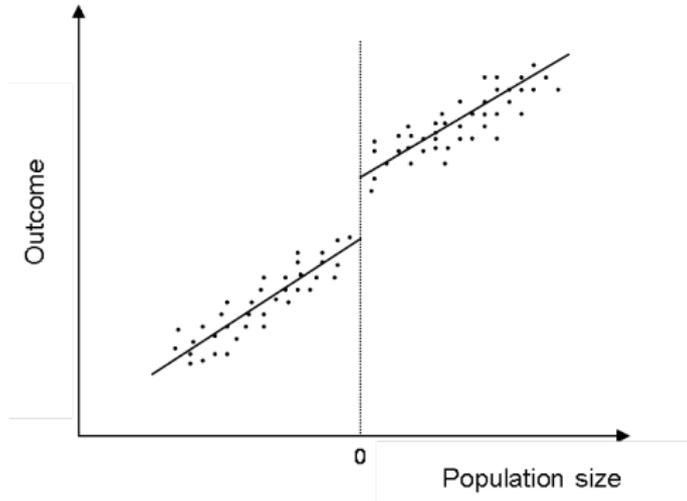# Regression Discontinuity Design

Figure: Research design

Figure: Research design

Assumption

- Continuity at the threshold

Motivation

- Recent literature on the causal effect of institutional features and constitutional rules. (Persson and Tabellini (2003), (2007))

- Much focus on cross-country, cross-states evidence

- Methods from the program evaluation literature are becoming more popular. (Acumolgu (2005), Pettersson-Lidbom (2008))

- RDD using population thresholds has seen some particular interest

Motivation (cont'd)

Research using population thresholds:

- Council size (Sweden, Germany) – Pettersson-Lidbom (2008, 2011, JPubE), Egger and Koethenbuerger (2010, AEJ-App)

- Wages of mayors (Italy)– Gagliarducci and Nannicini (forth. JEEA)

- Transfers (Brazil) – Brollo et al. (2013, AER)

- Mayor elections (Brazil) – Fujiwara (2011, QJPS)

- Ballots (US) – Hopkins (2011, AJPS)

- Direct democracy (Sweden) – Pettersson-Lidbom and Tyrefors (2013,cond. Econometrica)

Introduction (cont'd)

We found 16 additional working papers.

- Different countries: Brazil, Italy, Germany, Finland, Marocco, India, Spain, Japan

- Different topics: Transfers, wages, single vs runoff election systems, signature requirements, electoral rules, referenda and spending, fly paper effects, political participation of women, infrastructure

- Difference-in-discontinuity designs (5 papers)

- 5 more papers for Germany

- Stephan Litschig (2012) – Sorting in Brazil, Lyytikäinen & Tukiainen (2013) – Council size in Finland

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Our contribution

- Comparison of evidence for three countries

- Highlight the methodological issues:

    1 Confounding treatments
    2 Sorting and precise control

- Characterize the sorting

- Provide guidance for detecting and addressing these pitfalls

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France

Case study: France

- What institutions and policy areas change discontinuously at pop thresholds?
- Are municipalities in a position to manipulate the exact population figures?
- If yes, can we highlight some mechanism behind the sorting?

Data

- Census data on all municipalities in France

- Census information from 1962, 1968, 1975, 1982, 1990, 1999 and 2010

- Censuses are administered locally. Mayors appoint census officer and the municipality reports numbers to central authorities. (Except 2010)

Confounding treatments

Table: Population thresholds in French municipalities

	Policy changes at k inhabitants?												
---	0.1	0.5	1	1.5	2	2.5	3	3.5	5	9	10	20	30	50
Council size	x	x		x		x		x	x		x	x	x	x
Salary of mayor and deputy mayors		x	x					x			x	x		x
Max. number of deputy mayors	x	x		x		x		x	x		x	x	x	x
Max. number of non-resident councilors	x	x												
Must have a cemetery					x									
Prohibition on commercial water supply							x							
Campaign leaflets subsidized						x								
Council must approve property sales						x								
Electoral system – PR or plurality								x						
Gender parity								x						
Outsourcing scrutiny								x						
Council must debate budget prior to vote								x						
Committees follow PR principle								x						
Amount of paid leave for council work								x			x		x	
Commission on accessibility									x					
Max. electoral expenditure										x				
Outsourcing commission											x			
Max. municipal tax on salaries											x			x
Debt limit												x		

NOTE: The table identifies population thresholds (in thousands) at which given policies change. This is a partial list of policies, chosen to highlight the variety of policies that depend on population thresholds and the extent to which the same threshold often determines multiple policies. *Source*: French legal code.

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Evidence on sorting

Figure: Histogram of municipal population near 1000-inhabitant threshold in each of several censuses
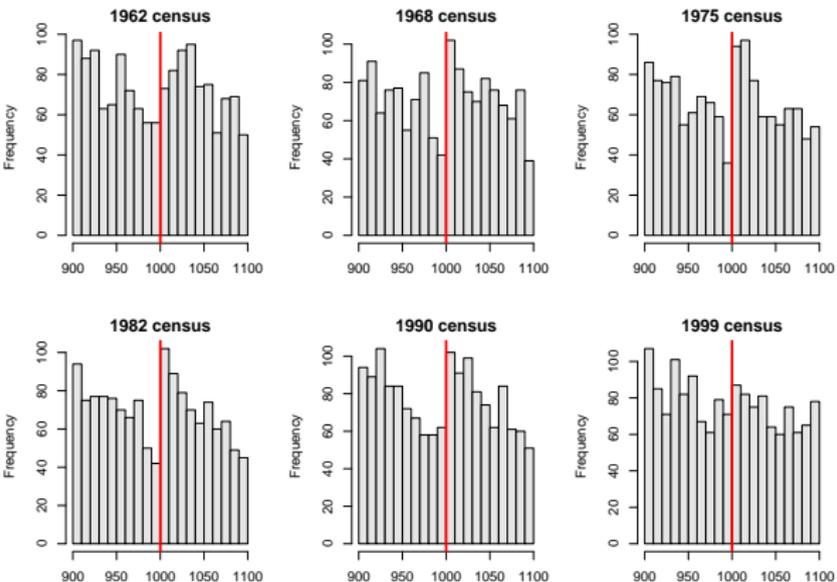
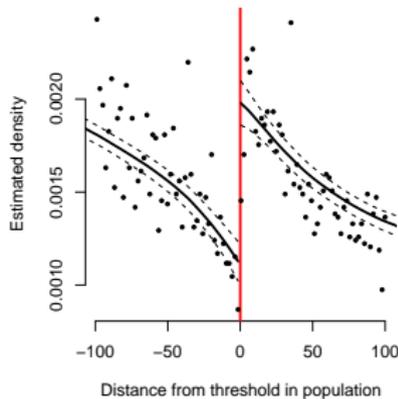Figure: Histogram and estimated density near 1000-inhabitant threshold, 1962-1999 censuses pooled
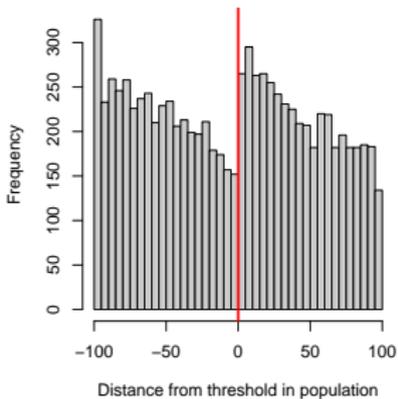
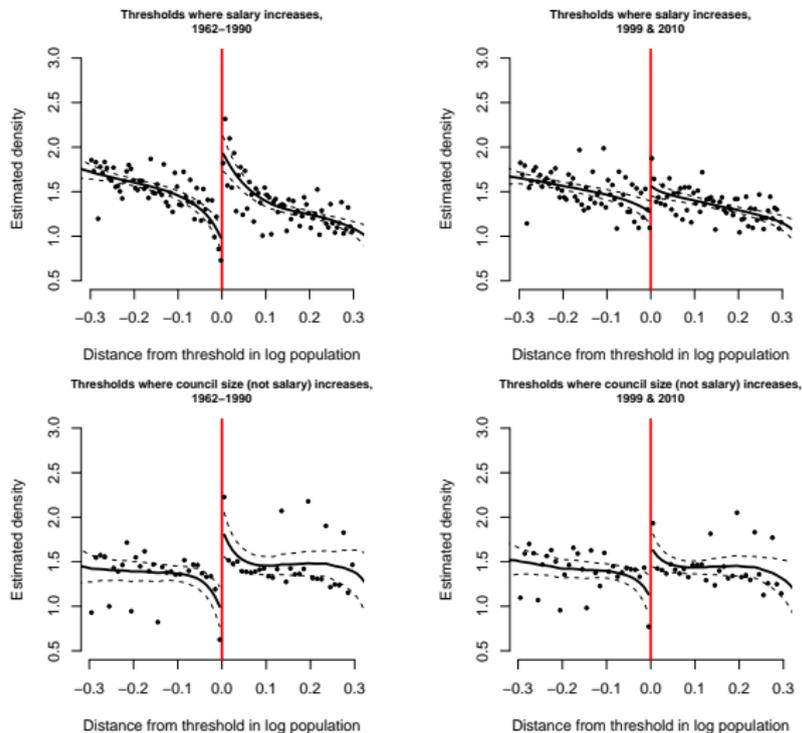# Figure: McCrary plots for thresholds where salary or council size increases

Figure: McCrary plots for thresholds where salary or council size increases
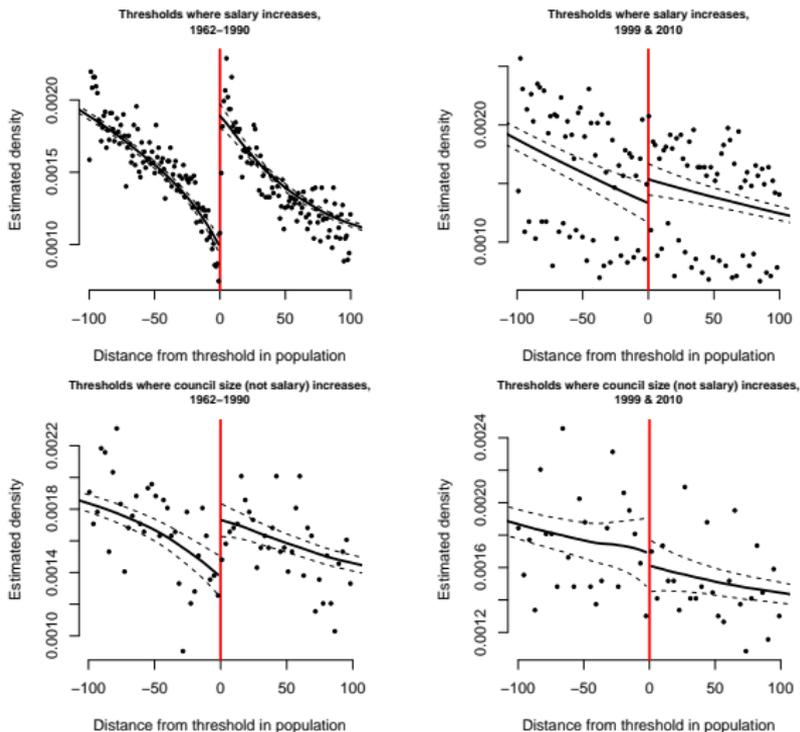
Table: McCrary tests for sorting at population thresholds over time

Threshold	Year of census						
	1962	1968	1975	1982	1990	1999	2010
Actual thresholds							
100	*** (C)	*** (C)	* (C)	** (C)	† (C)	*** (C)	(C)
500	*** (CS)	*** (CS)	*** (CS)	*** (CS)	*** (CS)	*** (CS)	* (CS)
1000	*** (S)	*** (S)	*** (S)	*** (S)	*** (S)	* (S)	(S)
1500	*** (C)	† (C)	(C)	(C)	(C)	(C)	(C)
2000	** (S)	** (S)	** (S)	* (S)	*** (S)		
2500	(C)	(C)	(C)	** (C)	(C)	(C)	(C)
3000	*	*					*
3500	(CS)	(CS)	(CS)	(CSE)	(CSE)	(CSE)	(CSEP)
5000	** (C)	** (C)	* (C)	(C)	(C)	(C)	† (C)
10000	(CS)	(CS)	† (CS)	(CS)	(CS)	(CS)	(CS)
Placebo thresholds							
250	†						
750			†	†			
1250					*	*	
4000				†	**		
6500							

Table: Summary of McCrary sorting tests, pooling all censuses

Type of threshold	$t < -1.96$	$t > 1.96$	KS p-value
Council size increase	0/42 (0)	14/42 (0.33)	0.02
Salary increase	0/28 (0)	15/28 (0.54)	0
Council size increase (no salary change)	0/24 (0)	8/24 (0.33)	0.04
Salary increase (no council size change)	0/10 (0)	9/10 (0.9)	0
Council size increase or salary increase	0/52 (0)	23/52 (0.44)	0
No policy change	0/38 (0)	3/38 (0.08)	

Table: Summarizing tests of placebo RD effects: effect of being above a population cut at time t on probability of being above that population cut at time $t-1$

Type of threshold	BW=5%			BW=10%			Imbens-Kalyanaraman		
	$t < -1.96$	$t > 1.96$	KS p	$t < -1.96$	$t > 1.96$	KS p	$t < -1.96$	$t > 1.96$	KS p
Council size increase	1/42 (0.02)	3/42 (0.07)	0.08	1/42 (0.02)	11/42 (0.26)	0.07	0/42 (0)	39/42 (0.93)	0.15
Salary increase	0/28 (0)	2/28 (0.07)	0.14	1/28 (0.04)	7/28 (0.25)	0.01	0/28 (0)	25/28 (0.89)	0.42
Council size increase (no salary change)	1/24 (0.04)	1/24 (0.04)	0.12	0/24 (0)	6/24 (0.25)	0.29	0/24 (0)	22/24 (0.92)	0.21
Salary increase (no council size change)	0/10 (0)	0/10 (0)	0.22	0/10 (0)	2/10 (0.2)	0.06	0/10 (0)	8/10 (0.8)	0.92
Council size increase or salary increase	1/52 (0.02)	3/52 (0.06)	0.04	1/52 (0.02)	13/52 (0.25)	0.02	0/52 (0)	47/52 (0.9)	0.2
No policy change	0/38 (0)	3/38 (0.08)		0/38 (0)	2/38 (0.05)		0/38 (0)	26/38 (0.68)	

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Italy

Case study: Italy

- What institutions and policy areas change discontinuously at pop thresholds?
- Are municipalities in a position to manipulate the exact population figures?
- If yes, can we highlight some mechanism behind the sorting?

Data

- Census data on all municipalities in Italy

- Census information from 1951, 1961, 1971, 1981, 1991, and 2001

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	1	3	5	10	15	20	30	50	60	100	250	500
					Policy changes at k inhabitants?							
Size of the city council		x		x			x			x	x	x
Wage of the mayor	x	x	x	x			x	x		x	x	x
Wage of the executive officers	x		x	x				x				
Attendance fee for city councilors				x			x					
Maximum number of executive officers				x						x	x	x
Electoral Rule (plurality/runoff)					x							
Neighborhood councils							x			x		
Hospitals						x						
Health district									x			
Balanced-budget rule			x									

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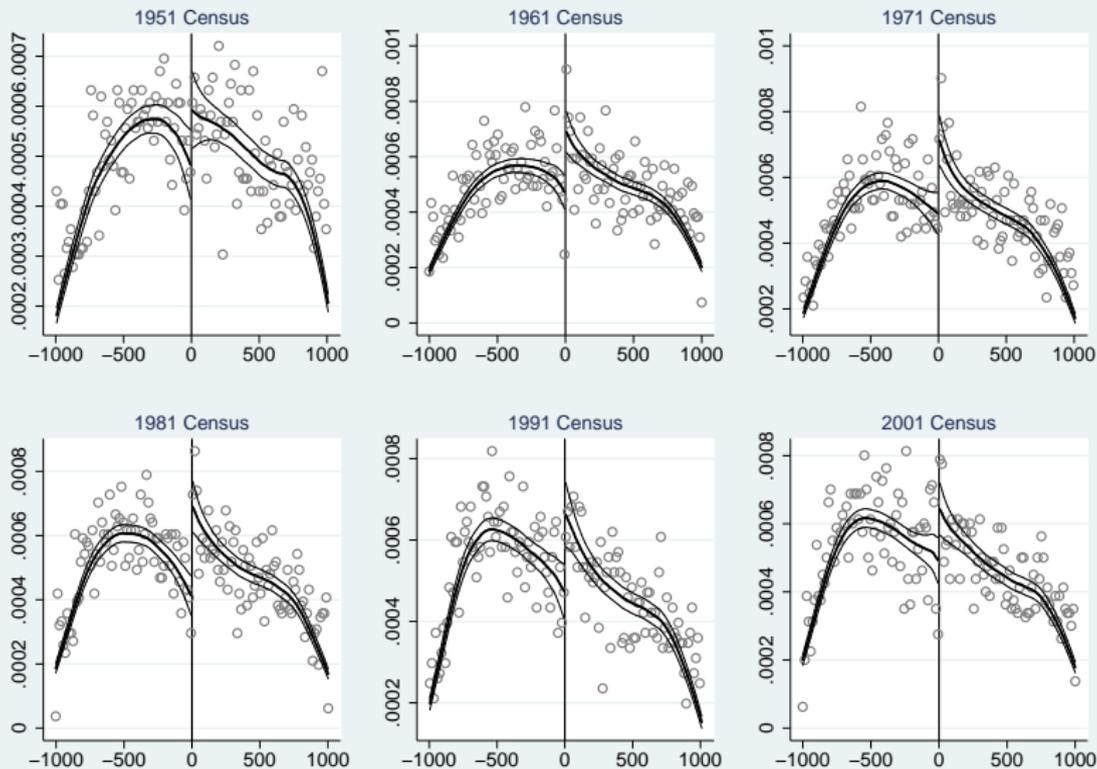Evidence on sorting

Figure: McCrary tests – Italy

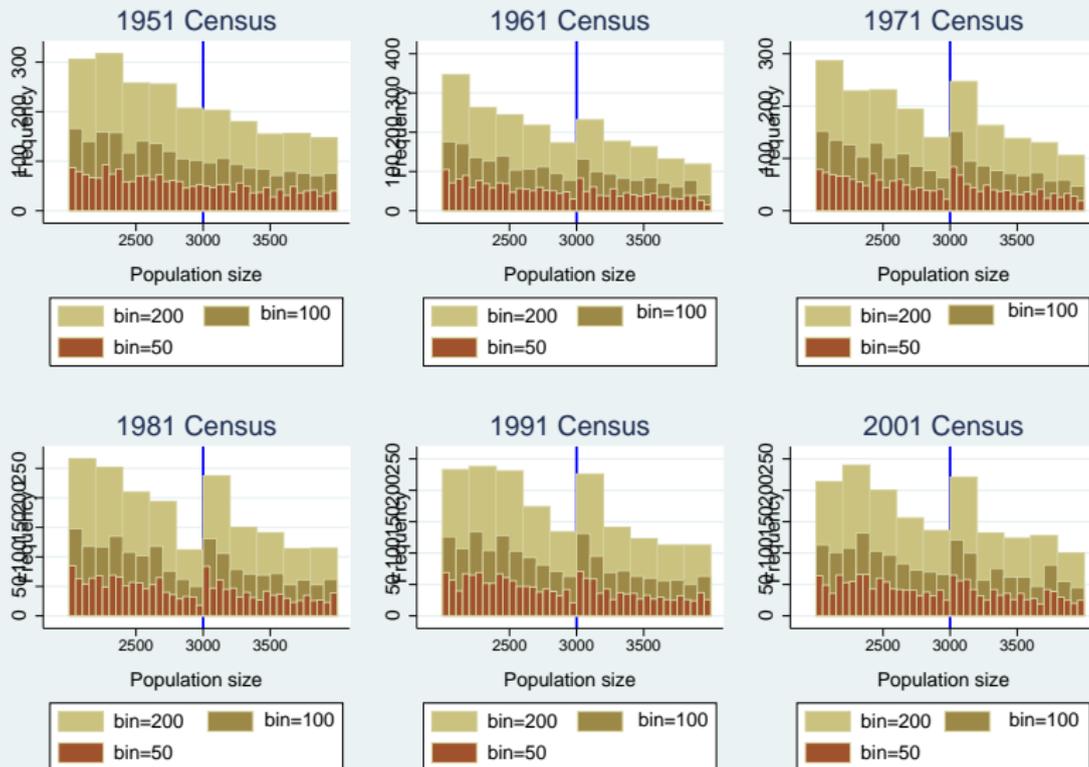Figure: Population histograms – Italy – 3,000 threshold
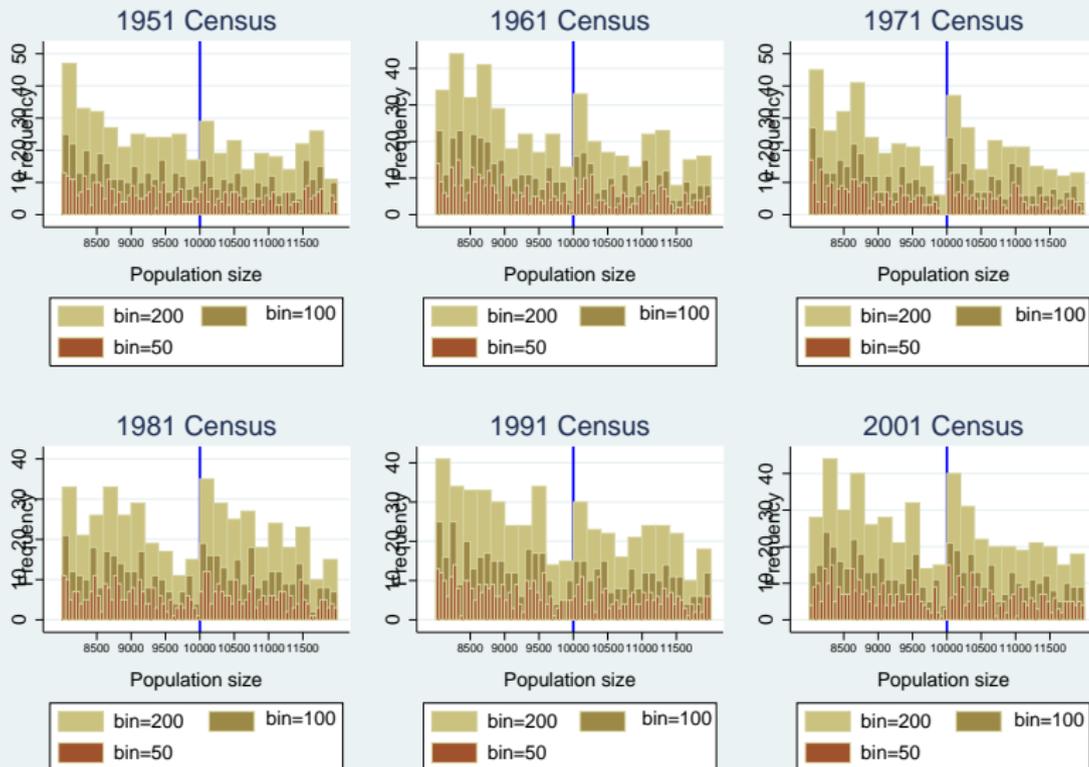
Figure: Population histograms – Italy – 10,000 threshold

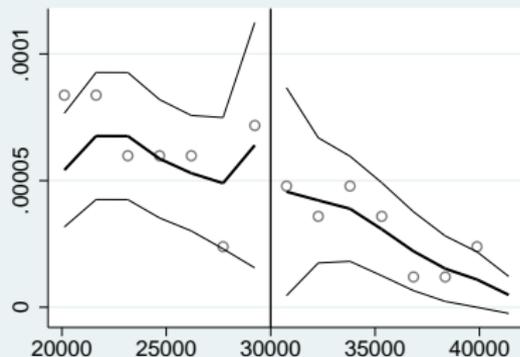Figure: Subanalysis: High social capital – Italy
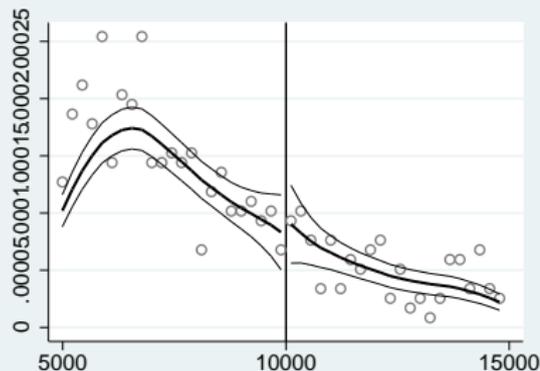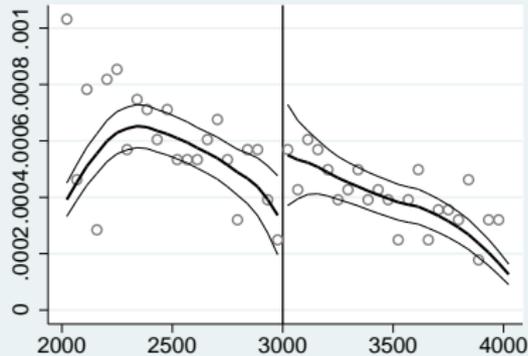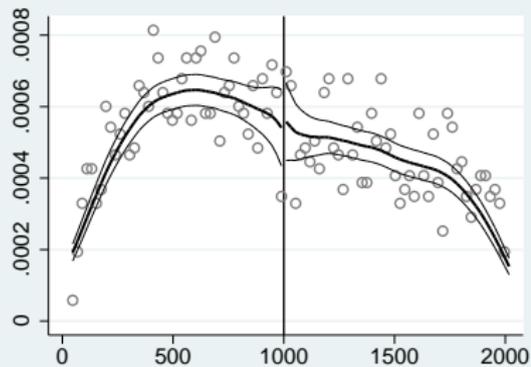
Figure: Subanalysis: Low social capital – Italy
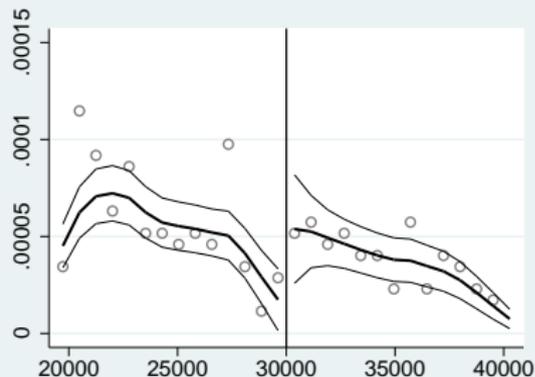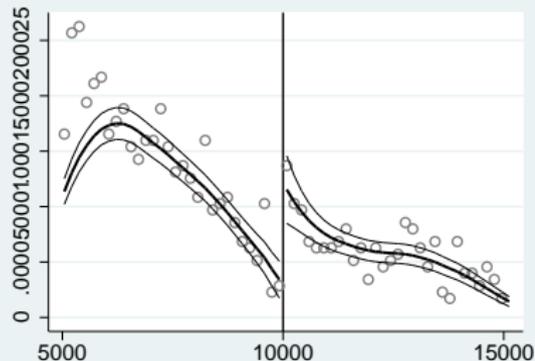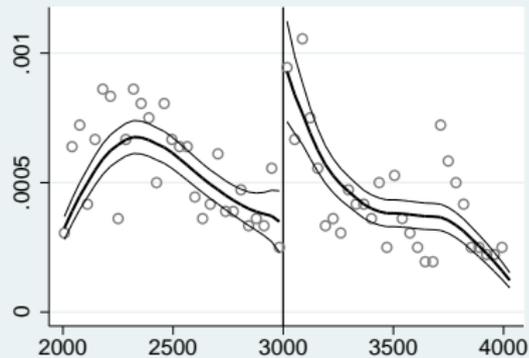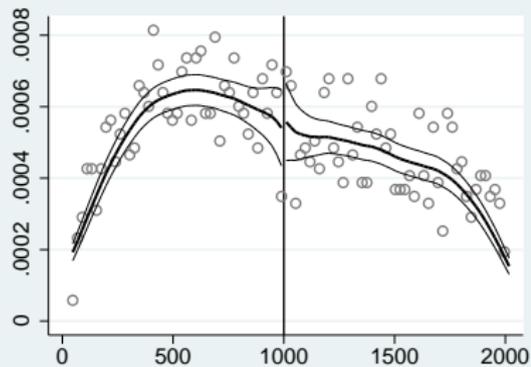
Germany

Case study: Germany

- What institutions and policy areas change discontinuously at pop thresholds?
- Are municipalities in a position to manipulate the exact population figures?
- What issues arise in detecting such manipulation?
- If yes, can we highlight some mechanism behind the sorting?

Data

- Yearly data on all municipalities in Germany

- Period 1998-2008

- Administered at the state level, however, based on regular updates by the local authorities

- Last full census was in 1987

Confounding treatments

Table: Changes at population thresholds – Bavaria

	Population thresholds at # of inhabitants (in tsd)									
	1	2	3	5	10	20	30	50	100	200
Local institutions										
Council size	x	x	x	x	x	x	x	x	x	x
Wage of elected civil servants					x		x	x	x	
Wage of full-time mayors		x	x	x	x		x	x	x	
Wage of part-time mayors	x		x	x						
Full-time council members					x					
Petition for referendum					x	x	x	x	x	
Referendum quota								x	x	
City districts									x	
Open council					x				x	
Accounting committee				x						
Mayor status				x	x					
Budgeting rules										
County free city								x		
Status of larger city							x			
Vehicle Tax				x						
Fiscal equalization				x	x			x	x	

#	Institution/ Rule	Population thresholds in the different German states													
		SH	NiedS	NRW	Hes	RP	BW	Bay	Saar	MVP	BB	Saan	Sax	Th	
	Councils														
1	Council size	(12)	(30)	(10)	(9)	[15]	(10)	(10)	[6]	(15)	(11)	(12)	(14)	[11]	165
2	Full-time council members / Deputies	(3)	[2]			[4]	[1]	[1]	[4]	[1]	[1]	[1]	(6)	(5)	
3	City districts			[1]		[1]	[1]	[1]	1						
4	City district council				1	[1]			(3)		[1]	[1]		[3]	
5	Administrative units		(2)							(2)	[1]	[1]		[1]	
6	Council of the administration units									[4]	(5)				
	Wages														
7	Wage of mayors	[7]	[9]	[9]	(11)	[8]	(11)	(9)	(7)	(7)	(7)	(10)	(12)	[9]	
8	Additional compensation of the mayor	(5)	[5]	[5]		[7]				[7]		[7]			
9	Wage of head of admin. units	[3]								[1]		[5]	[3]	(8)	
10	Wage of deputies								[5]				[8	[7]	
11	Wage of mayors in recreational cities	[1]			[1]		[1]			[1]					
	Fiscal rules														
12	Status of a larger city	[1]	[2]	(6)	[1]	[1]	[1]	[1]	[1]		[1]		1		
13	Status of a county free city	[1]						[1]				1			
14	Fiscal equalization		[6]	19*	[7]		[1]	(7)	(7)		(6)	(3)	(6)	[7]	
15	Special transfers for mergers									[1]			[1]	[1]	
	Citizen involvement														
16	Citizen request	[6]	[3]	[2]		(6)				[1]				1	
17	Petition for referenda	[6]		[7]	[2]	(4)	[4]	[6]	[3]	[1]	(2)	[3]		[1]	
18	Quota requirements for referenda	[6]		[2]				[2]						[2]	

Table: Population Thresholds in Germany (by rule and state)

		Population thresholds in the different German states												
#	Institution/ Rule	SH	NiedS	NRW	Hes	RP	BW	Bay	Saar	MVP	BB	Saan	Sax	Th
	Elections													
19	Signatures for party lists		[2]	[2]		[14]	[5]		[1]		[5]		(7)	
20	Signatures for mayoral candidacy		[1]	[1]			[4]			[1]				
21	Election districts	[4]	1		1	[3]				1	(6)	1	1	[1]
22	Ballot districts			1		[2]	1				[2]	1		
23	Reevaluation of an election				[1]		[2]						[1]	
	Committees/commisioners													
24	Equal opportunity commissioner	[1]		[1]					[1]	[1]	1	[1]	[1]	[1]
25	Integration council			(3)	1	[1]								
26	Accounting agency	[1]			[1]				[1]			[1]	[1]	
27	Oversight regulation	[1]			[1]									
28	Council for top-secret issues						[3]						[2]	
29	Open council						(4)	[2]						
	Mayor													
30	Mayor status	(2)			1		[2]	[2]					[2]	[2]
31	Mayor title	[1]			[1]				[1]			[1]		
32	Deselection of mayors			[2]									[1]	
33	Qualification of mayor								[1]	[1]		[1]		

Table: Population Thresholds in Germany (by rule and state)

#	Institution/ Rule	SH	NiedS	NRW	Hes	RP	BW	Bay	Saar	MVP	BB	Saan	Sax	Th
	Unique rules													
34	Direct democracy	[1]												
35	Consolidated accounts	[1]												
36	Youth welfare office			[1]										
37	Construction oversight			[2]										
38	Mayor deputy recall				[1]									
39	County financing				[1]									
40	Additional transfers				[1]									
41	Key transfers				[3]									
42	Deputies in administrative units					[6]								
43	Pension funds					[1]								
44	Municipal treasurer						[1]							
45	Office hours on election day						[1]							
46	Election statistics						[1]							
47	Economic status						(8)							
48	Accounting committee							[1]						
49	Water management							4						
50	Vehicle Tax							[1]						
51	Deputy mayor status								[1]					
52	Naming of city districts								[1]					
53	Cooperation councils								[1]					
54	Council after mergers									[1]				
55	Outside administrative units									[2]				
56	Forced administrative reconsideration									[1]				
57	Administrator qualification requirement									[1]				
58	Format of the ballots										[2]			
59	Add compensation of head of admin											[4]		
60	City district elections												[2]	
61	Infrastructure subsidies												[4]	
62	Country-side municipalities													[1]
63	General committee													[1]
64	Annual audits													[1]
65	Election proposals													[1]

Figure: Distribution of thresholds in Germany

Evidence on sorting
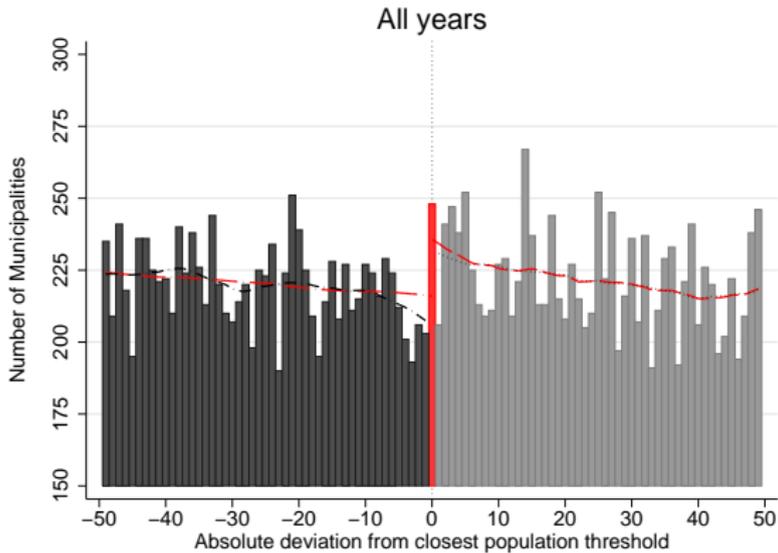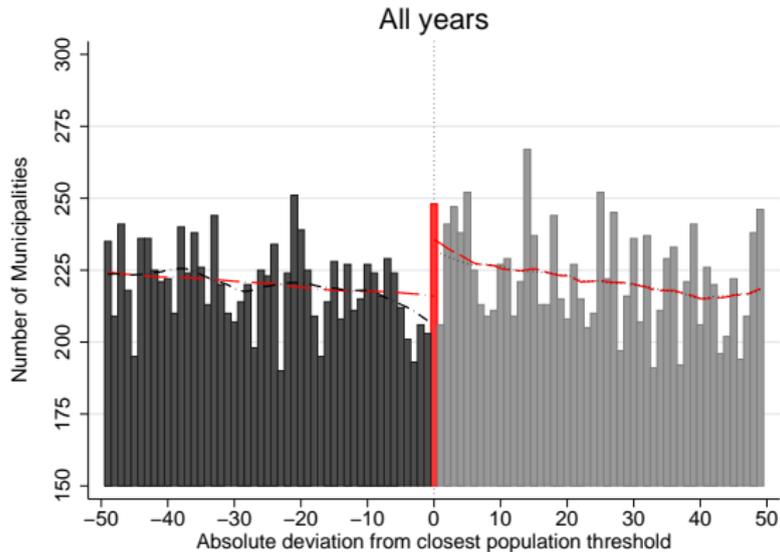
Figure: RDD validity - frequency histograms
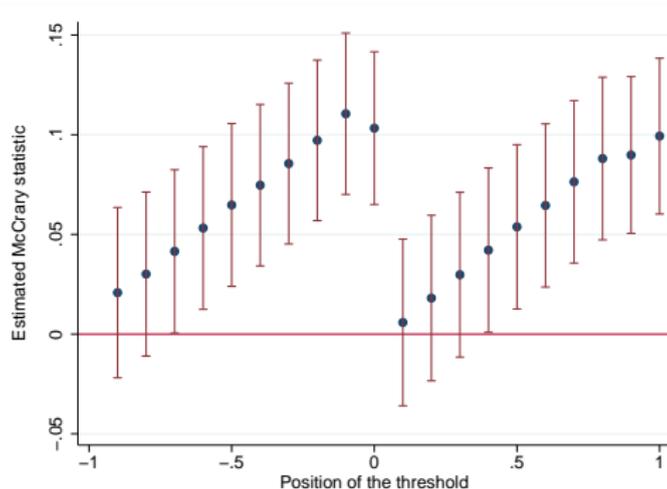
Figure: RDD validity - frequency histograms

Focal point versus actual threshold

Issue of discrete distributions in a McCrary test

DCdensity *score-variable*, breakpoint(?)

Issue of discrete distributions in a McCrary test

DCdensity *score-variable*, breakpoint(?)

Issue of discrete distributions in a McCrary test, cont'd

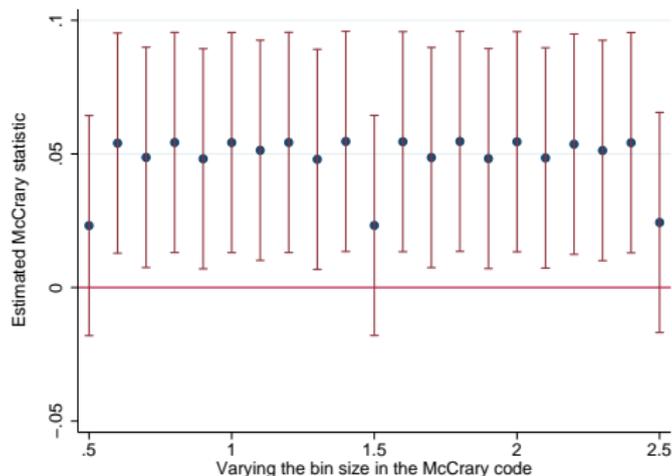DCdensity *score-variable*, breakpoint(0.5) b(?)

Issue of discrete distributions in a McCrary test, cont'd

DCdensity *score-variable*, breakpoint(0.5) b(?)

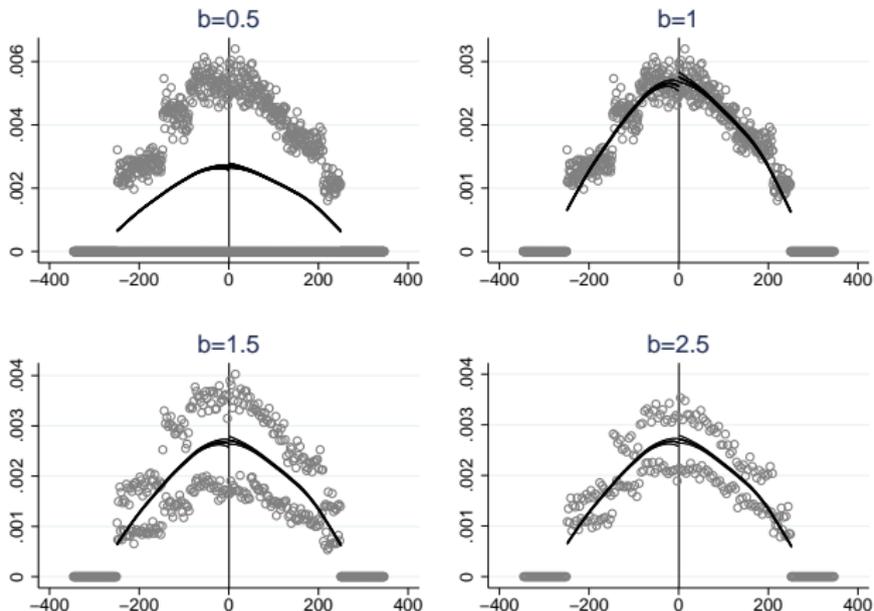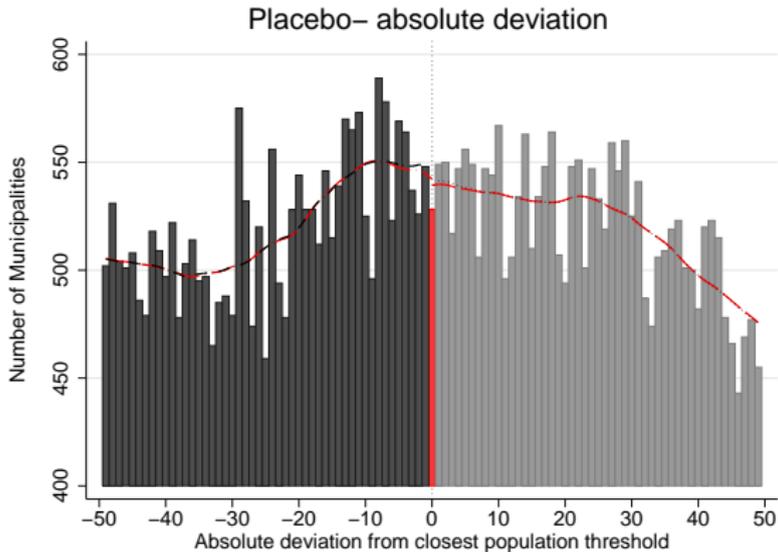# Issue of discrete distributions in a McCrary test, cont'd

Table: Summary of McCrary sorting tests

Type of municipalities	All years				Election years
	All thresholds	C	S	C & S	C & S
Absolute deviation					
Sorting at threshold	0.068***	0.079***	0.142***	0.086***	0.132***
	(0.028)	(0.030)	(0.058)	(0.031)	(0.061)
Sorting at the focal point	0.094***	0.108***	0.139***	0.106***	0.174***
	(0.028)	(0.030)	(0.058)	(0.031)	(0.061)
Excluding the focal point	0.081***	0.095***	0.145***	0.097***	0.156***
	(0.027)	(0.029)	(0.061)	(0.030)	(0.061)

Notes

Figure: Evidence from Placebo thresholds

Placebo– absolute deviation

Motivation	France	Italy	Germany	Conclusions
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Issue of pooling thresholds in the log scale

Figure: Evidence from Placebo thresholds
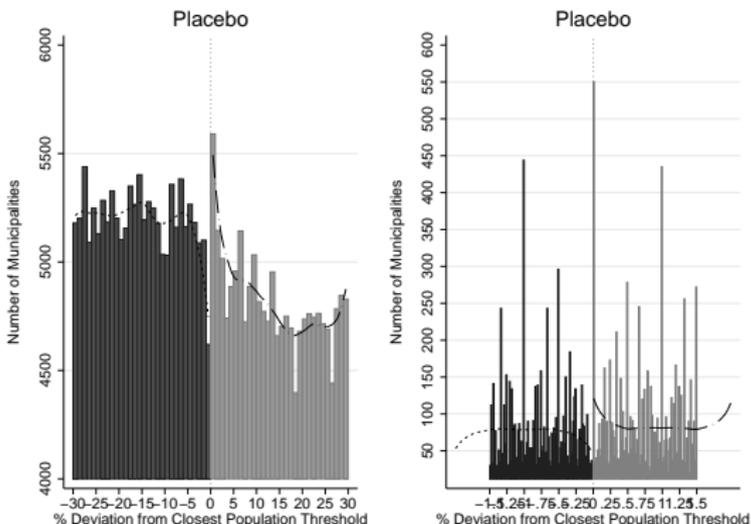
Issue of discrete distributions in a McCrary test, cont'd

DCdensity *score-variable*, breakpoint(0.5) b(0.007) h(?)

Issue of discrete distributions in a McCrary test, cont'd

DCdensity *score-variable*, breakpoint(0.5) b(0.007) h(?)
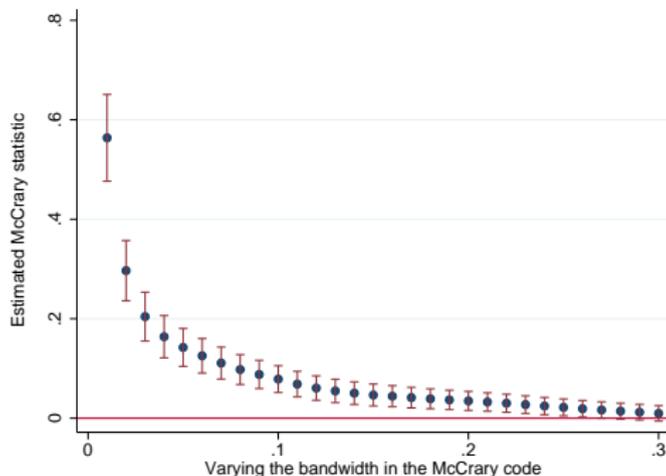
Table: Summary of McCrary sorting tests (relative deviations)

Type of municipalities	All years				Election years
	All thresholds	C	S	C & S	C & S
Relative deviation					
Sorting at threshold	0.000	0.049***	0.066*	0.039**	0.052
	(0.017)	(0.019)	(0.034)	(0.019)	(0.043)
Sorting at the focal point	0.088***	0.153***	0.103***	0.133***	0.161***
	(0.017)	(0.019)	(0.035)	(0.020)	(0.046)
Excluding the focal point	0.046***	0.106***	0.088***	0.091***	0.107**
	(0.018)	(0.020)	(0.035)	(0.021)	(0.050)

Notes

Summary McCrary tests subgroups

Table: McCrary sorting tests for different subsamples

| Type of municipalities	Absolute deviation			Relative deviation		
	All thresholds	C	S	All thresholds	C	S
By region						
East German states	0.140***	0.145***	0.095	0.070***	0.126***	0.134***
	(0.046)	(0.059)	(0.181)	(0.034)	(0.043)	(0.041)
West German states	0.049	0.089***	0.145***	0.028	0.087***	0.065***
	(0.033)	(0.035)	(0.066)	(0.019)	(0.021)	(0.021)
By size						
Below 5,500 inhabitants	0.091***	0.107***	0.149***	0.045***	0.110***	0.107***
	(0.028)	(0.030)	(0.063)	(0.015)	(0.021)	(0.022)
Above 5,500 inhabitants	0.099	0.112	0.093	-0.016	0.065*	0.025
	(0.105)	(0.124)	(0.154)	(0.025)	(0.035)	(0.028)
By demographics						
Shrinking municipalities	0.141***	0.161***	0.152*	0.049***	0.100***	0.096***
	(0.042)	(0.046)	(0.085)	(0.022)	(0.030)	(0.028)
Growing municipalities	0.039	0.054	0.155**	0.030	0.107***	0.069***
	(0.032)	(0.035)	(0.075)	(0.023)	(0.027)	(0.025)

Predetermined variables

Table: Predetermined variable: Treatment and population in t-1: Different Window Sizes and Specifications

	Predetermined variable tests for the sample of							
	Actual thresholds				Placebo thresholds			
	2% Window	5% Window	15% Window	25% Window	2% Window	5% Window	15% Window	25% Window
Control Function	Panel 1: Log deviation from the next population threshold in t-1							
Linear	0.001	-0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000*
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Quadratic	0.002	0.001	-0.000	-0.000	0.001	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Cubic	0.001	0.002	-0.000	-0.000	0.002	0.001	-0.000	-0.000
	(0.002)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Control Function	Panel 2: Treatment in t-1							
Linear	0.103***	0.369***	0.717***	0.819***	0.100***	0.354***	0.697***	0.805***
	(0.016)	(0.007)	(0.003)	(0.002)	(0.013)	(0.006)	(0.002)	(0.001)
Quadratic	0.040*	0.109***	0.478***	0.645***	0.000	0.110***	0.456***	0.621***
	(0.023)	(0.011)	(0.004)	(0.002)	(0.019)	(0.009)	(0.003)	(0.002)
Cubic	0.026	0.021	0.269***	0.460***	-0.030	0.006	0.257***	0.435***
	(0.031)	(0.014)	(0.005)	(0.003)	(0.026)	(0.012)	(0.004)	(0.003)

Fraud or active population policy I

Figure: Changes in pop (per municipality)
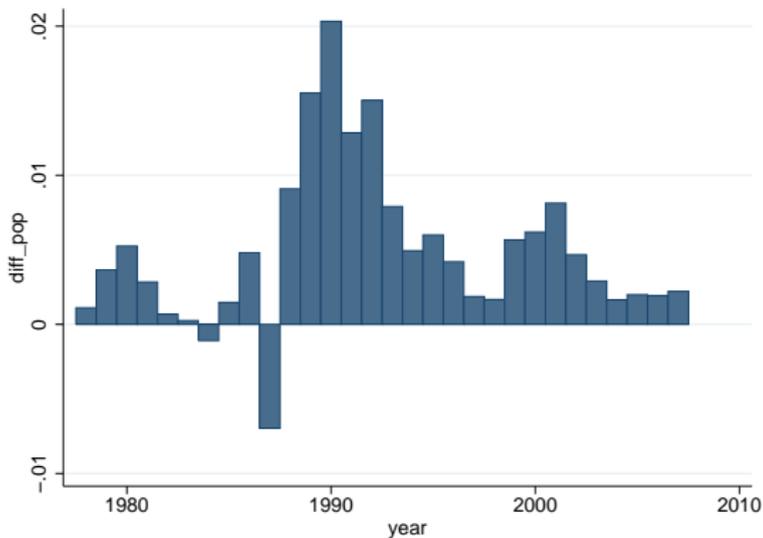
Fraud or active population policy II

Table: Population change from 1983 to census in 1987

	(1)	(2)	(3)	(4)	(5)	(6)
	Change in population from 1983-1987					
	2.5%	2.5%	2.5%	2.5%	1%	1%
above threshold	-0.0169**	-0.0170**	-0.0172***	-0.0172***	-0.0178*	-0.0178*
	(0.0066)	(0.0066)	(0.0066)	(0.0066)	(0.0103)	(0.0103)
Pop (in 100 tsd)		-0.0005*	-0.0031***	-0.0031***	-0.0030***	-0.0030***
		(0.0003)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Pop^2			0.0000***	0.0000***	0.0000***	0.0000***
			(0.0000)	(0.0000)	(0.0000)	(0.0000)
Constant	0.0206***	0.0207***	0.0210***	0.0210***	0.0206***	0.0206***
	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0012)
N	2135	2135	2135	2135	2135	2135
Sample rest (pop)	at 20500	at 20500	at 20500	at 10250	at 20200	at 10100

Conclusions

RDDs using population thresholds require careful inspections.

- Confounding treatments
    - Precise statement on co-treatments
    - Track changes over time
    - Follow up on second order effects

Conclusions, cont'd

- Sorting and manipulation of the population thresholds
    - Frequency tests (MC)
        - Issue of discreteness of the running variable (choice of cutoff and bin size)
        - Issue of pooling in the log scale (how to treat the zeros)
    - Predetermined variable tests
        - Sticky population numbers
        - Steep functional form for lagged treatment variables

Conclusions, cont'd

- Characterizing the sorting

  - Sizable and significant sorting at small thresholds (all countries)

  - Larger at thresholds at which the wage of the mayor changes (compared to council size) (all countries)

  - More prevalent in shrinking municipalities (Germany)

  - Larger in election years (Germany)

  - Evidence for focal point argument (Germany)

  - Unbalanced for variables of social capital (blood donations, turnout at referenda, voluntary club membership) (Italy)

Conclusions, cont'd

- Addressing the pitfalls
    - Referee's with institutional detail
    - Name and discuss all policy changes at population thresholds (also other than the important threshold)
    - Be careful in testing for sorting
    - Be aware of false significance on the sorting tests or predetermined variable test
- Potential remedies
    - Difference-in-discontinuity (in time)
    - Difference-in-discontinuity (in space)

Motivation
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France
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Italy
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Germany
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Conclusions
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Thank you for your attention!