Policy Evaluation

Lecture 8: Regression Discontinuity Design

Edmund Malesky, Ph.D.
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Duke University

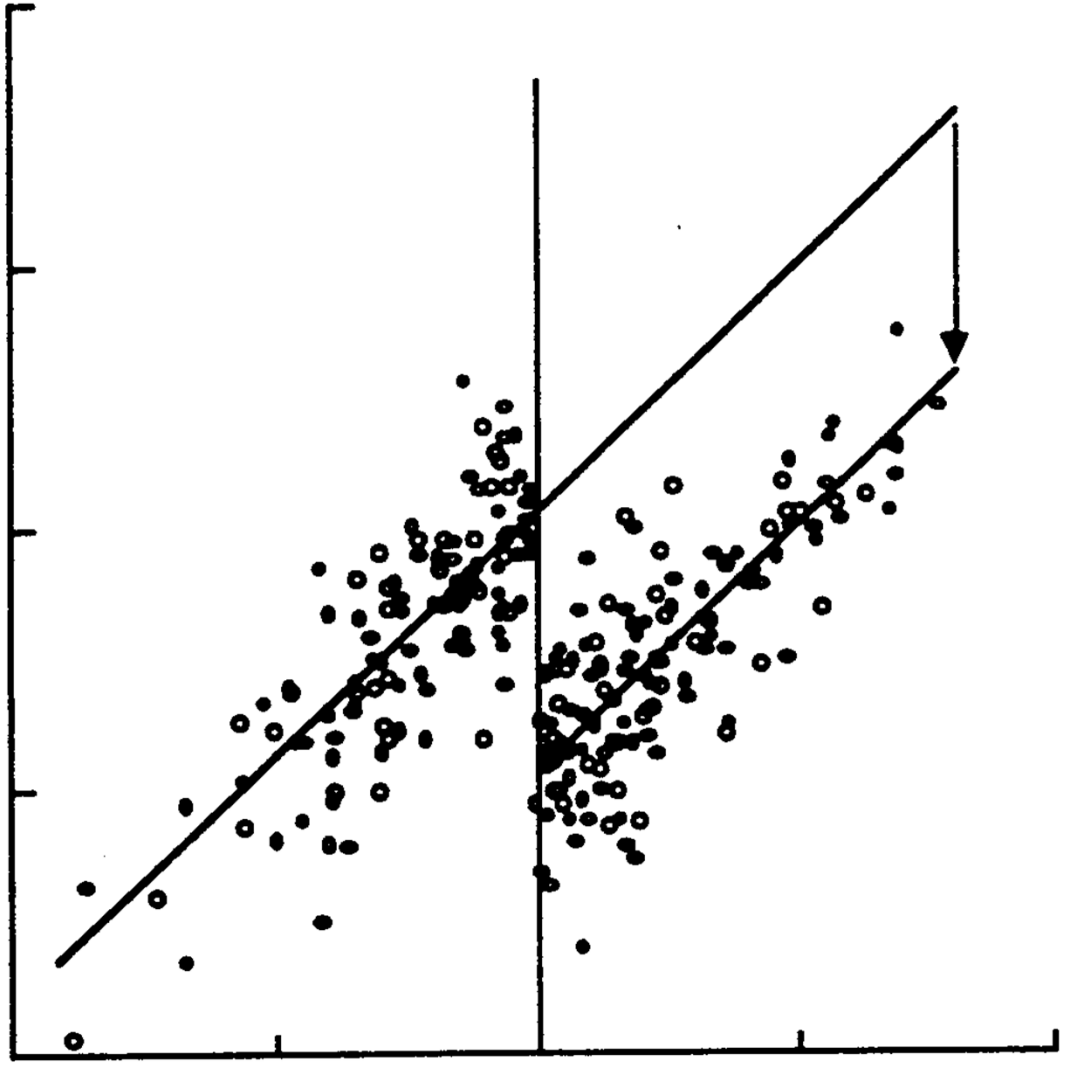
Outline

Overview of RDD

Welfare & Employment

Tax Incentives Buying

Regression Discontinuity Design (RDD)



Source: Trochim, 1994.

Regression Discontinuity Design (RDD)

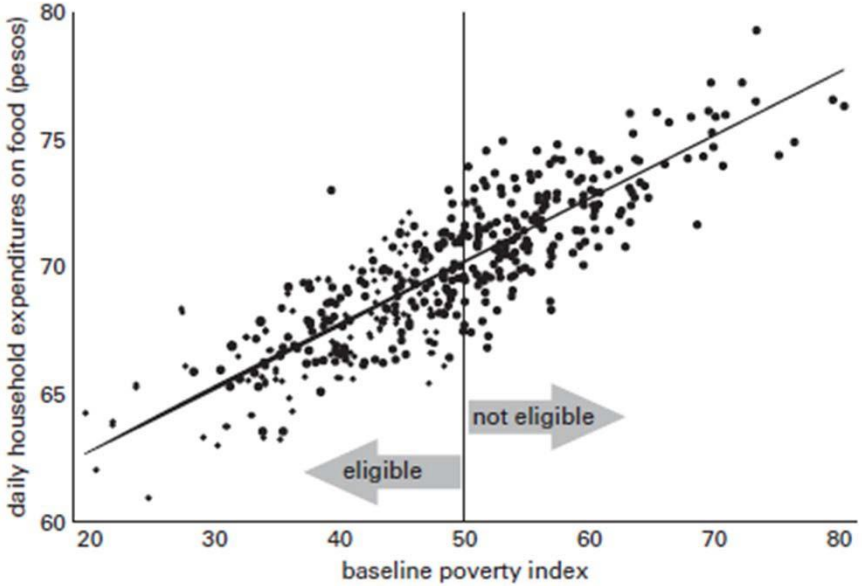
- Many programs use index with cutoff score to choose recipients
- RDD examines whether there is a “jump” in outcome at cutoff score
- Units just below or above cutoff very similar, except for treatment
- Units barely ineligible serve as counterfactual for units barely eligible
- Impact evaluation using RDD requires:
  - Continuous eligibility index
  - Clearly defined cutoff score
- Can estimate impact without excluding eligible population as control
- Issue of external validity: estimates valid near cutoff
  - Local average treatment effect, not estimate for *all* participants
  - Excellent for deciding if should expand program on margin

RDD Selection Mechanism

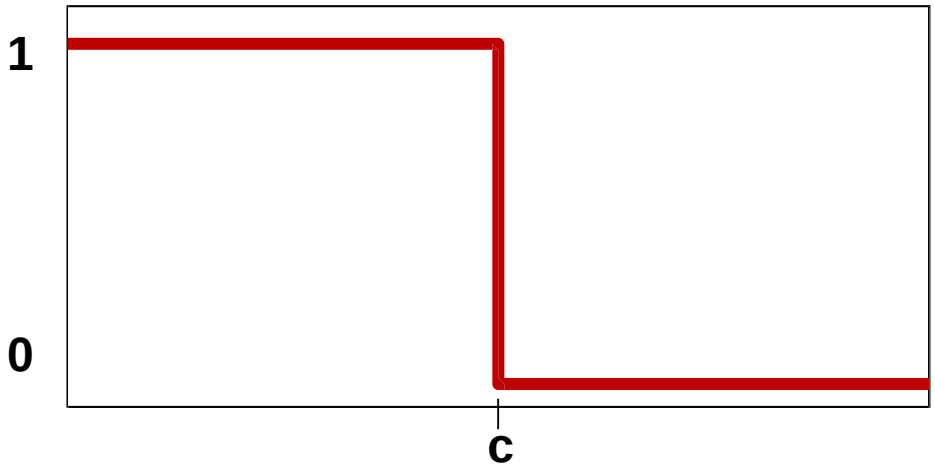
- With RDD, selection based on cutoff score, not discretion
  - Sharp vs fuzzy RDD
- Assignment to treatment (D_i=1) or control (D_i=0) depends on forcing variable X
- Treated (receive program) only if forcing variable ≤ cutoff (c)

$$D_i = \begin{cases} D_i = 1 & \text{if } X_i \leq c \\ D_i = 0 & \text{if } X_i > c \end{cases}$$

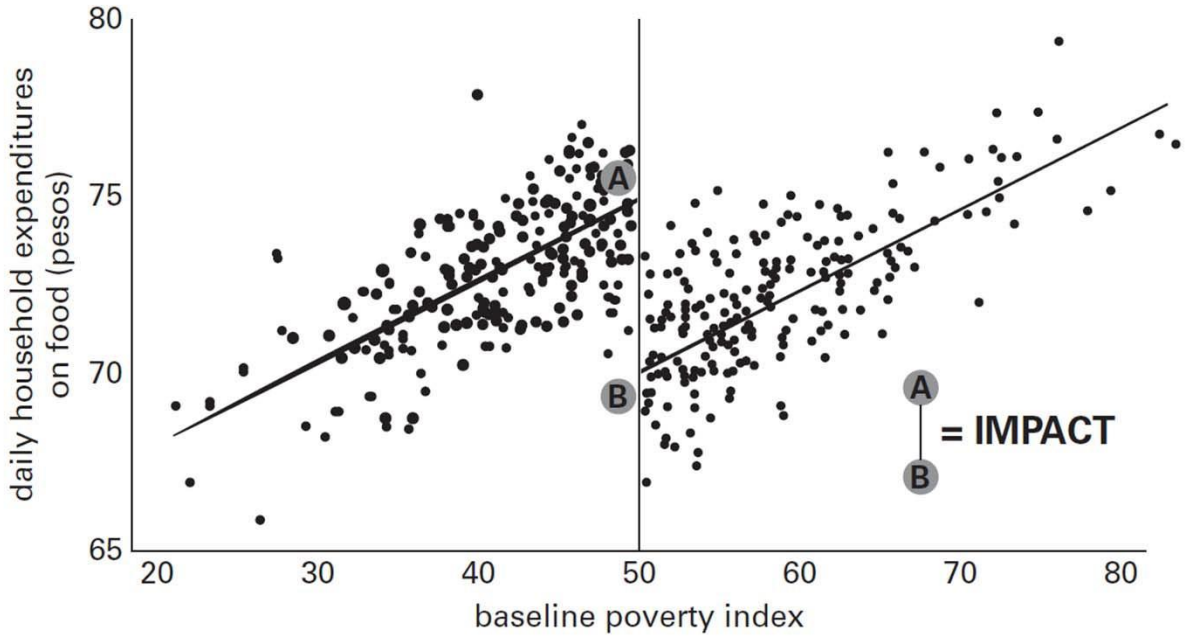
- X often correlated with Y → Nonparticipants not a good counterfactual for participants



Probability of Treatment



RDD Estimates



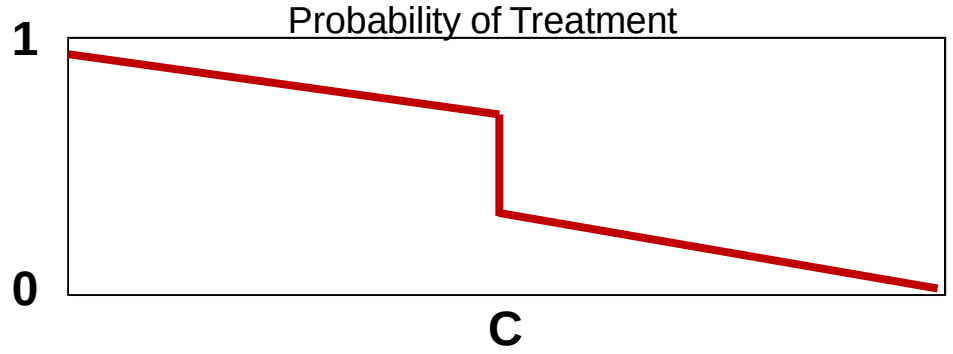
- Ineligible but near c: comparison group to estimate counterfactual
- Near threshold: similar baseline characteristics, except no program
- If relationship between X & Y otherwise continuous, program is only plausible explanation for discontinuity

$$y_i = \beta_0 + \beta_1 D_i + \delta(index_i) + \varepsilon_i$$

Source: Figure from Gertler et al, 2011.

Fuzzy RDD

- Previous example: *sharp* regression discontinuity design
  - Probability of treatment jumped from 0 to 1 at threshold
- But many programs have cutoffs that are not so deterministic
- *Fuzzy* RDD: cutoff creates discontinuity in probability of treatment



- For units near cutoff, can use Z_i as an instrument for D_i (treatment)

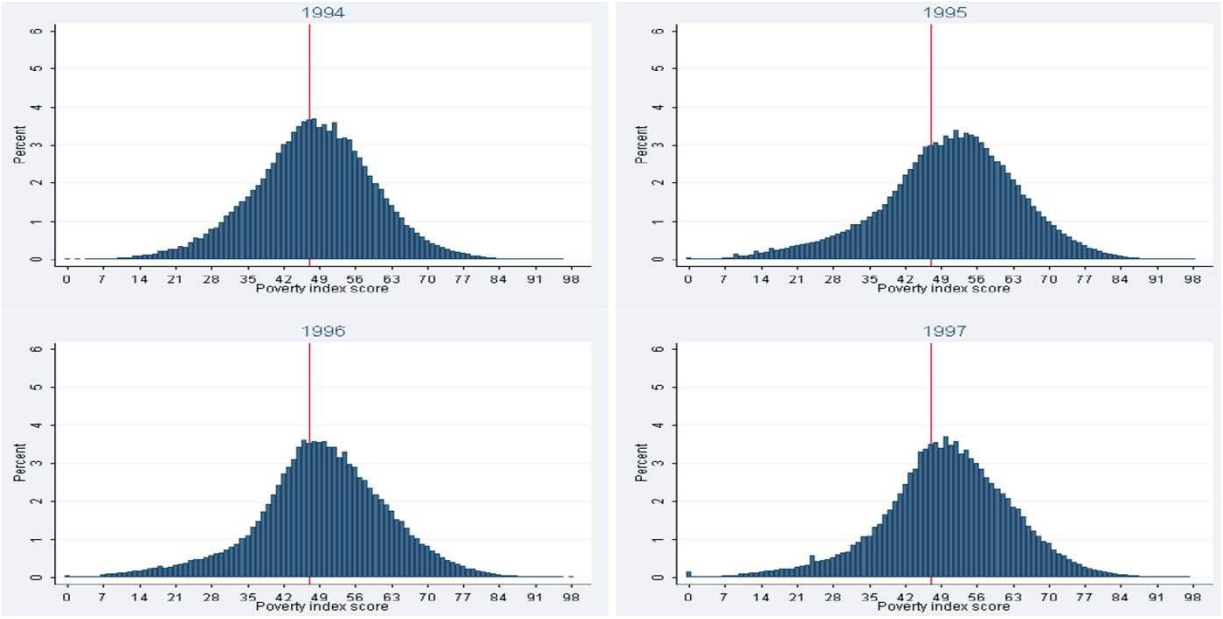
$$Z_i = \begin{cases} 1 & \text{if } X_i \leq c \\ 0 & \text{if } X_i > c \end{cases}$$

- Can estimate treatment effect for compliers (D_i depends on Z_i)

Credibility of RDD Estimates

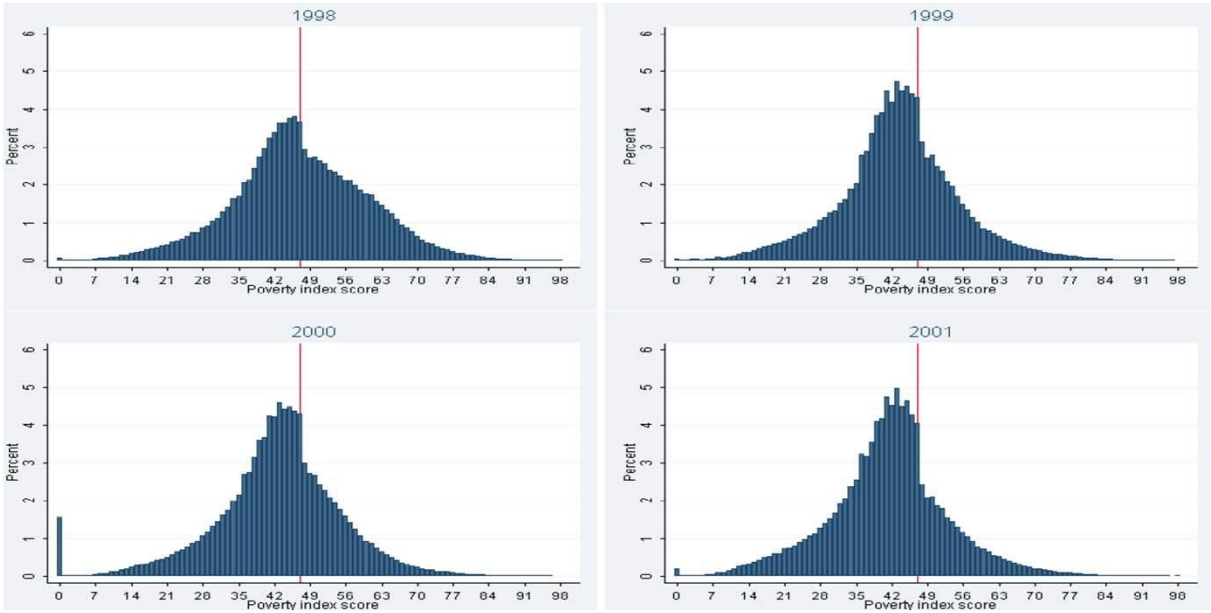
- Must examine credibility of RDD estimates
- Four key issues involve sorting, balance, robustness to alternative specifications, and placebo tests
- *Sorting*: Investigate whether individuals sort around the cutoff
- *Balance*: Examine whether other covariates jump at the cutoff
- *Robustness*: Ensure estimates are not sensitive to specification
- *Placebo Tests*: Show no discontinuities at “fake” cutoffs
- We now examine examples of each

Sorting



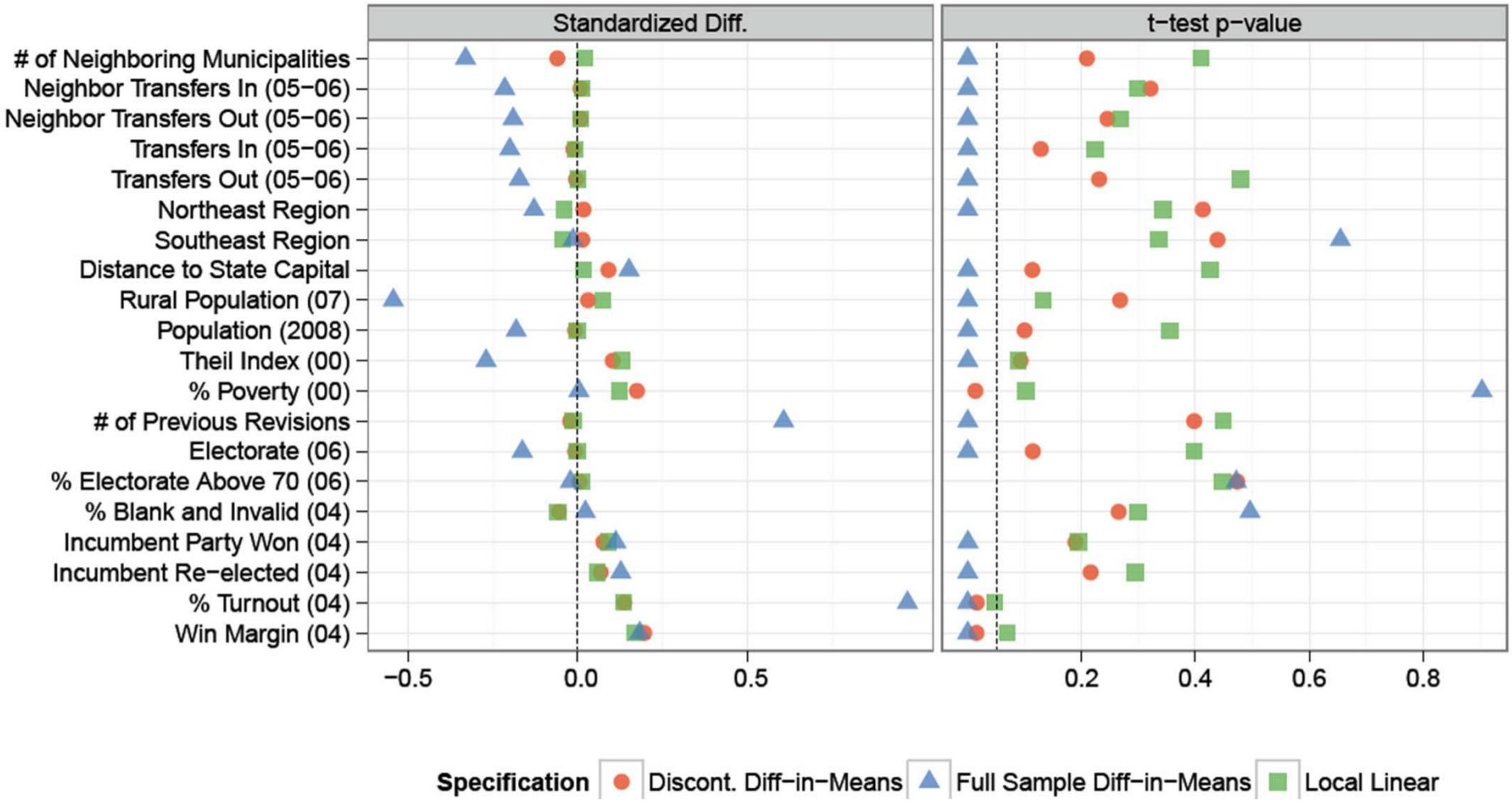
- Colombia: Starting in early 1990s, poverty score index for social program eligibility
- Info on dwelling, demographics, income, employment
- ≤47→ health insurance

- Algorithm for score provided to municipal administrators in July 1997



Source: Camacho & Conover, 2010.

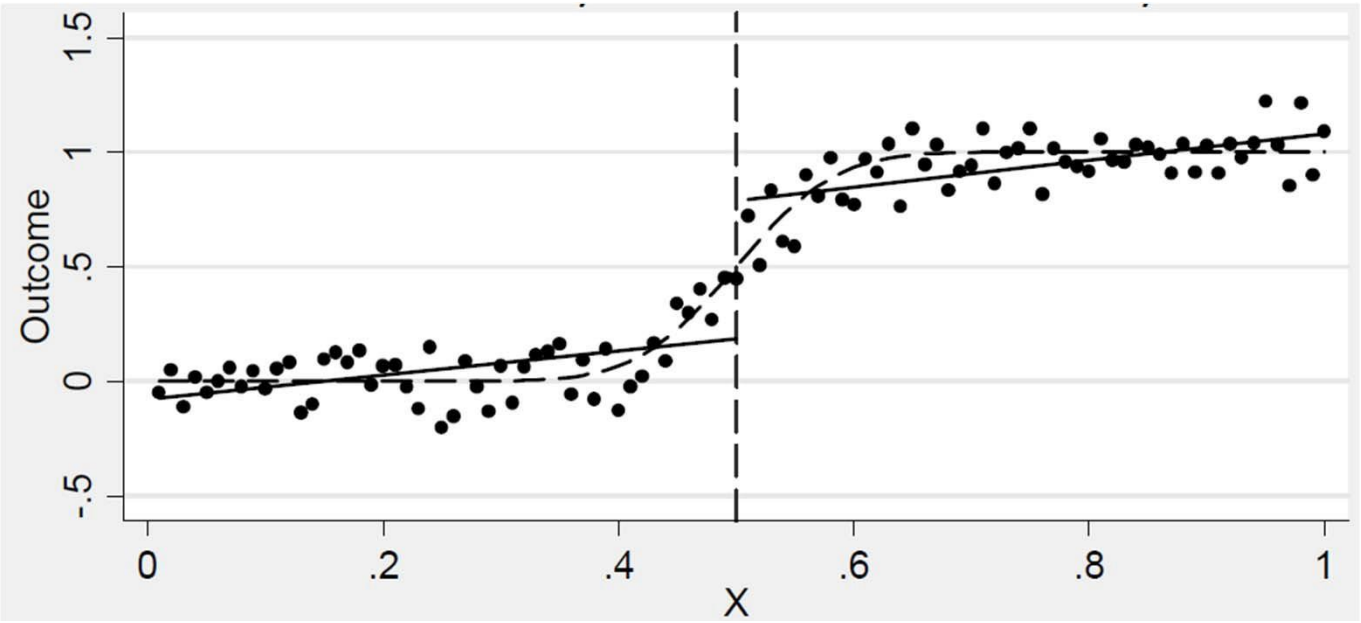
Balance



Source: Hidalgo & Nichter, 2012.

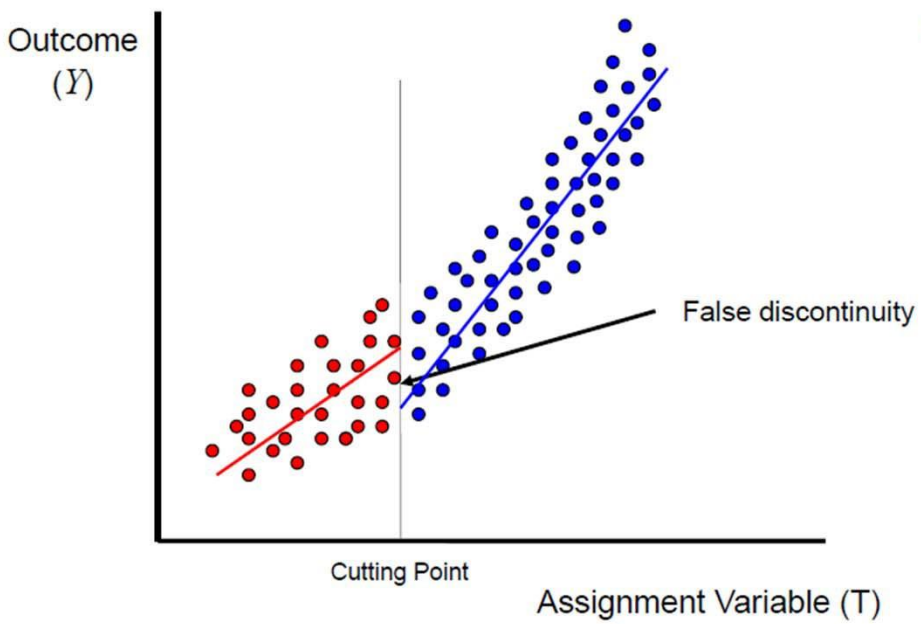
Robustness

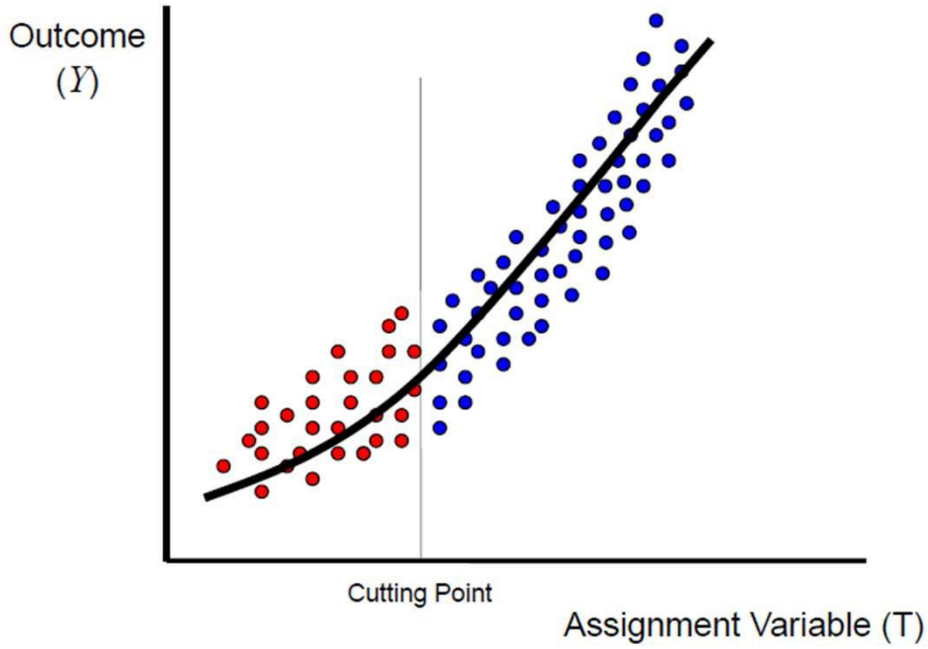
- Crucial to ensure that estimates are not sensitive to specification
- For example, nonlinearities can be mistaken for discontinuities
- Try more flexible specifications to show robust treatment effects



Source: Angrist & Pischke, 2008.

Robustness
Using a Polynomial

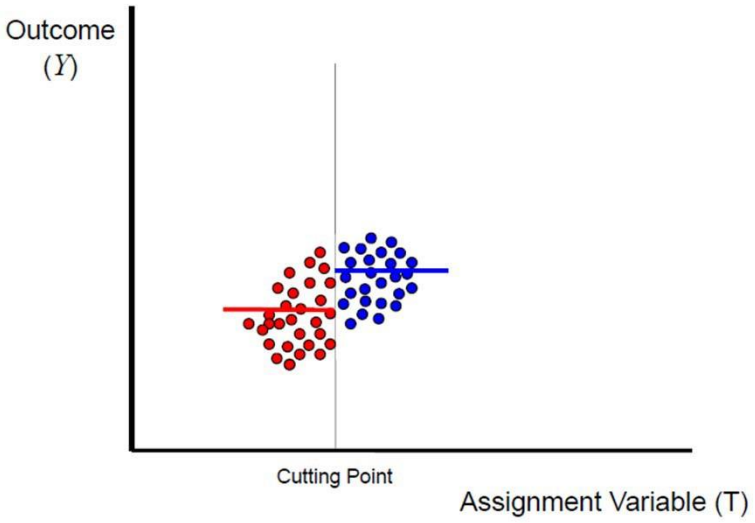


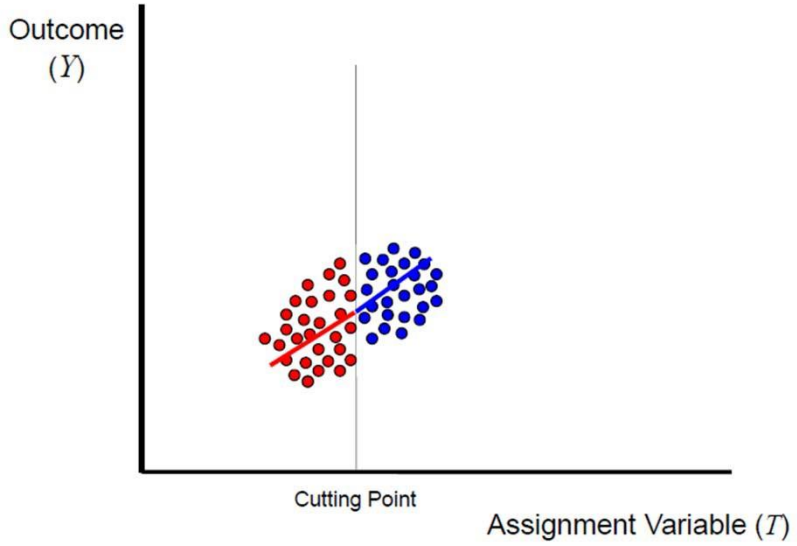


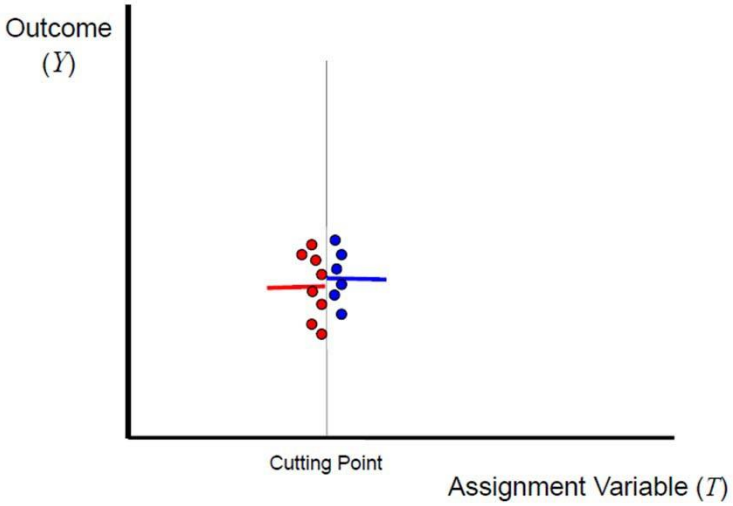
Source: Berry, 2011.

Robustness

Difference-in-Means vs Local Linear; Bandwidth Size







Source: Berry, 2011.

Placebo Tests

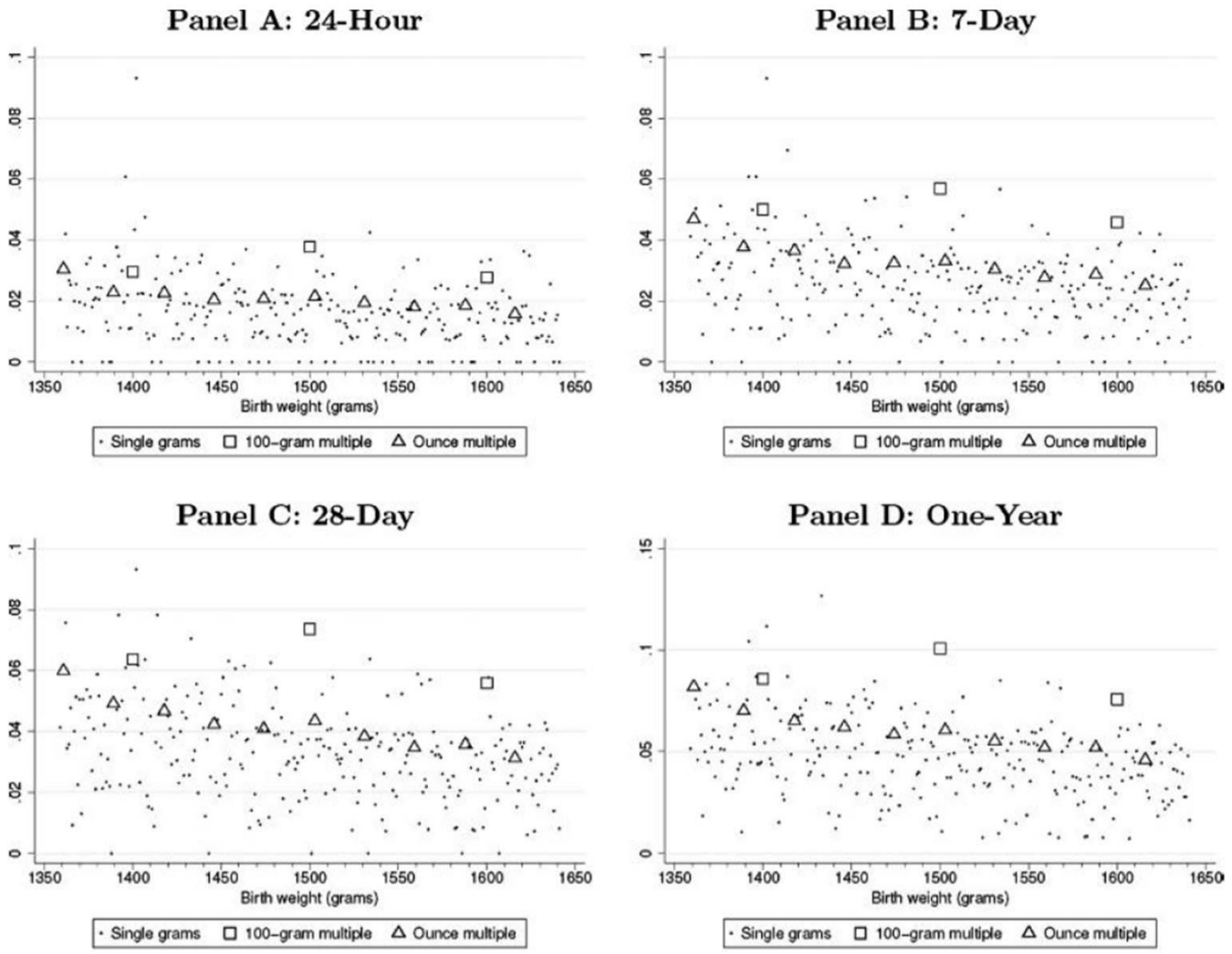


FIGURE I

Means of Mortality Rates

Source: Barecca et al, 2011.

Outline

Overview of RDD

Welfare & Employment

Voter Buying

Impact of Welfare on Employment

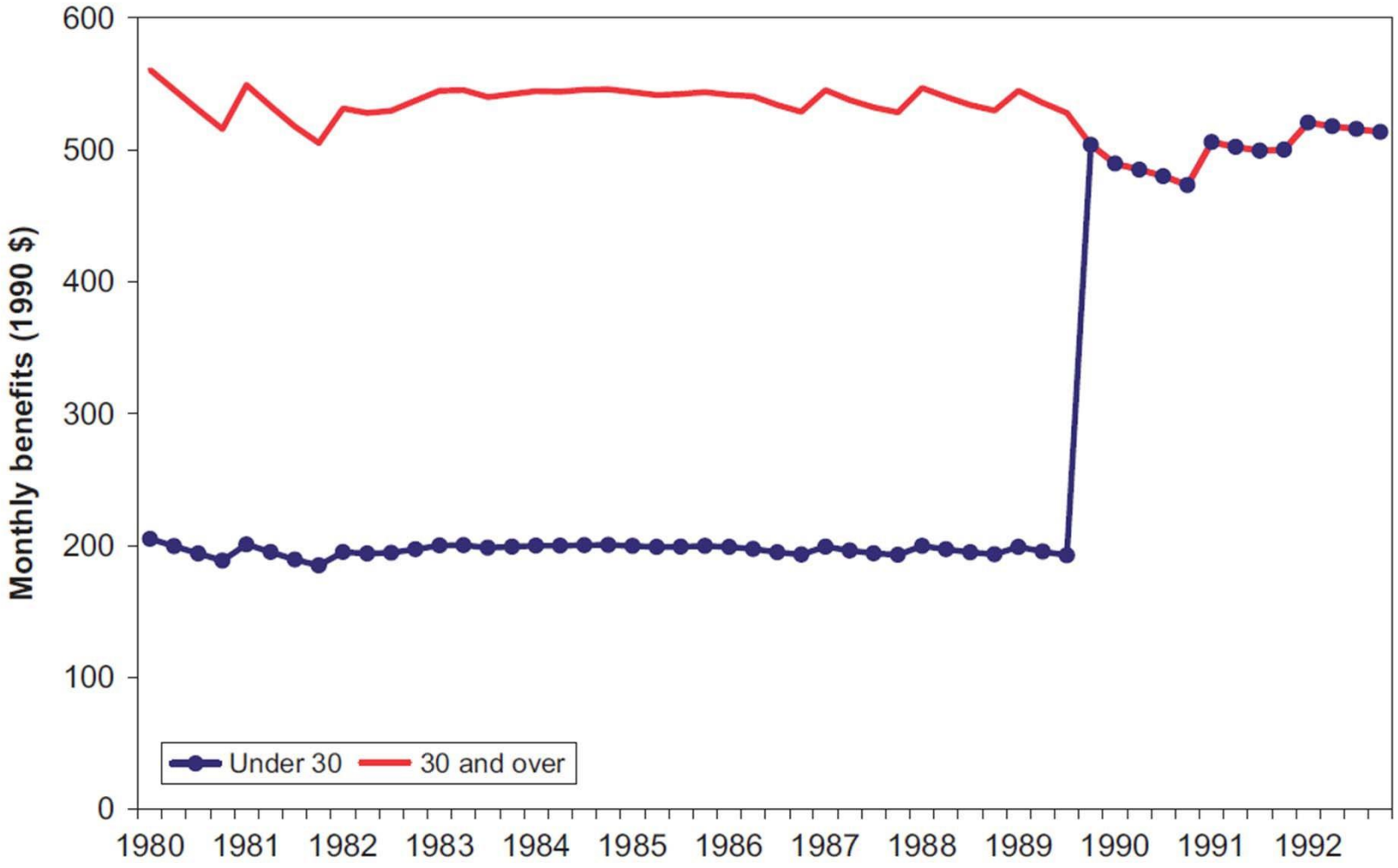
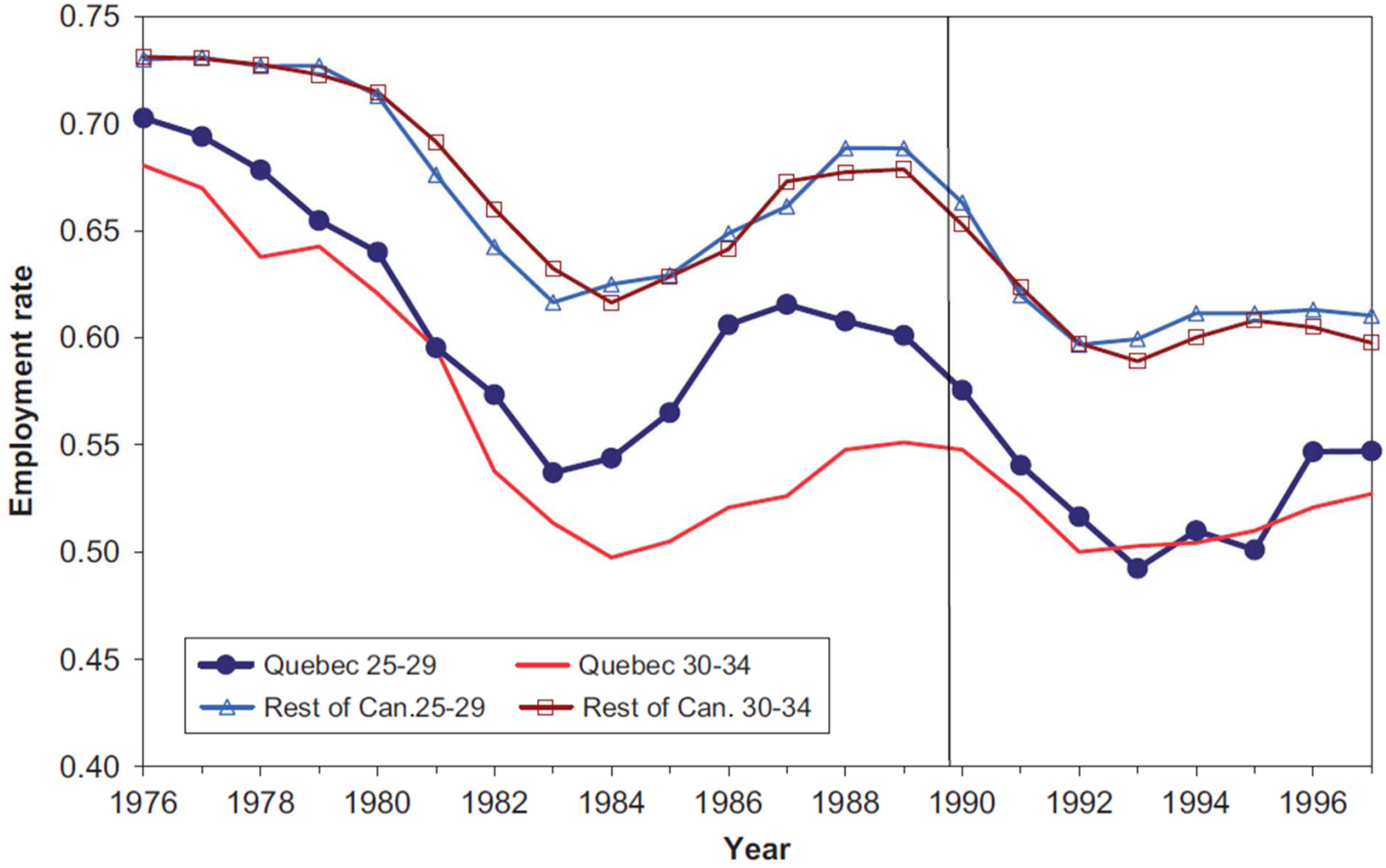


Fig. 1. Social assistance benefits, single individual.

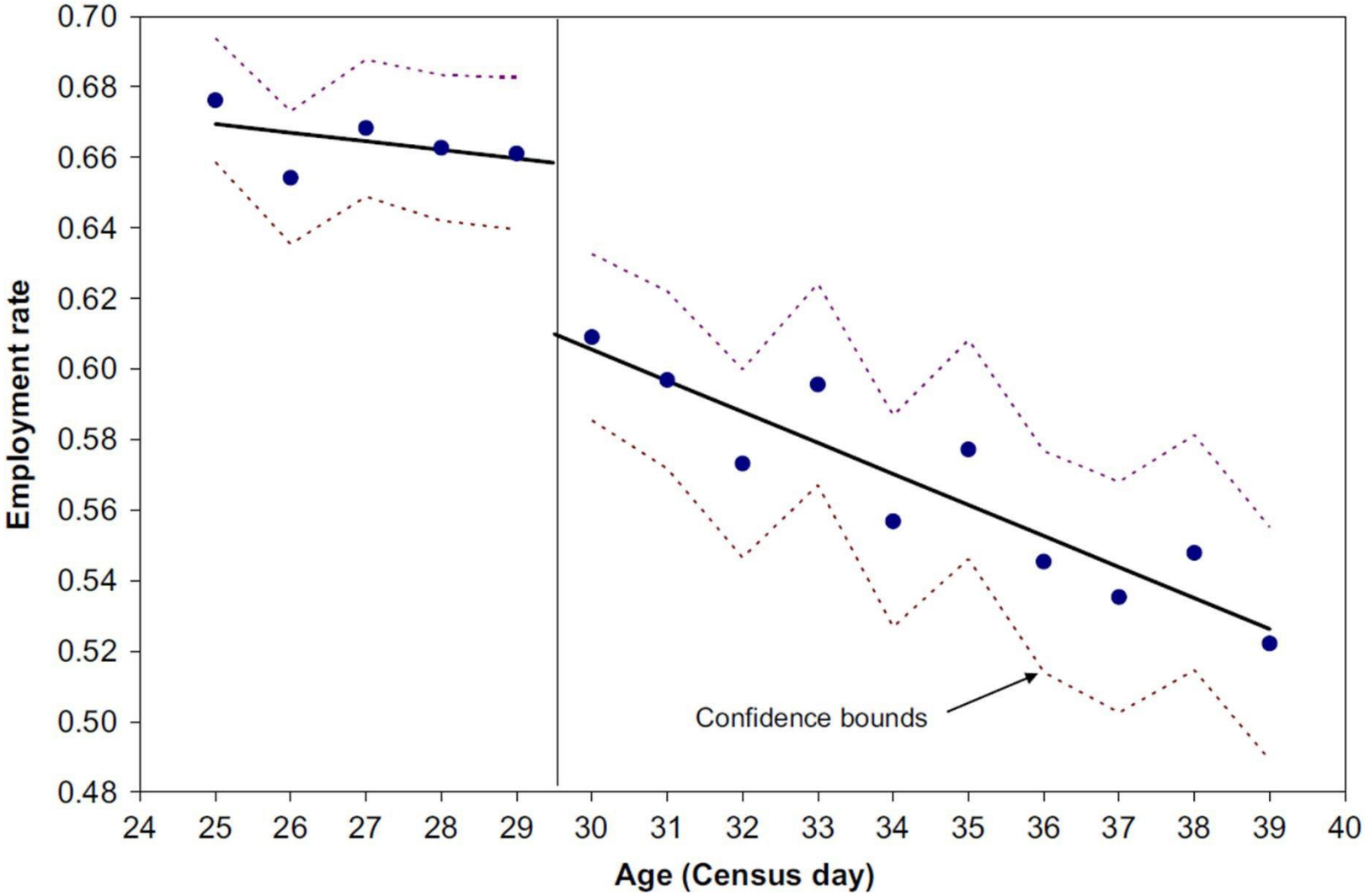
Source: Lemieux & Milligan, 2008.

Impact of Welfare on Employment



Source: Lemieux & Milligan, 2008.

Impact of Welfare on Employment



Source: Lemieux & Milligan, 2008.

Impact of Welfare on Employment

RD Estimates

$$Y_{ia} = \beta_0 + \beta_1 TREAT_{ia} + \delta(a) + \varepsilon_{ia}, \qquad TREAT_{ia} = \begin{cases} 0 & \text{if } a < 30, \\ 1 & \text{if } a \geqslant 30. \end{cases}$$

Regression discontinuity estimates of the effect of higher social assistance benefits on labour supply in Quebec, 1986

Specification for age	Empl. rate last year	Empl. rate at Census	Difference in empl. rate	Weekly hours
Mean of the dependent variable				
	0.562	0.618	0.056	24.39
Regression discontinuity estimates				
Linear	−0.045***	−0.041***	−0.029**	−1.45**
	(0.012)	(0.012)	(0.011)	(0.54)
Quadratic	−0.048***	−0.051***	−0.031**	−1.75**
	(0.013)	(0.012)	(0.012)	(0.61)
Cubic	−0.043**	−0.048***	−0.030**	−1.47*
	(0.018)	(0.014)	(0.013)	(0.70)
Linear spline	−0.047***	−0.049***	−0.032**	−1.72***
	(0.013)	(0.011)	(0.013)	(0.55)
Quadratic spline	−0.038	−0.056**	−0.035*	−1.66
	(0.024)	(0.018)	(0.016)	(0.94)

Note:
***Indicate statistical significance at the 1% level.
**For the 5% level.
*For the 10% level.

Source: Lemieux & Milligan, 2008.

Impact of Welfare on Employment
Robustness to Alternative Bandwidths

Linear spline regression discontinuity estimates with different age windows in Quebec, 1986

Window width	Empl. rate last year	Empl. rate at Census	Difference in empl. rate	Weekly hours
All ages 25–39	−0.047***	−0.049***	−0.032**	−1.72***
	(0.013)	(0.011)	(0.013)	(0.55)
±5 years	−0.056***	−0.046**	−0.037**	−1.49**
	(0.014)	(0.014)	(0.015)	(0.66)
±4 years	−0.042**	−0.057**	−0.038**	−2.09**
	(0.013)	(0.015)	(0.010)	(0.62)
±3 years	−0.050*	−0.039**	−0.034*	−1.37*
	(0.014)	(0.006)	(0.012)	(0.34)
±2 years	−0.033 (–)	−0.045 (–)	−0.044 (–)	−1.60 (–)

Note:
***Indicate statistical significance at the 1% level.
**For the 5% level.
*For the 10% level.

Source: Lemieux & Milligan, 2008.

Impact of Welfare on Employment

Falsification Tests

Falsification test: comparing labour supply response in Quebec and rest of Canada in 1986 and 1991

Specification for age	Quebec, 1986	Rest of Canada, 1986	Quebec, 1991	Rest of Canada, 1991
Regression discontinuity estimates: employment rate on Census week				
Linear	−0.041***	−0.013**	0.041*	0.005
	(0.012)	(0.006)	(0.022)	(0.011)
Quadratic	−0.051***	−0.013*	0.012	−0.017***
	(0.012)	(0.007)	(0.023)	(0.006)
Cubic	−0.048***	−0.009	0.037**	−0.016**
	(0.014)	(0.007)	(0.015)	(0.007)
Linear spline	−0.049***	−0.014*	0.010	−0.010
	(0.011)	(0.006)	(0.017)	(0.007)
Quadratic spline	−0.056**	−0.007	0.042*	−0.007
	(0.018)	(0.010)	(0.022)	(0.007)
Regression discontinuity estimates: difference in employment rate				
Linear	−0.029**	−0.009	0.022*	−0.007
	(0.011)	(0.007)	(0.011)	(0.006)
Quadratic	−0.031**	−0.006	0.022	−0.005
	(0.012)	(0.007)	(0.013)	(0.006)
Cubic	−0.030**	−0.004	0.020	−0.002
	(0.013)	(0.006)	(0.014)	(0.006)
Linear spline	−0.032**	−0.004	0.021	−0.003
	(0.013)	(0.008)	(0.014)	(0.006)
Quadratic spline	−0.035*	0.001	0.012	−0.005
	(0.016)	(0.009)	(0.016)	(0.008)

Note:
***Indicate statistical significance at the 1% level.
**For the 5% level.
*For the 10% level.

Source: Lemieux & Milligan, 2008.

Pandering Upward:

Tax Incentives and Credit Claiming

EDMUND MALESKY, DUKE

AND

NATE JENSEN, UNIVERSITY OF TEXAS

What Are Tax Incentives?

- Definition: Deduction, exclusion, or exemption from a tax liability, offered as an enticement to engage in a specified activity (such as investment) for a certain period.

- Can be targeted at all firms, sectors, size categories, regions, and even individual firms.

- Includes:
  - Tax Abatements
  - Tax Holidays
  - Corporate Income Tax (CIT) Reductions
  - Research and Development Incentives
  - Land Clearance
  - Infrastructure Subsidies

Vietnam: Single-Party, Quasi-Meritocracy

- Single-Party State with Internal Promotions
- Strict retirement age for officials.
  - No promotions after age 60.
  - May take an appointment if between 2 and 5 years away from retirement.
  - Because terms are 5 years, officials 54 and above are no longer eligible for promotion.
  - About 17% of People's Committee Chairmen each year promoted to:
    - Party Secretary in current province
    - PCOM Chairmen in bigger province
    - Minister in Hanoi
    - Central Committee Member
- Provincial Officials Have Discretion over FDI
  - Official CIT and tax incentives are set nationally
  - Provincial leaders can determine eligibility for size, sector, and research breaks.
  - Have full discretion over land free reductions
  - Have full discretion in industrial zones or backward districts
- Excellent Data on Firm-Specific Incentives
  - Vietnam PCI-FDI Survey, 2010-2014
  - 1500 foreign firms per year across 63 provinces.

Do Incentives Work?

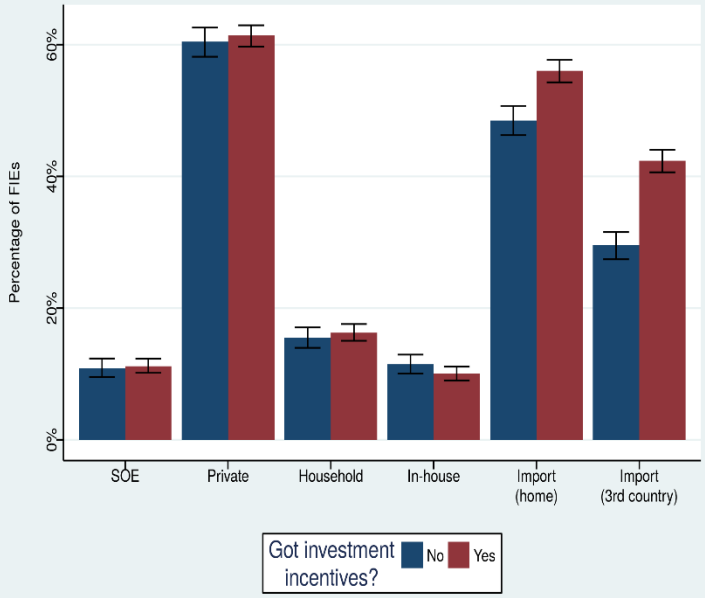
Inefficient – Less Revenue

Tax and tariff reductions and exemptions have contributed to a downward trend in revenues as a share of GDP… Staff recommended broadening the tax base by *eliminating exemptions, reducing incentives*, introducing a property tax, and including pensions under personal income tax (IMF Article 4, p. 11 & 15

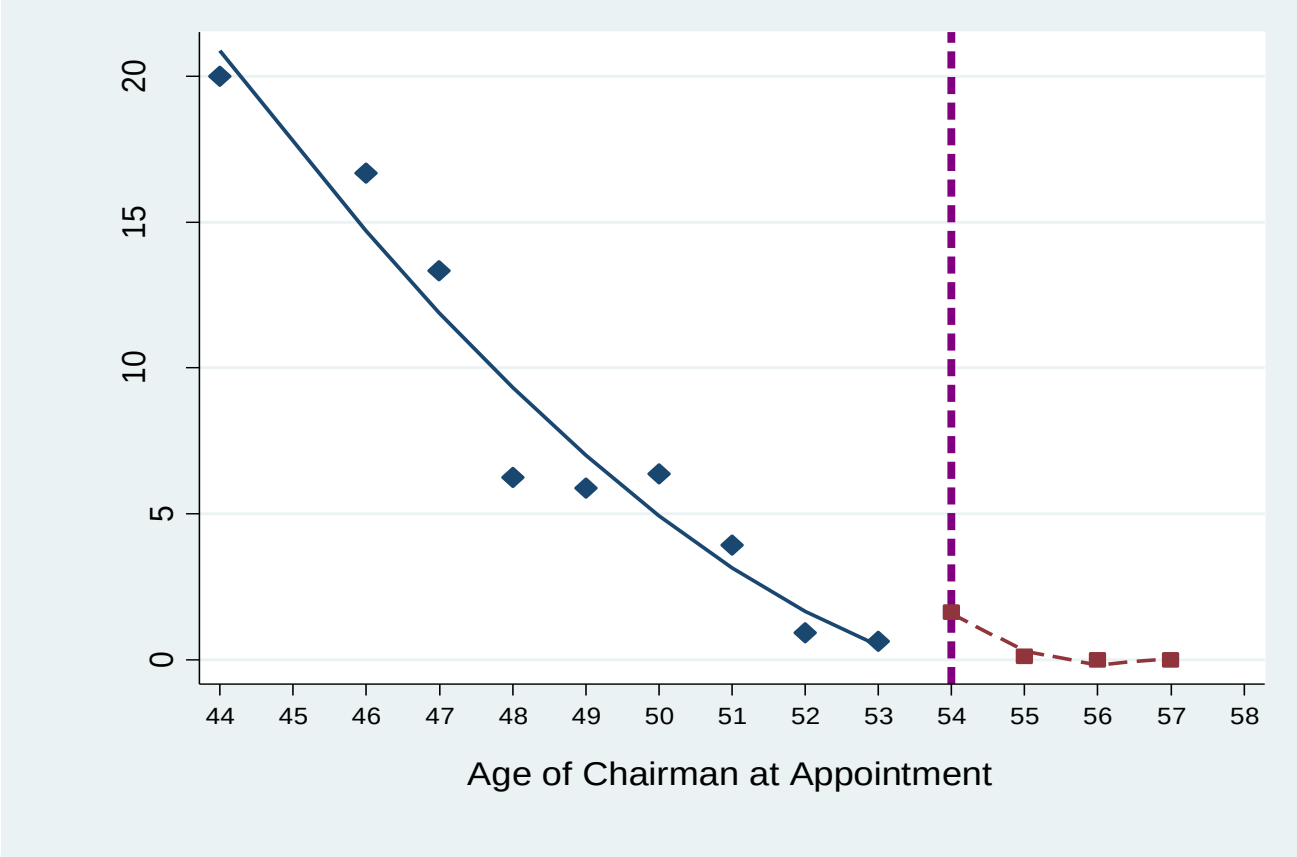
Ineffective

- 66% would have invested in the province without the inducement
- 68% said package offered by a competing province was exactly the same as the province where the invested
- No difference in profits or expansion.

Less Spillover



Probability of Promotion of Provincial People's Committee Chairman by Age at Appointment



PCI-FDI: Tax Incentive Battery

6. Did the province you eventually selected offer you an investment incentive package?
   - ☐ Yes *((If yes, please tell us a little more about the incentive package in question B6.1to B6.6)*
   - ☐ No *(Please skip to question B7)*

6.1. Was your firm provided with a corporate income tax holiday?	☐ Yes	☐ No
6.2. Was your firm provided with a corporate income tax reduction?	☐ Yes	☐ No
6.3. Were you provided with a reduction in land use right purchase fees?	☐ Yes	☐ No
6.4. Were these the province's original offers or were they negotiated?	☐ Original offer	☐ Negotiated
6.5. Would you have invested in the province without the tax incentive?	☐ Yes	☐ No

7. If you considered investing in another province, how did the tax incentive (if any) of the other province compare to the one where you invested?
   - ☐ Better
   - ☐ About the same
   - ☐ Worse
   - ☐ Our business did not consider investing in another province.

Regression Discontinuity Specification

$$PR(incentive_{ift} = 1)$$

$$= \beta_0 + \beta_1 R_{it} + \beta_2 Age(-54)_{it} + \beta_3 R_{it} * Age(-54)_{it} + \gamma PCOM_{it} + \pi Firm_{ft} + \delta_t + u$$

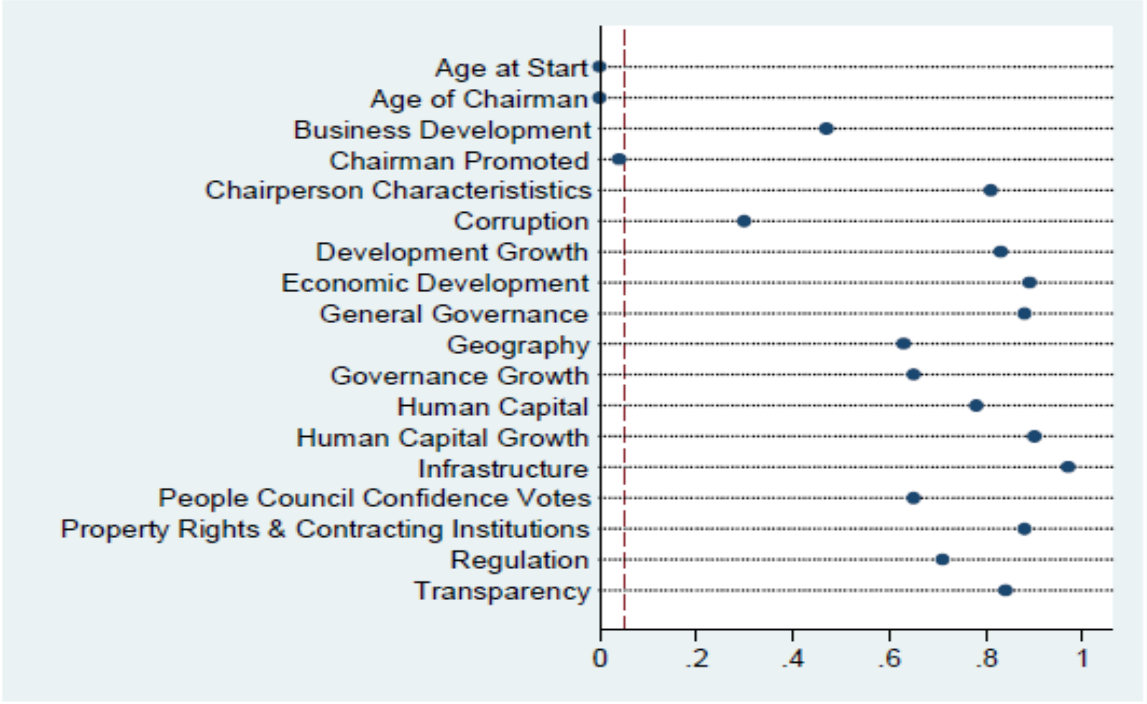
- ***Incentive***: Dependent Variable; = 1 if new FIE received any incentive
- ***Age at Appointment***: Forcing Variable, =re-centered to zero.
- ***R***: Treatment Variable; R=1 if Age>=54, R=0 if Age<54.
- Individual People's Committee Chairmen are indexed by ***i***.
- Each new firm entrant is indexed by *f*, and the entry year in our dataset is indexed by **t**, which ranges from 2006 to 2015.
  - All firms entering before 2006 were dropped, so that we could track the entire career of each PCOM
- **δ** introduces entry year fixed effects to account for potential trending in global or country allocation of incentives.

Strong Balance between Treatment and Control on Confounders

P-Values of MANOVA Test of

Difference between

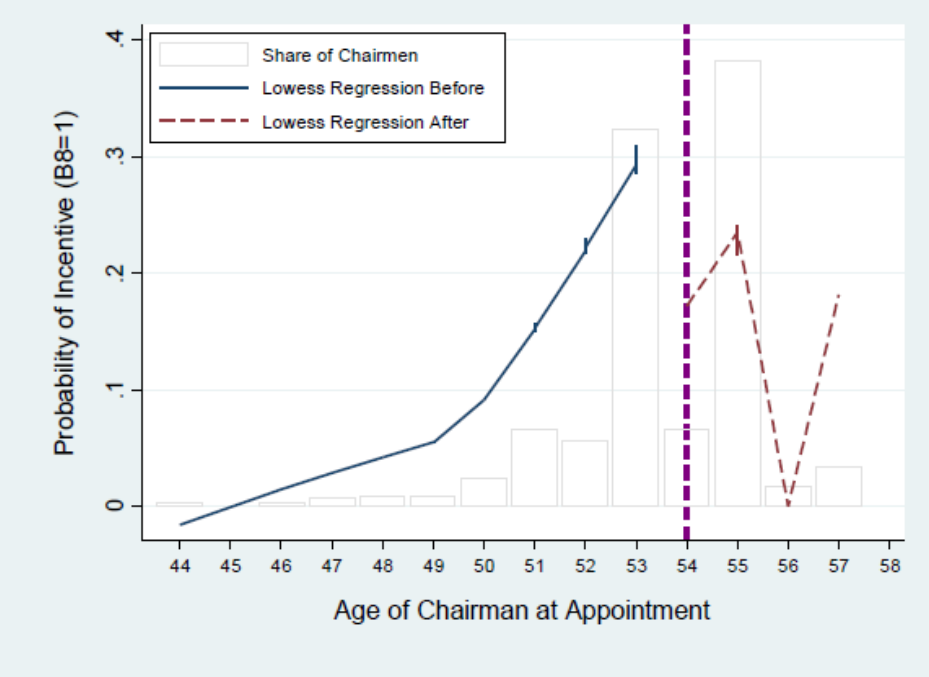
"Must Retire" &"Promotion Eligible"



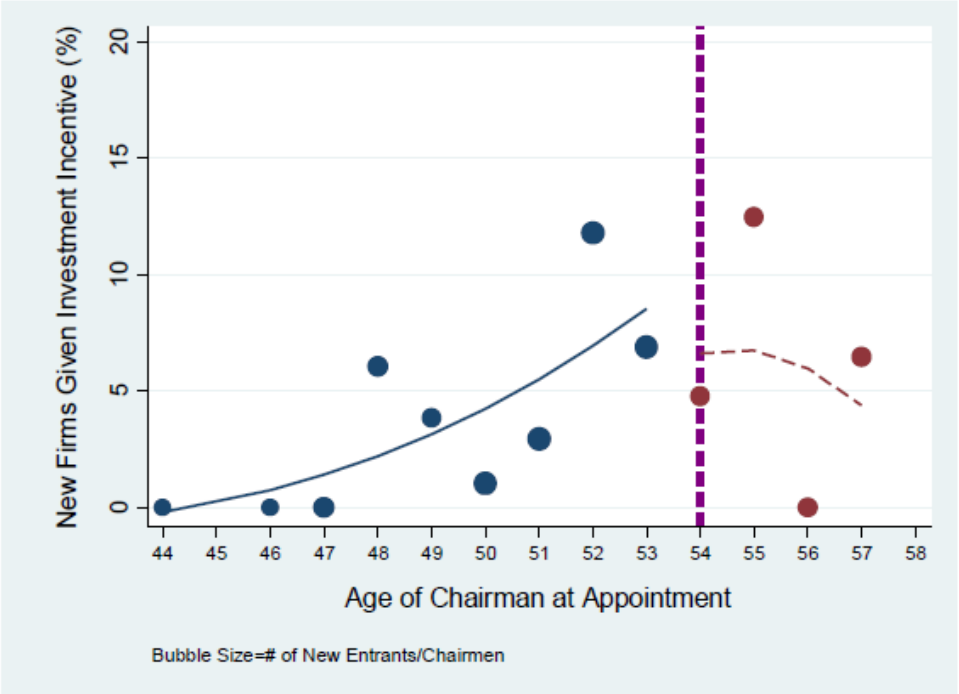
Note: Blue dots represent p-values from MANOVA analyses of grouped variables. The y-axis supplies the title of each grouping. A full list of indicators under each title can be found in Online Appendix B. Dashed line represents p=.05 from the MANOVA analysis. For dots below that number, we reject the null hypothesis that the treatment and control are different on that set of criteria.

Share of New Firms Given Incentive

Panel A: Firm-Level Lowess Regressions



Panel B: People's Committee Chairman-Level Averages Quadratic Fit

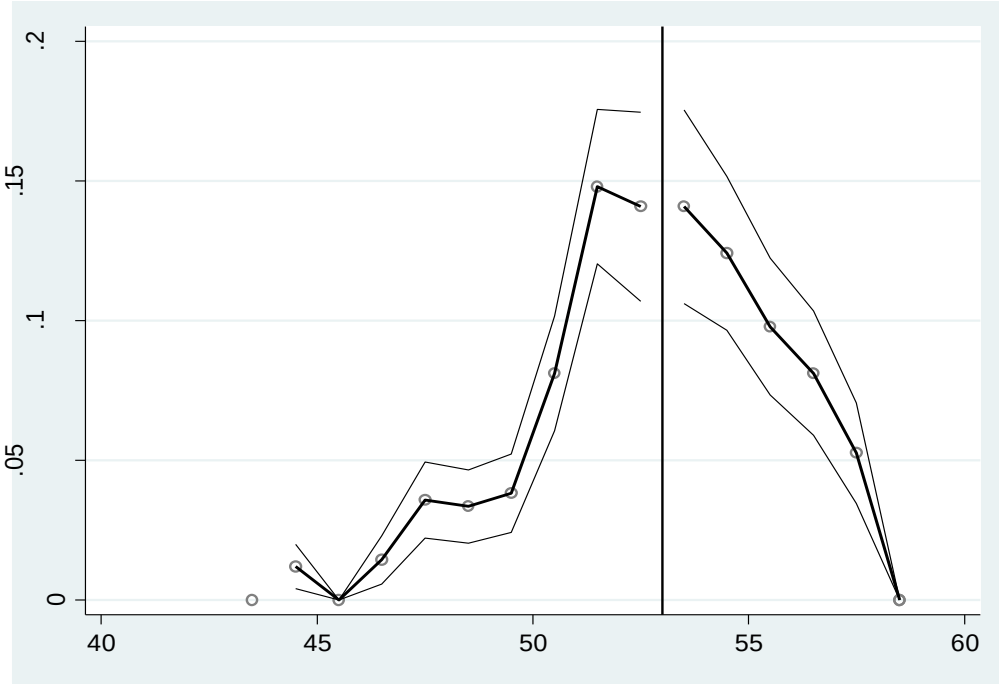


Robust to Functional Form

Dependent Variable =	Regression Specifications						Alternative Approaches			
Offered Any Incentive to	Diff-in-Means	Interactions	Quadratic	Entry Year FE	Controls	Sector FE	Optimal BW	CV-BW	CTV	CTV^2
Foreign Entrant	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Must Retire=1	-0.148**	-0.168***	-0.131***	-0.157***	-0.193***	-0.256***	-.186*	-0.211***	-0.154***	-0.197***
	(0.058)	(0.036)	(0.043)	(0.053)	(0.049)	(0.040)	(.067)	(.079)	(0.142)	(0.142)
Age at Start -54	0.044**	0.105***	-0.002	0.110	-0.004	-0.036				
	(0.017)	(0.019)	(0.087)	(0.108)	(0.114)	(0.094)				
Must Retire*Age at Start		-0.121***	0.069	-0.149	0.105	0.193				
		(0.029)	(0.161)	(0.201)	(0.215)	(0.189)				
Entry Year Fixed Effects	No	No	No	Yes	Yes	Yes	No	No	No	No
Sector Fixed Effects	No	No	No	No	No	Yes	No	No	No	No
Controls	No	No	No	No	Yes	Yes	No	No	No	No
Observations	1,829	1,829	1,829	1,767	1,690	1,542	1,829	1,829	1,829	1,829
Chairmen Clusters	81	81	81	68	53	24				
Pseudo R-Squared	0.00680	0.0150	0.0164	0.0427	0.0434	0.0757				
Pbar	0.231	0.231	0.231	0.239	0.249	0.270				
Log Likelihood										
Kolmorgorov-Smirnov									0.788***	0.788***
Rank Sum Z-test									26.005***	26.011***

No Evidence of Sorting at Cut-Off

McCrary (2008) Density Test of Age at Start

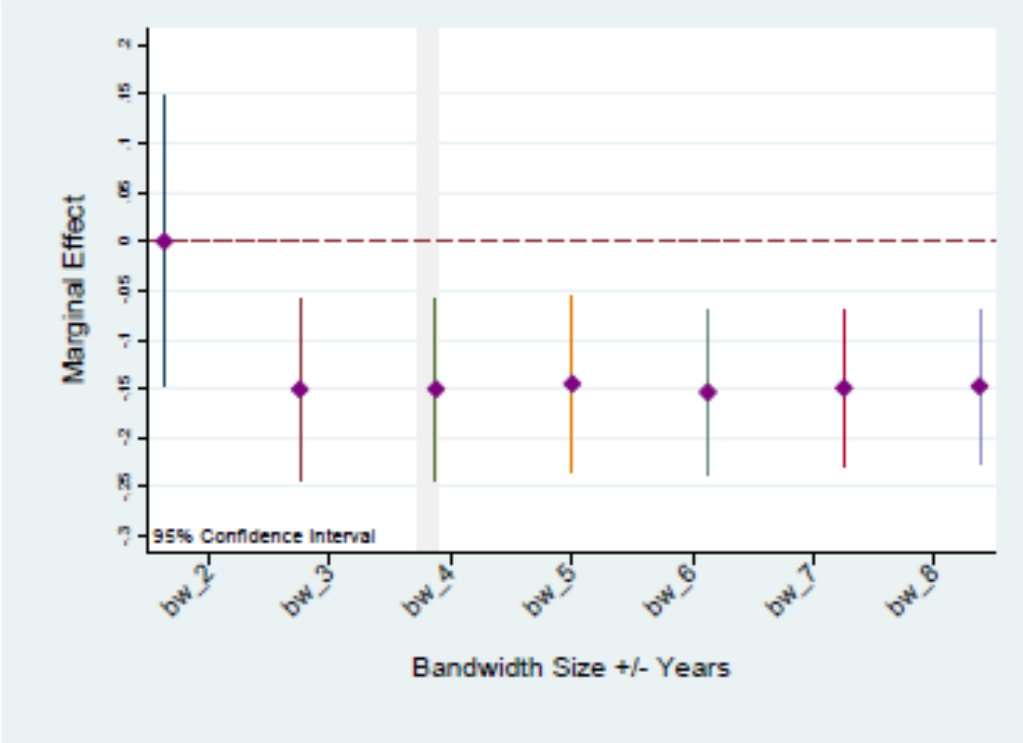


McCrary, Justin. "Manipulation of the running variable in the regression discontinuity design: A density test." *Journal of Econometrics* 142.2 (2008): 698-714.

Robust to Choice of Bandwidth

(Number of Years around Age Cut-Off)

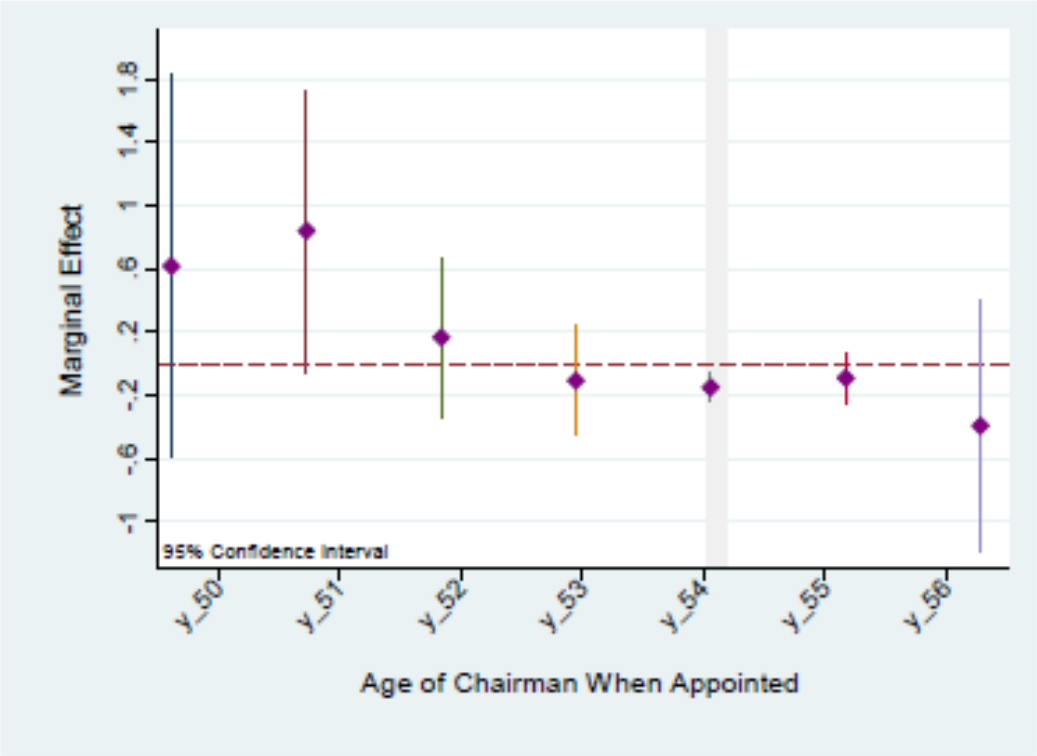
Panel A: Alternative Bandwidths



Placebo Test of Cut-Off Date

(Do we see similar effects for non-retirement years?)

Panel B: Alternative Cut-Off Dates



Other Measures of Incentives

Dependent Variable	How did offer from competing province compare to this one ?	Did you receive a Tax Holiday?	Legth of Holiday	Did you receive a tax reduction?
Coding	*1. Better; 2) The Same; 3) Worse*	*Yes=1/No=0*	*Months (ln)*	*Yes=1/No=0*
	(1)	(2)	(3)	(4)
Must Retire=1	-0.220	-0.290***	-1.244*	-0.692**
	(0.129)	(0.111)	(0.638)	(0.285)
Age at Start -54	0.124**	0.181**	1.016**	0.263
	(0.052)	(0.074)	(0.447)	(0.287)
*Must Retire*Age at Start*	-0.013	-0.209**	-1.247	-0.057
	(0.058)	(0.098)	(1.223)	(0.309)
Entry Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	548	613	131	356
Pbar/Mean DV	1.85	0.514	3.59	0.418

Dependent Variable	**Reduction Size** Size of Reducation	**Reduction Length** Length of Reducation	**Land Fees** Were you provied with a reduction in Land Use Fees?	**Offered/Negotiated** Was this the province's first offer or negotiated?
Coding	*Percentage Points*	*Months*	*Yes=1/No=0*	*First Offer=1/Negotiated=0*
	(5)		(7)	(8)
Must Retire=1	-22.576**	-14.730**	-0.131	0.153
	(9.979)	(6.455)	(0.079)	(0.141)
Age at Start -54	12.699	4.769	0.063	-0.126*
	(9.704)	(4.734)	(0.053)	(0.074)
*Must Retire*Age at Start*	-11.453	0.780	-0.106	0.143
	(14.211)	(6.545)	(0.084)	(0.114)
Entry Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	369	315	545	416
Pbar/Mean DV	18.97	21.69	0.247	0.291

Models replicated 6.3 (Model 3) using alternative measures of tax incentives. Robust standard errors, clustered at People's Committee Chairmen, in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Controls include whether the chairman is serving in his hometown, years of education, possess MBA=1, serving in central committee=1, firm size and sector, provincial GDP per capita, population, number of FDI projects, and high school graduation rate.