Regression Discontinuity Design: A test for manipulation of the running variable

Research Module in Econometrics and Statistics
WS 2019/20

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Outline

1. Manipulation Test
2. Properties and Parameter Choice
3. Simulation Study
4. Real Data Application
5. Conclusions

Manipulation Test

Fundamental Problem of Causal Inference

- Identifying effect from cause requires us to ask:
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- Individual unit in one state only (treatment or control)
- Regression Discontinuity Design (RDD) is quasi-experimental research design creating local random assignment in treatment and control
- Treatment assignment changes discontinuously as function of running variable
- In absence of manipulation, treatment and control units locally very similar
- Can recover ATE, weighted by probability to be close to cutoff

Manipulation of Running Variable

- With perfect manipulation treatment and control units locally not similar anymore
- Counterfactual outcomes and treatment effect not identifiable
- Perfect manipulation if individuals (i) have precise control of running variable, (ii) know cutoff and (iii) benefit from treatment

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- Perfect manipulation if individuals (i) have precise control of running variable, (ii) know cutoff and (iii) benefit from treatment
- Need to know assignment rule and context very well
- Nevertheless, testing for manipulation is inevitable

A Manipulation Test (McCrary, 2008)

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- Idea: test for discontinuity in density function of running variable at cutoff

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- Idea: test for discontinuity in density function of running variable at cutoff
- Estimation at cutoff for data approaching cutoff from above and below separately:
  - Step 1: Bin data and create histogram
  - Step 2: Smooth with local linear regression

Local Linear Density Estimation: First Step

- To deploy regression methods we need regressor and response variable
- Bin data, count observations in bins, center and normalize
  - Returns bin midpoints and bin heights, i.e. histogram

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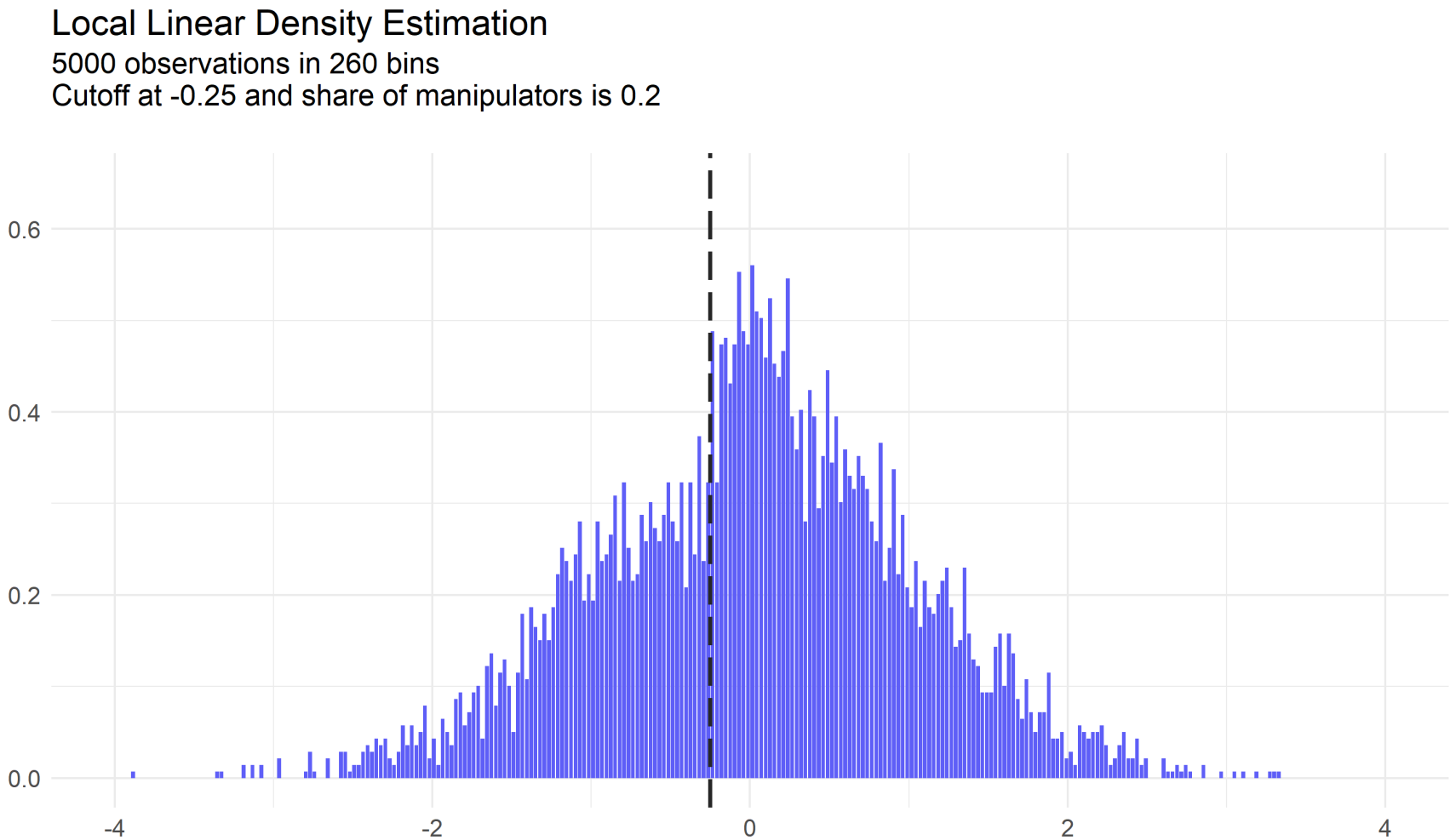
- Bin data, count observations in bins, center and normalize
  - Returns bin midpoints and bin heights, i.e. histogram
- Binsize is first smoothing parameter we choose
  - Depends on number of observations and variance

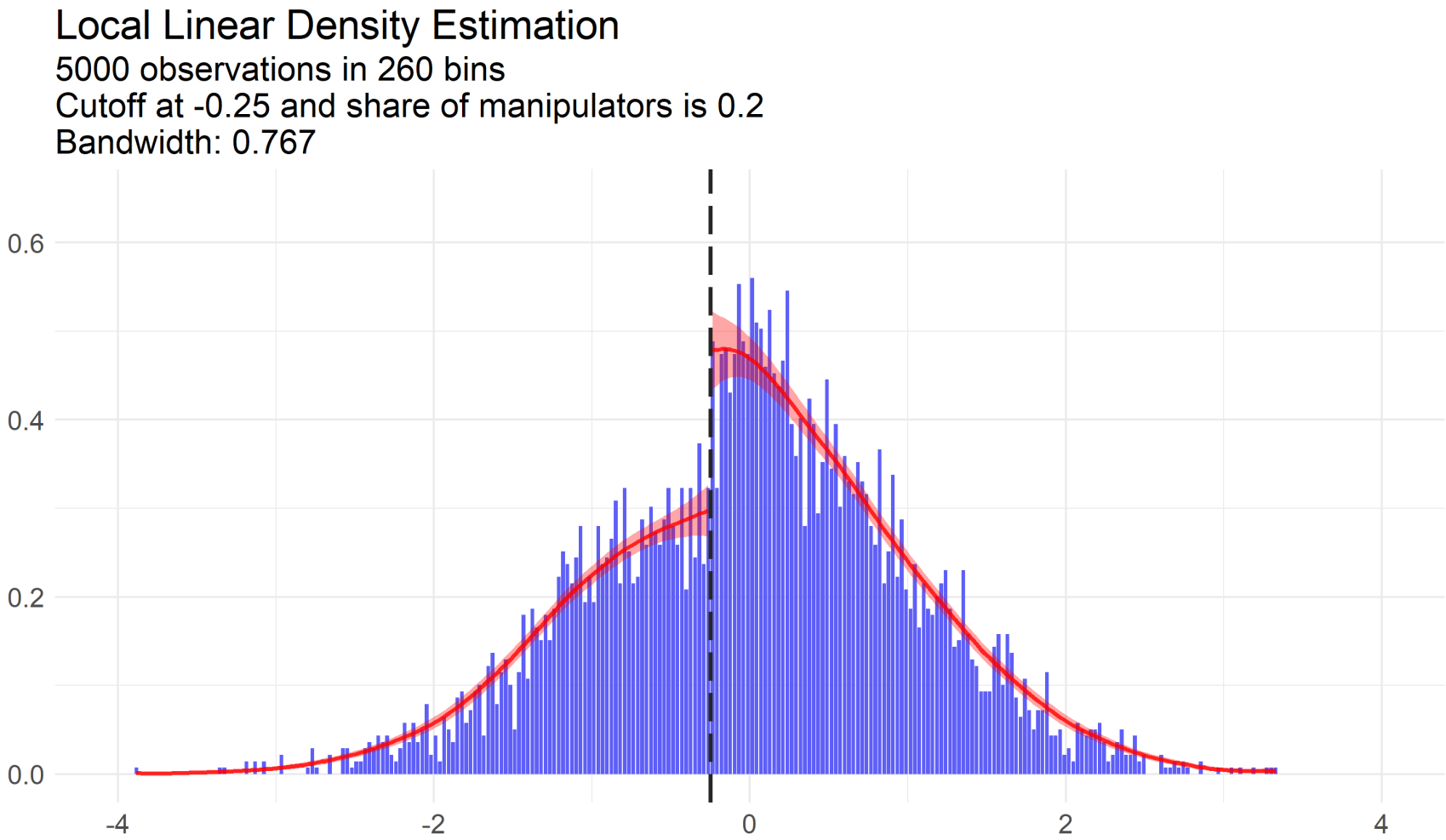
First Step: Histogram



Local Linear Density Estimation: Second Step

- Use non-parametric methods to smooth histogram
- Local linear regression essentially Weighted Least Squares
- At point of interest, fit linear model to weighted data
  - Weight increases the closer observation is to point of interest
  - Zero weight for data on other side of cutoff
- Second smoothing parameter is bandwidth, which decides range of data to use for estimation

Second Step: Local Linear Smoothing



Estimator and Wald Test

- Estimator is transformed difference of density estimates $\widehat{f}(r)$ approaching cutoff from above and below:

$$\widehat{\theta} = \ln(\lim_{r \downarrow c} \widehat{f}(r)) - \ln(\lim_{r \uparrow c} \widehat{f}(r))$$

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$$\widehat{\theta} = \ln(\lim_{r \downarrow c} \widehat{f}(r)) - \ln(\lim_{r \uparrow c} \widehat{f}(r))$$

- Test $H0 : \theta = 0$ with Wald test:

$$\frac{\widehat{\theta}}{\widehat{\sigma}_{\theta}} \xrightarrow{d} \mathcal{N}(0, 1)$$

Properties and Parameter Choice

Properties of Estimator

- Asymptotic normality
- Consistency (with correct choice of bandwidth)

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Problems:

- Non-parametric setting: need large sample size
- Asymptotic bias with incorrect choice of bandwidth

Parameter Choice

- Binsize: determines appearance of the first-step histogram
- Bandwidth: determines size of the local neighborhood used for estimation in step 2
- McCrary uses automatic selection procedures and subjectively adjusts afterwards

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Problem:

- Automatically selected bandwidth leads to asymptotic bias
  - Need to shrink (undersmooth) obtained bandwidth
  - Optimal amount of undersmoothing is unknown

Simulation Study

Data-Generating Process

Idea:

- Assess test's power when increasing discontinuity gap
- Assess validity of asymptotic normality

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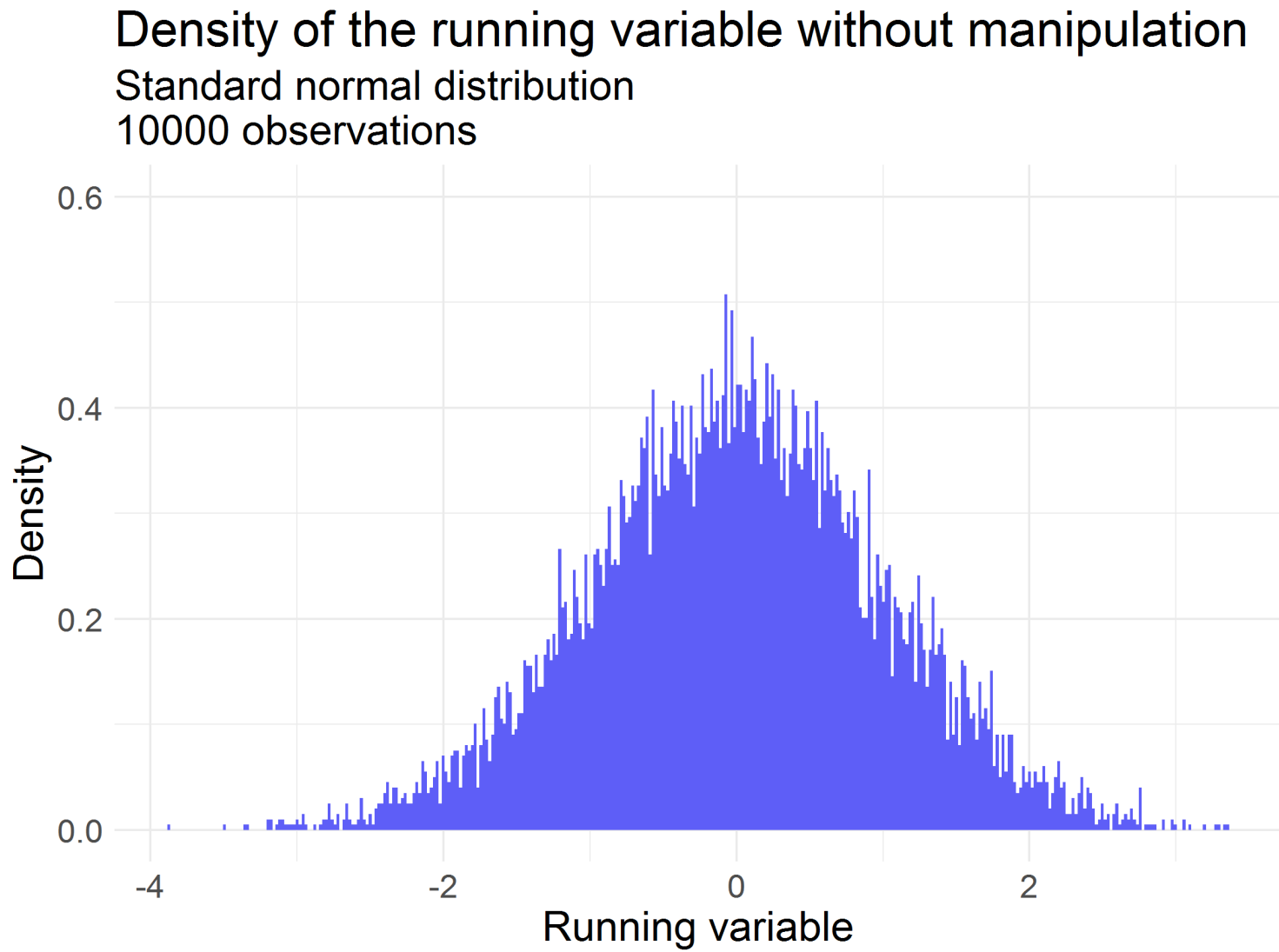
Data-generating process:

- Draw i.i.d. running variable values from fixed distribution
- Let individuals in fixed region below cutoff flip an unfair coin
- In case of "success": assign additional value of running variable leading to a change in treatment status

Data-Generating Process



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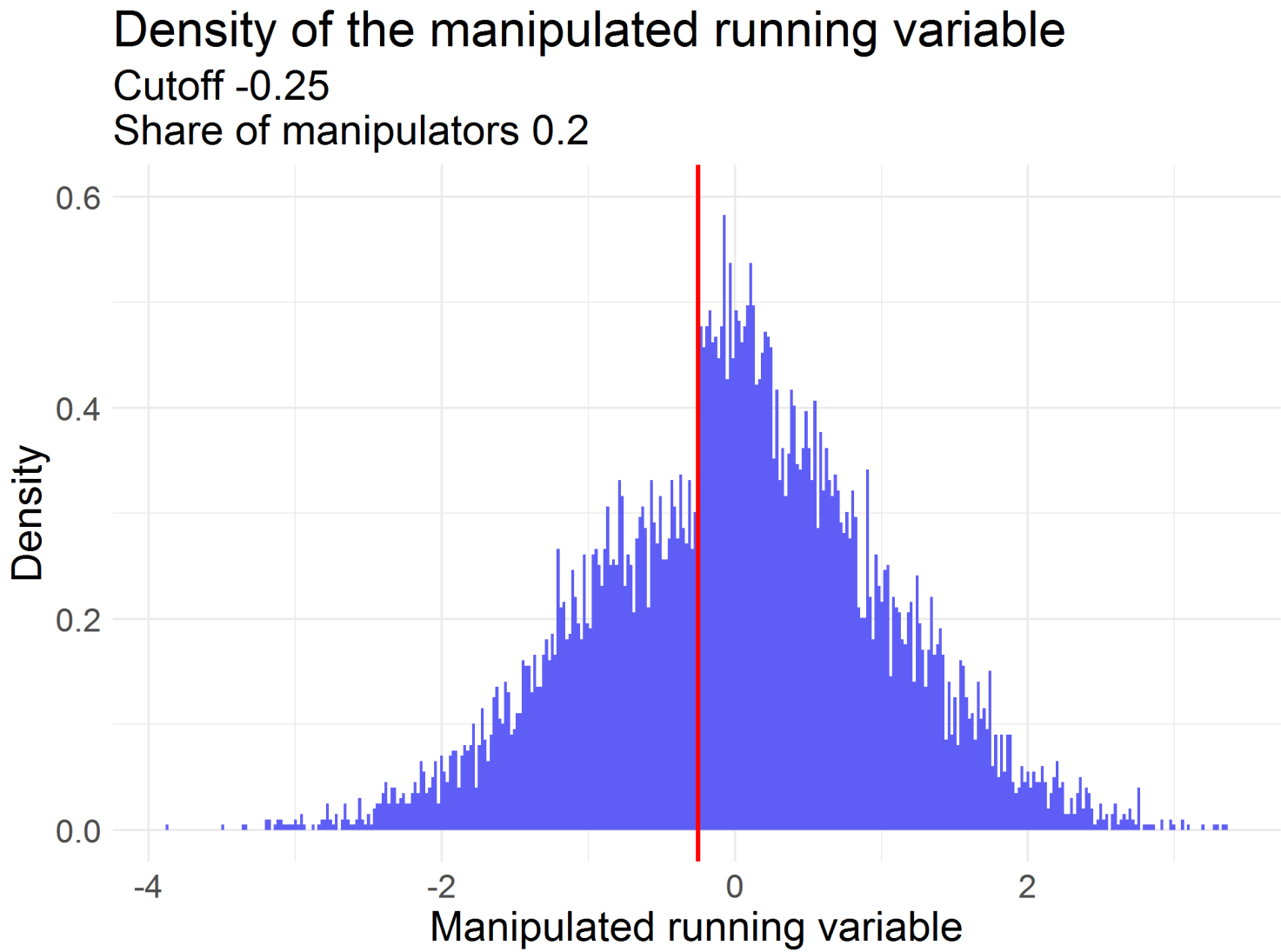

Power of Test

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- Sample non-manipulated running variable values from different probability distributions

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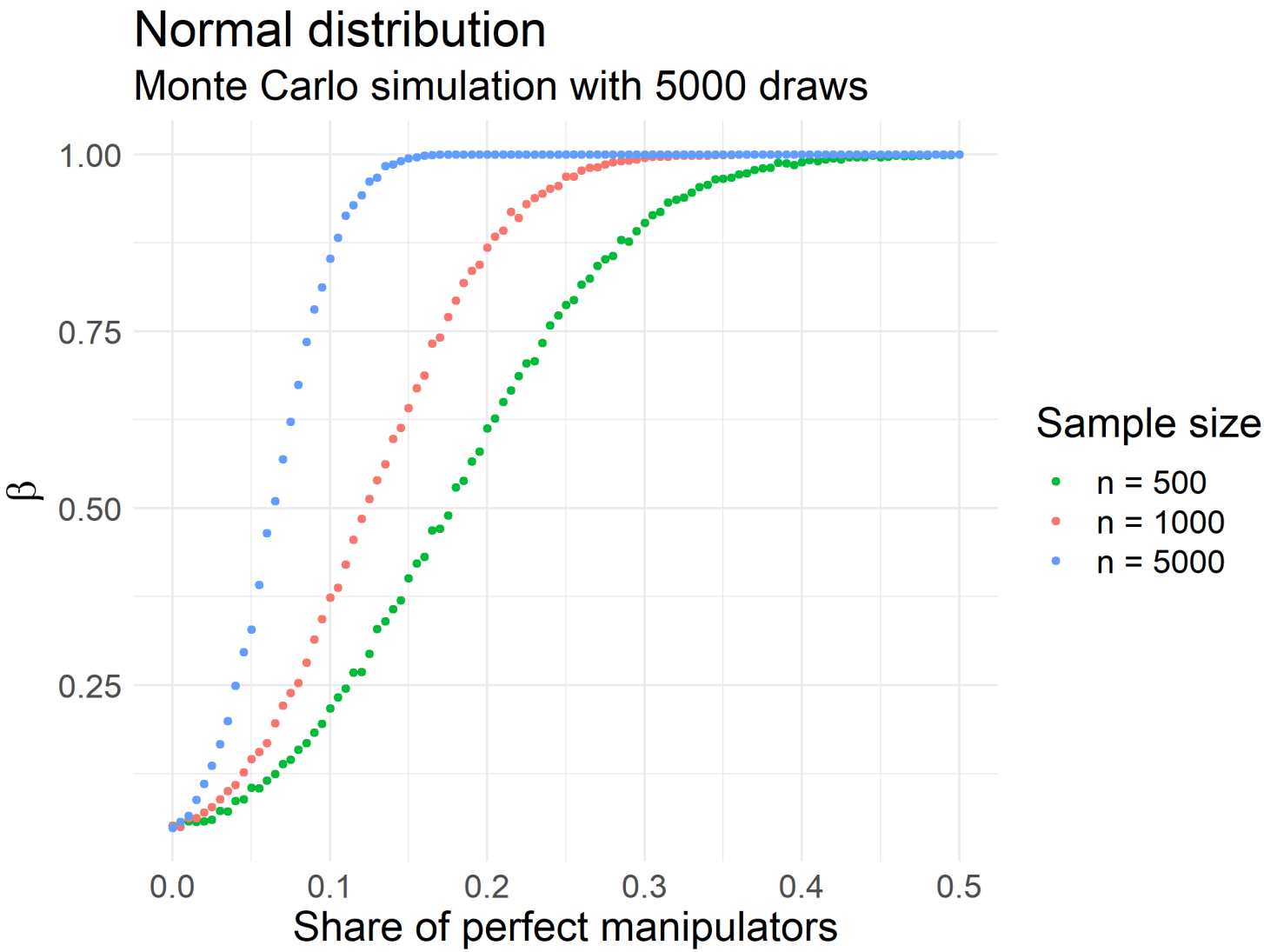
- Sample non-manipulated running variable values from different probability distributions

Expect:

- Power approaches one when increasing manipulation
- Faster convergence for larger sample sizes

Power of Test



Asymptotic Normality

- Assess quality of test statistic's normal approximation
- Use quantile-quantile plots to plot standard normal quantiles against quantiles of test distribution

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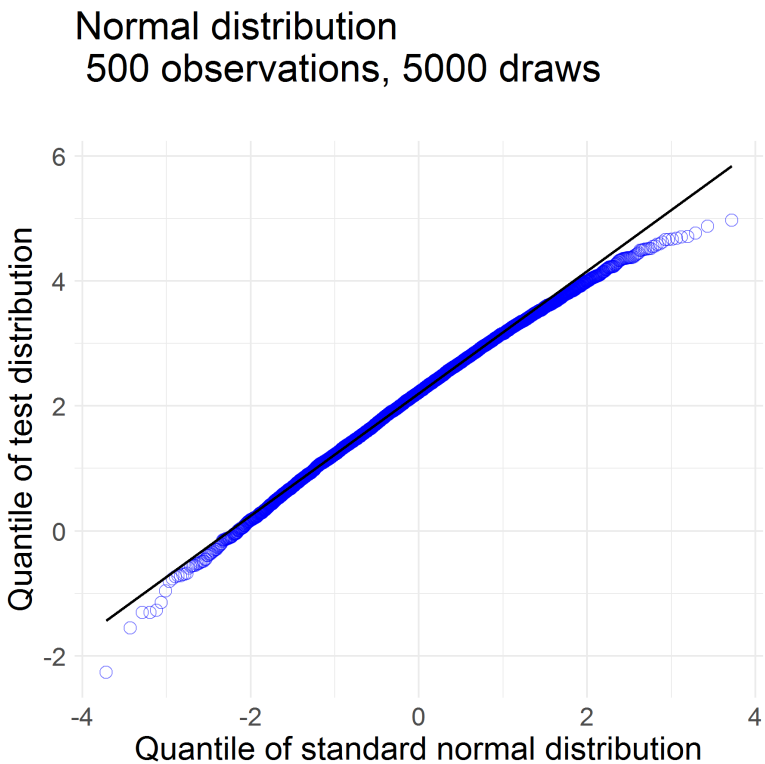
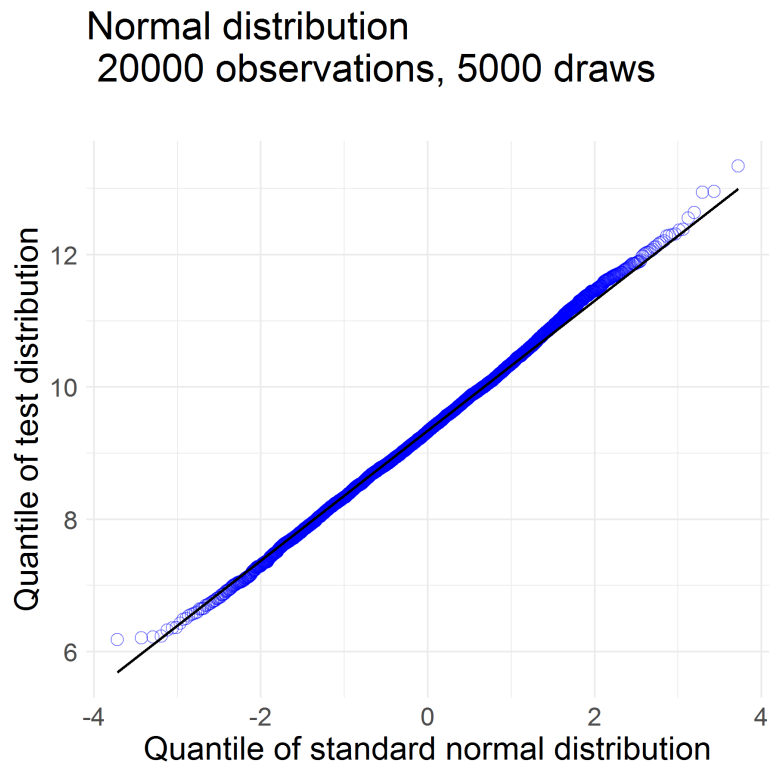
Expect:

- Normality becomes more valid with increasing sample size
- Normality becomes more valid when undersmoothing bandwidth

Asymptotic Normality





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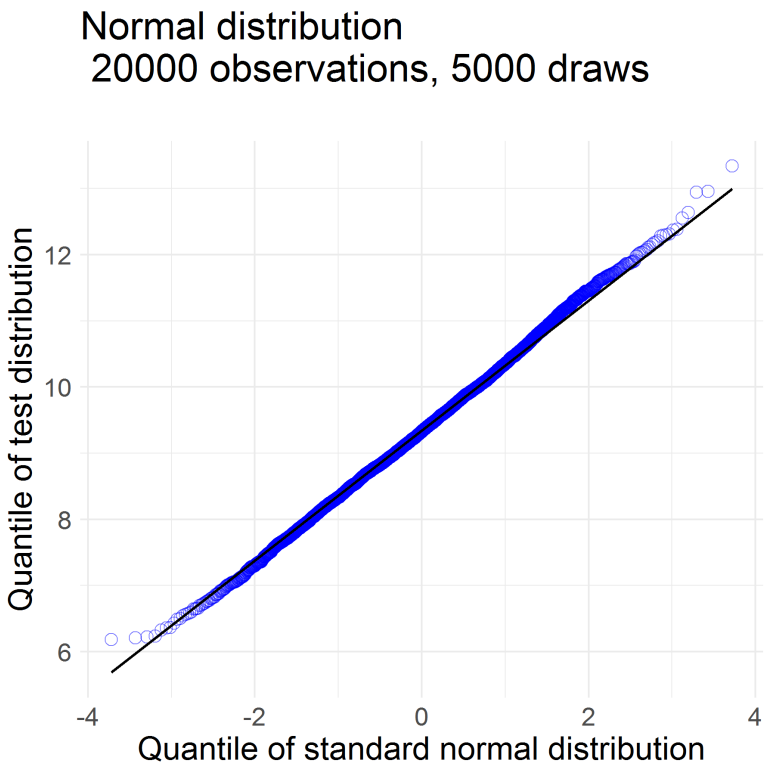

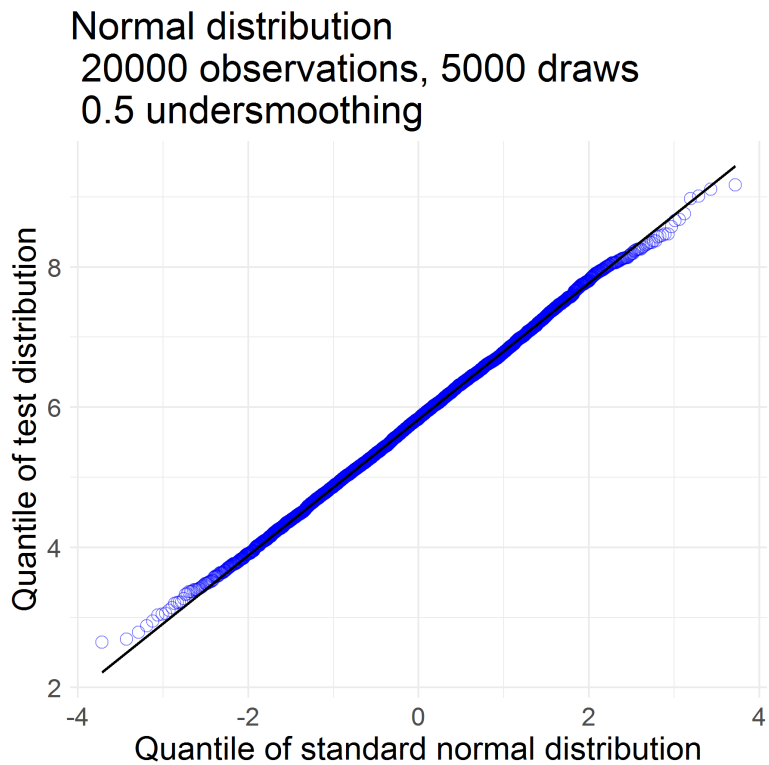

Real Data Application

Manipulation of Social Program Eligibility in Colombia: the Case of SISBEN

- Camacho and Conover (2011), published in *American Economic Journal: Economic Policy*
- Manipulation of Census of the Poor, a score-based targeting system for social welfare programs in Colombia

Manipulation of Social Program Eligibility in Colombia: the Case of SISBEN

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- Manipulation of Census of the Poor, a score-based targeting system for social welfare programs in Colombia
- Large-scale corruption at local government level and mass manipulation of data at entry stage
- Estimated costs of corruption: roughly 7% of National Health and Social Security budget

The Census of the Poor (SISBEN)

- National survey managed by municipalities which collects comprehensive information on long-term quality of life
- Used to assign poverty index score, from 0 (poorest) to 100 (least poor), determining eligibility to social welfare programs

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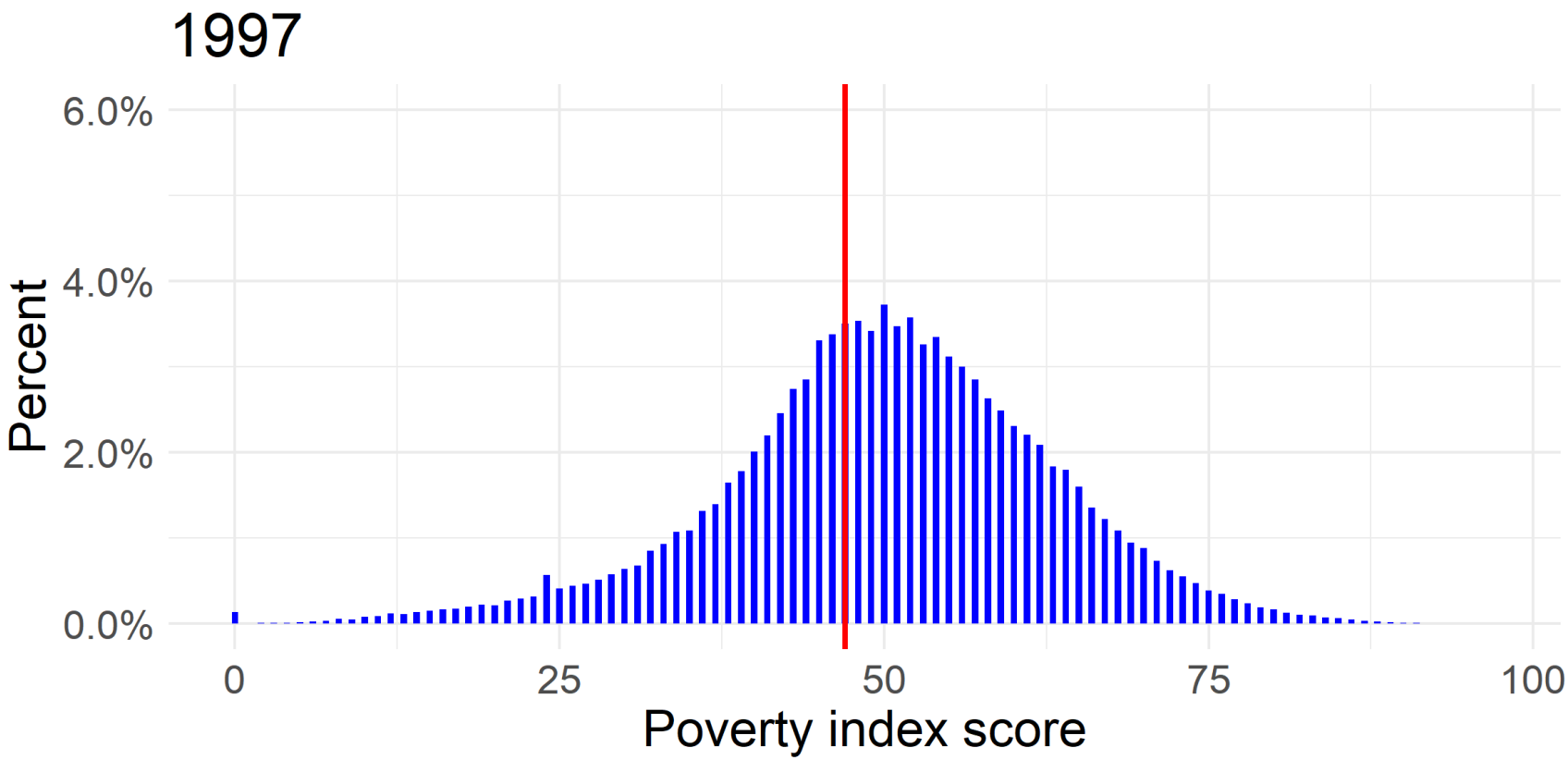
- 1993-2004: first SISBEN, most common cutoff for urban families is 47
- Algorithm revealed to local officers in 1997

Score Distribution Over Time



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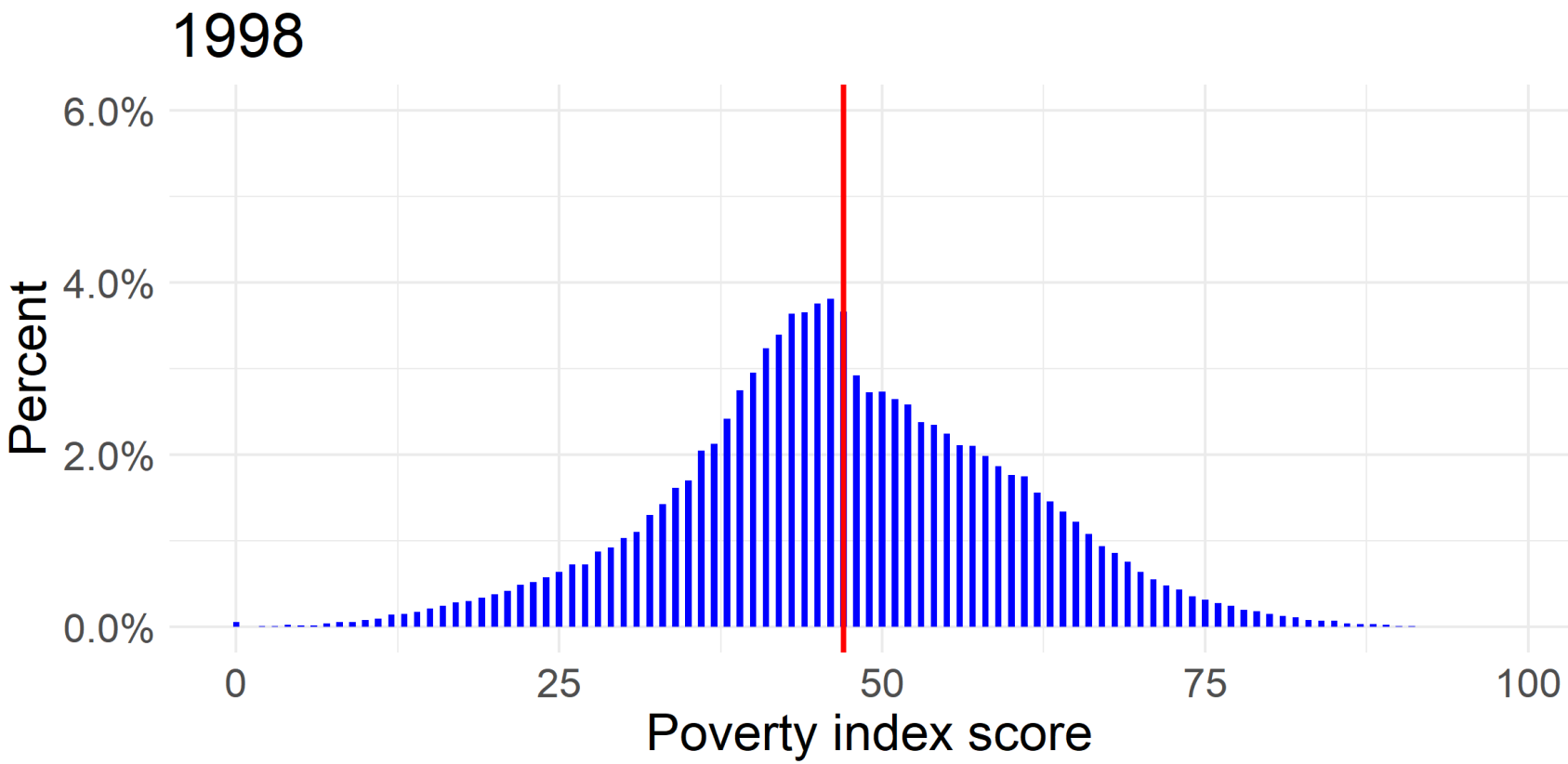

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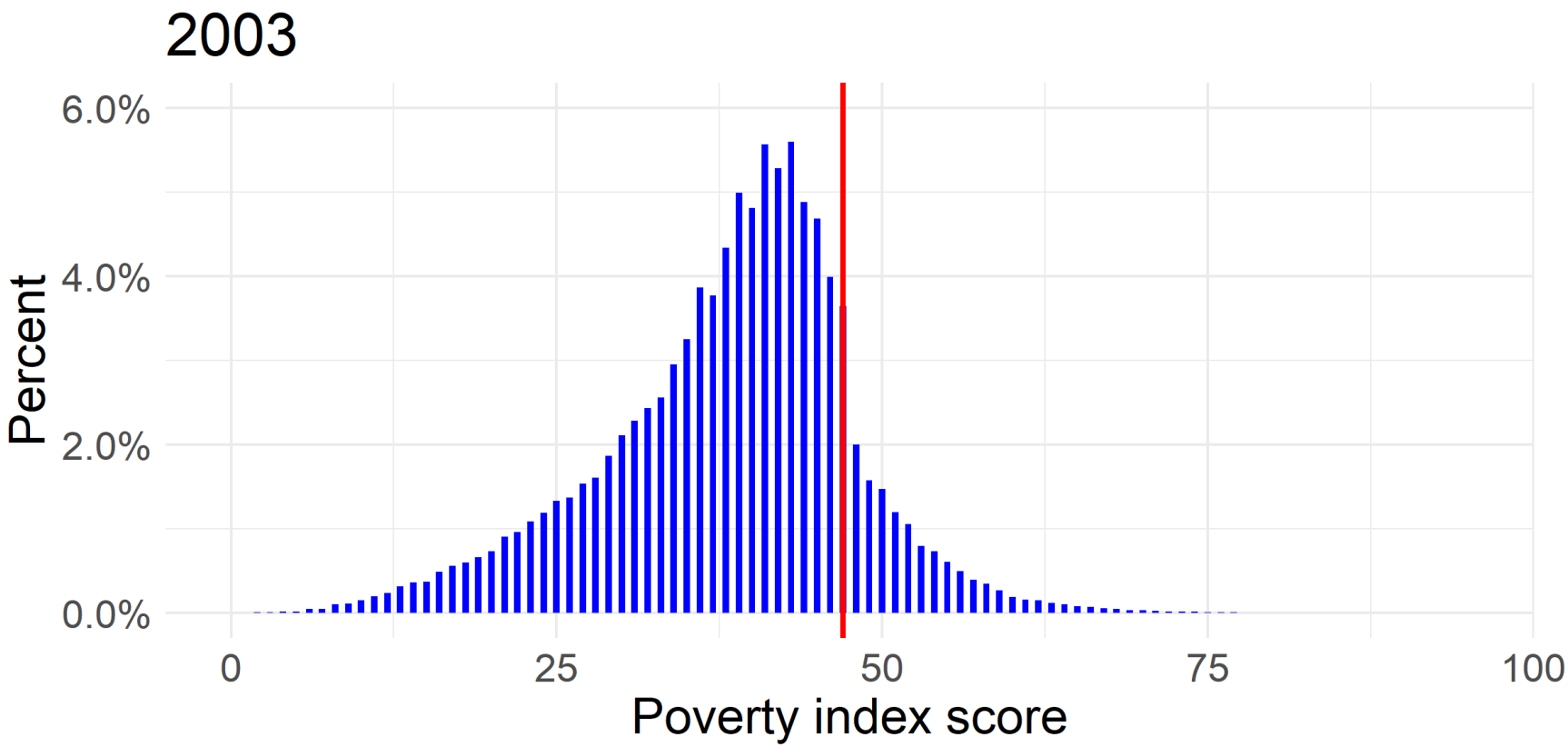

Size of Discontinuity at Cutoff

McCrary's density test

	Pilot Bandwidth		50% Undersmoothing	
Year	Estimator	SE	Estimator	SE
1994	-0.010	[0.007]	0.014	[0.010]
1995	-0.026***	[0.004]	0.004	[0.006]
1996	-0.002	[0.006]	-0.001	[0.009]
1997	-0.006	[0.005]	-0.016**	[0.007]
1998	-0.256***	[0.005]	-0.219***	[0.007]
1999	-0.314***	[0.004]	-0.271***	[0.006]
2000	-0.374***	[0.003]	-0.313***	[0.004]
2001	-0.510***	[0.003]	-0.450***	[0.005]
2002	-0.571***	[0.004]	-0.486***	[0.006]
2003	-0.542***	[0.008]	-0.459***	[0.012]

*** Significant at 1 percent level. ** Significant at 5 percent level.

Further Evidence of Manipulation

- A test rejection is **not** definitive proof of manipulation! Need for additional evidence
- Manipulation could have occurred in different ways at different stages of surveying process

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- Manipulation could have occurred in different ways at different stages of surveying process
- Analysis of data suggests centralized manipulation rather than coordination at individual level
- Empirical findings motivated by theoretical framework: mayors attempt to influence their chances of reelection

Conclusions

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- Manipulation test performs like it should
- Power of test increases when increasing manipulation or sample size
- Quality of normal approximation improves with larger number of observations
- Parameter choice depends on data at hand
- Further analysis of manipulation always needed

Thanks for your attention!