Technical Track
Session V
Regression Discontinuity (RD)

Christel Vermeersch

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Reminder: main objective of an evaluation…….

- Estimate the effect of an intervention *D* on a results indicator *Y*

- For example:
  - What is the effect of an increase in the minimum wage on employment?
  - What is the effect of a school meals program on learning achievement?
  - What is the effect of a job training program on employment and on wages?

Indexes are common in targeting of social programs

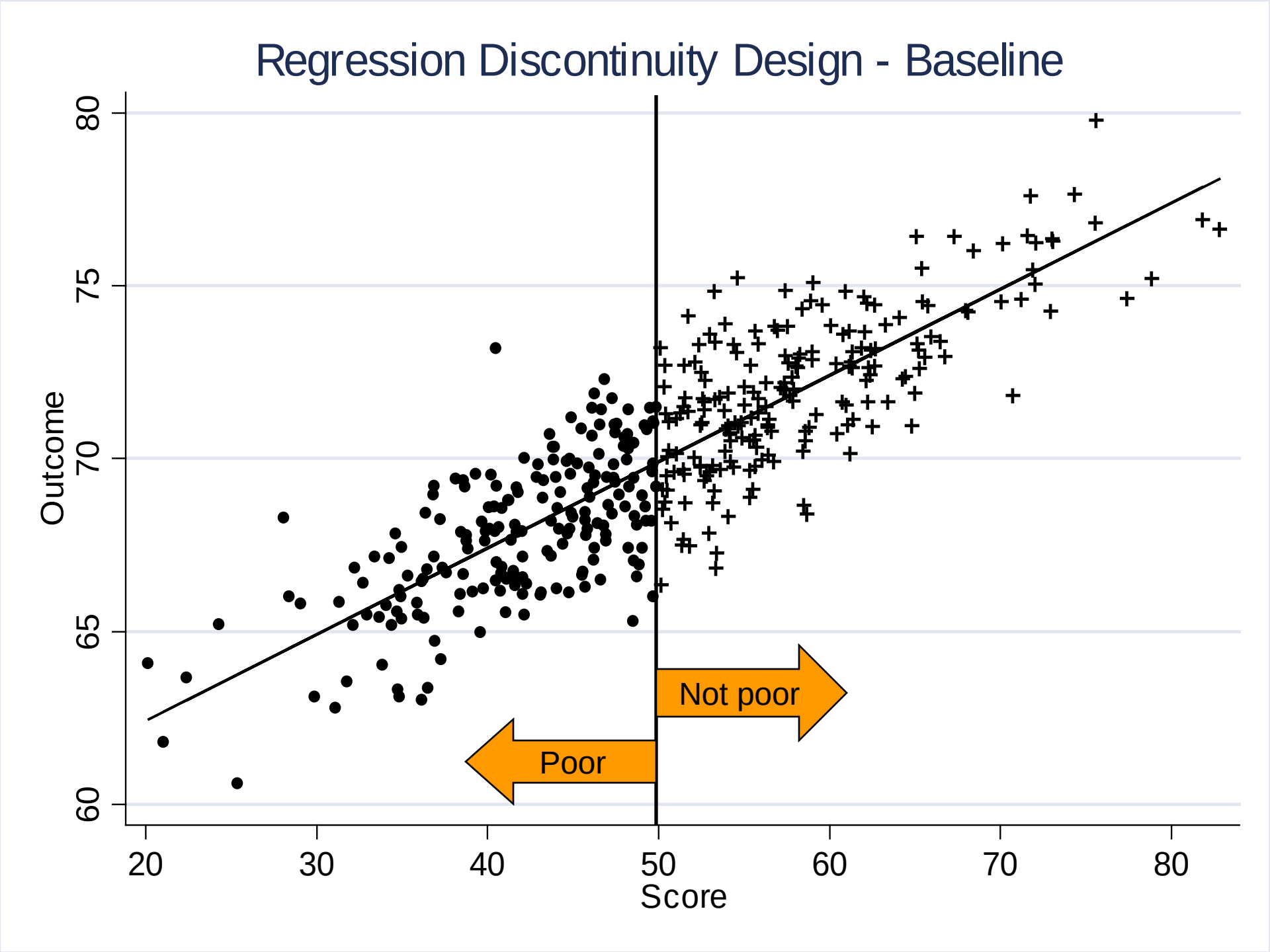
- Anti-poverty programs
  - ➔ targeted to households below a given poverty index
- Pension programs
  - ➔ targeted to population above a certain age
- Scholarships
  - ➔ targeted to students with high scores on standardized test
- CDD Programs
  - ➔ awarded to NGOs that achieve highest scores

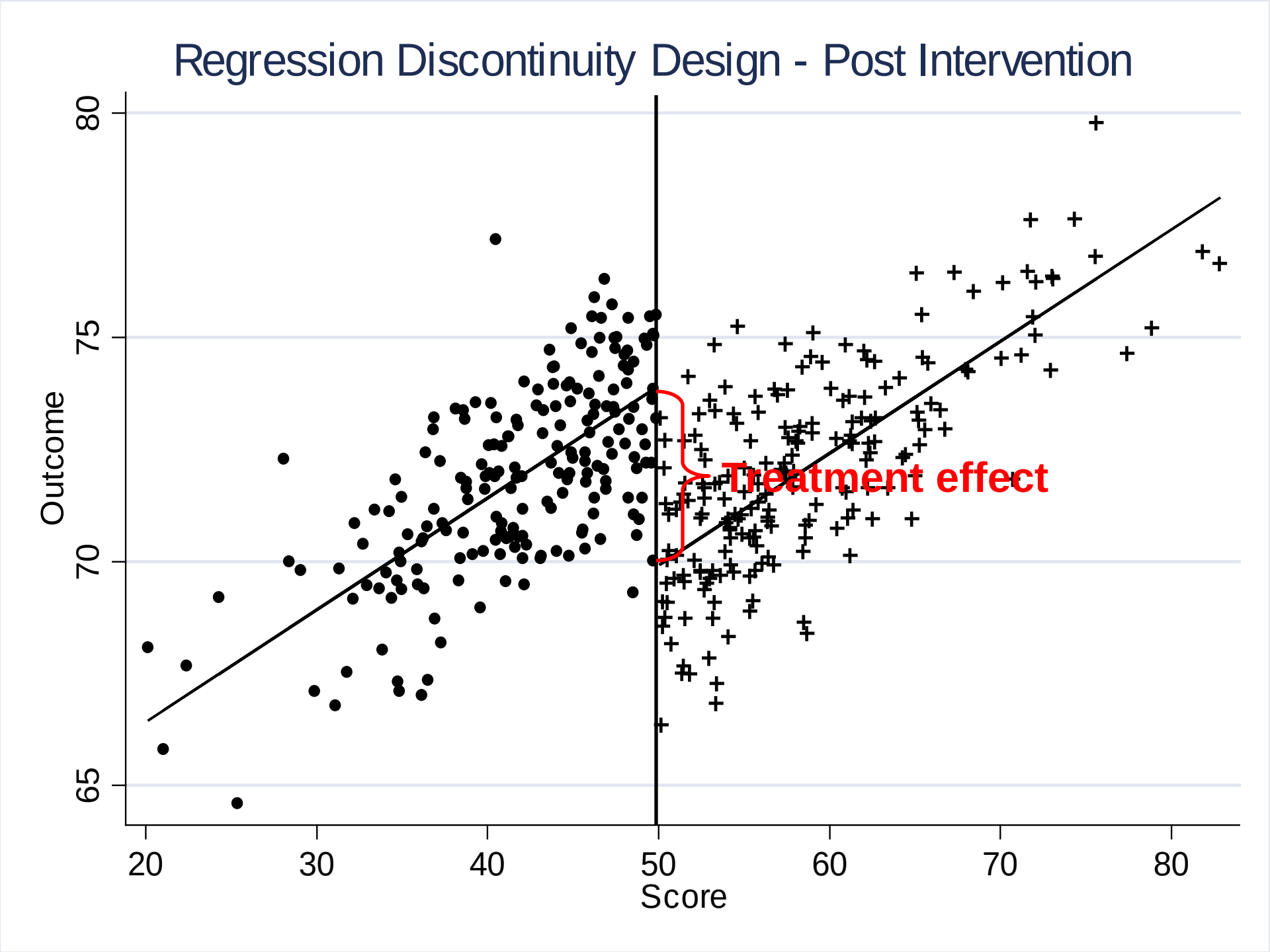
Regression discontinuity

- When to use this method?
  - The beneficiaries/non-beneficiaries can be ordered along a quantifiable dimension.
  - This dimension can be used to compute a well-defined index or parameter.
  - The index/parameter has a cut-off point for elegibility.
  - The index value is what drives the assignment of a potential beneficiary to the treatment. (or to non-treatment)
- Intuitive explanation of the method:
  - The potential beneficiaries (units) just above the cut-off point are very similar to the potential beneficiaries just below the cut-off.
  - We compare outcomes for units just above and below the cutoff.

Example: effect of cash transfer on consumption

- **Goal:** Target transfer to poorest households
- **Method:**
  - Construct poverty index from 1 to 100 with pre-intervention characteristics
  - Households with a score <=50 are poor
  - Households with a score >50 are non-poor
- **Implementation**:
  - Cash transfer to poor households
- **Evaluation:**
  - Measure outcomes (i.e. consumption, school attendance rates) before and after transfer, comparing households just above and below the cut-off point.


Regression Discontinuity Design - Baseline
Outcome
80
75
70
65
60
20
30
40
50
60
70
80
Score
Not poor
Poor


Regression Discontinuity Design - Post Intervention
Outcome
80
75
70
65
20
30
40
50
60
70
80
Score
Treatment effect

Sharp and Fuzzy Discontinuity

- Sharp discontinuity
  - The discontinuity precisely determines treatment
  - Equivalent to random assignment in a neighborhood
  - E.g. Social security payment depend directly and immediately on a person's age
- Fuzzy discontinuity
  - Discontinuity is highly correlated with treatment .
  - E.g. Rules determine eligibility but there is a margin of administrative error.
  - Use the assignment as an IV for program participation.

Identification for sharp discontinuity

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

$D_i = 1$ if household i receives transfer

$D_i = 0$ if household i does not receive the transfer

$\delta(score_i)$ is a function that is continuous around the cut-off point

Assignment rule under sharp discontinuity:

$D_i = 1 \Leftrightarrow score_i$ <=50

$D_i = 0 \Leftrightarrow score_i$ >50

Identification for fuzzy discontinuity

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

Where:

D_i = 1 if household receives transfer

D_i = 0 if household doesn't receive the transfer

BUT:

Treatment depends on - whether $score_i$ ><50

AND - endogenous factors

Identification for fuzzy discontinuity

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

IV estimation:

First stage: $$D_i = \gamma_0 + \gamma_1 \underbrace{I(score_i > 50)}_{\text{dummy variable}} + \eta_i$$

Second stage: $$y_i = \beta_0 + \beta_1 \hat{D}_i + \underbrace{\delta(score_i)}_{\text{continous function}} + \varepsilon_i$$

Examples

- Effect of transfers on labor supply

  (Lemieux and Milligan, 2005)

- Effect of old age pensions on consumption - BONOSOL in Bolivia

  (Martinez, 2005)

- The Effects of User Fee Reductions on School Enrollment

  (Barrera, Linden and Urquiola, 2006)

Example 1: Lemieux & Milligan: Incentive Effects of Social Assistance

- Social assistance to the unemployed:
  - Low social assistance payments to individuals under 30
  - Higher payments for individuals 30 and over
- What is the effect of increased social assistance on employment?

Figure 6: Social Assistance Income, Quebec 1986

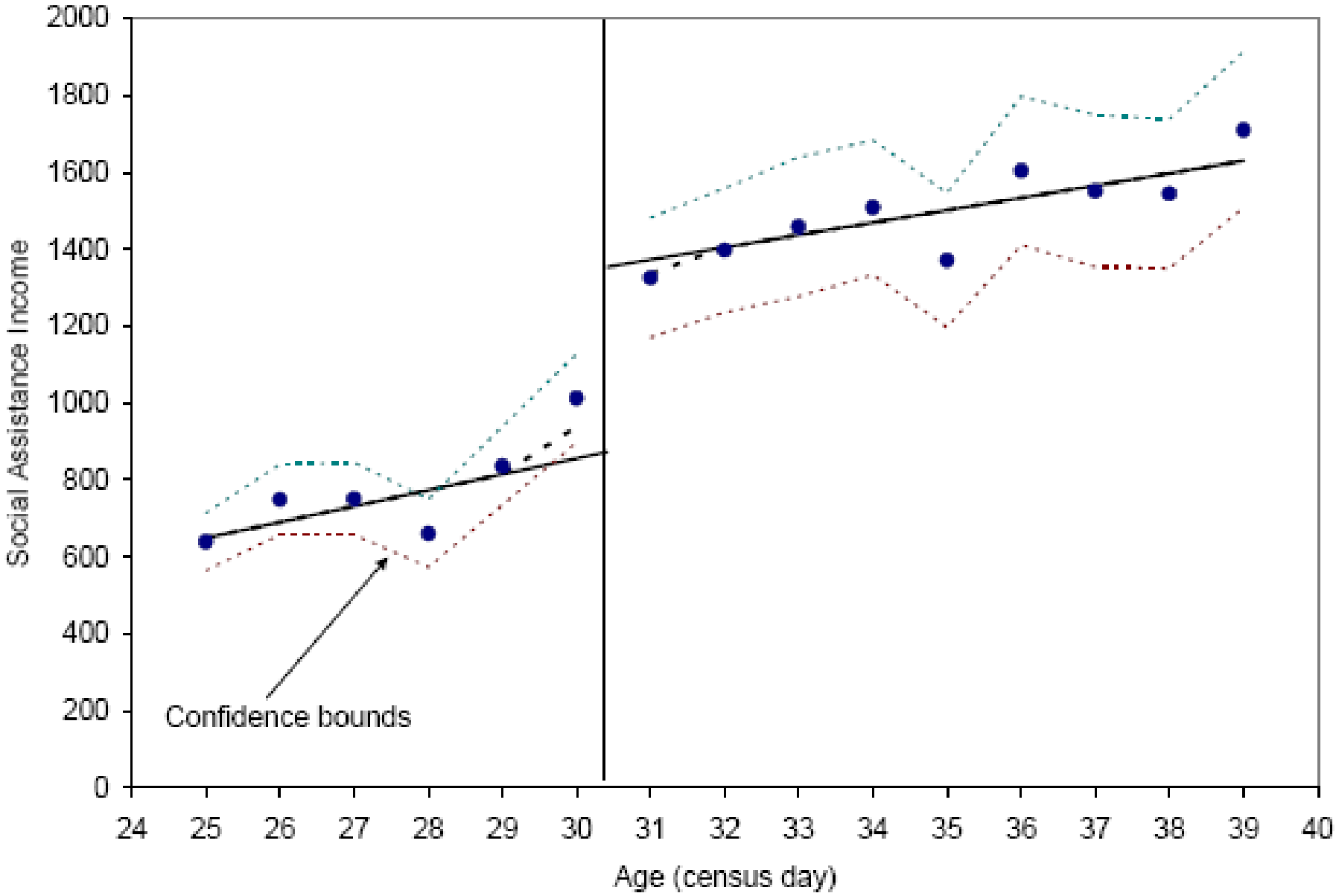
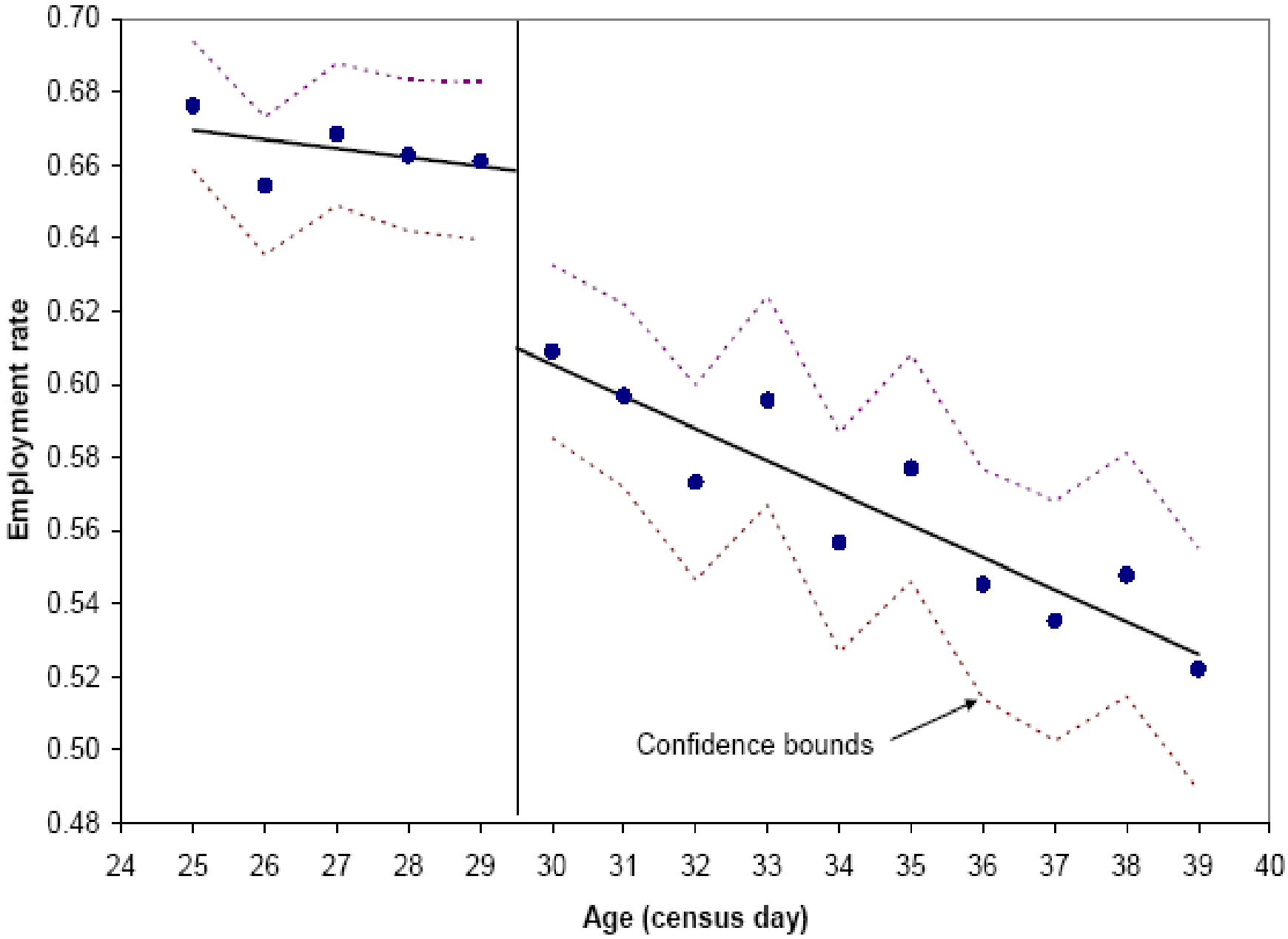


Figure 3: Employment Rate in Census Week, Quebec 1986



Example 2: Martinez: BONOSOL

- Old age pension to all Bolivians
  - Pension transfer to large group of poor households
  - pensions paid as of 2001
  - Known eligibility criteria: 65+ years
- Have pre- (1999) and post- (2002) data on consumption
- Goal: Estimate effect of BONOSOL on consumption

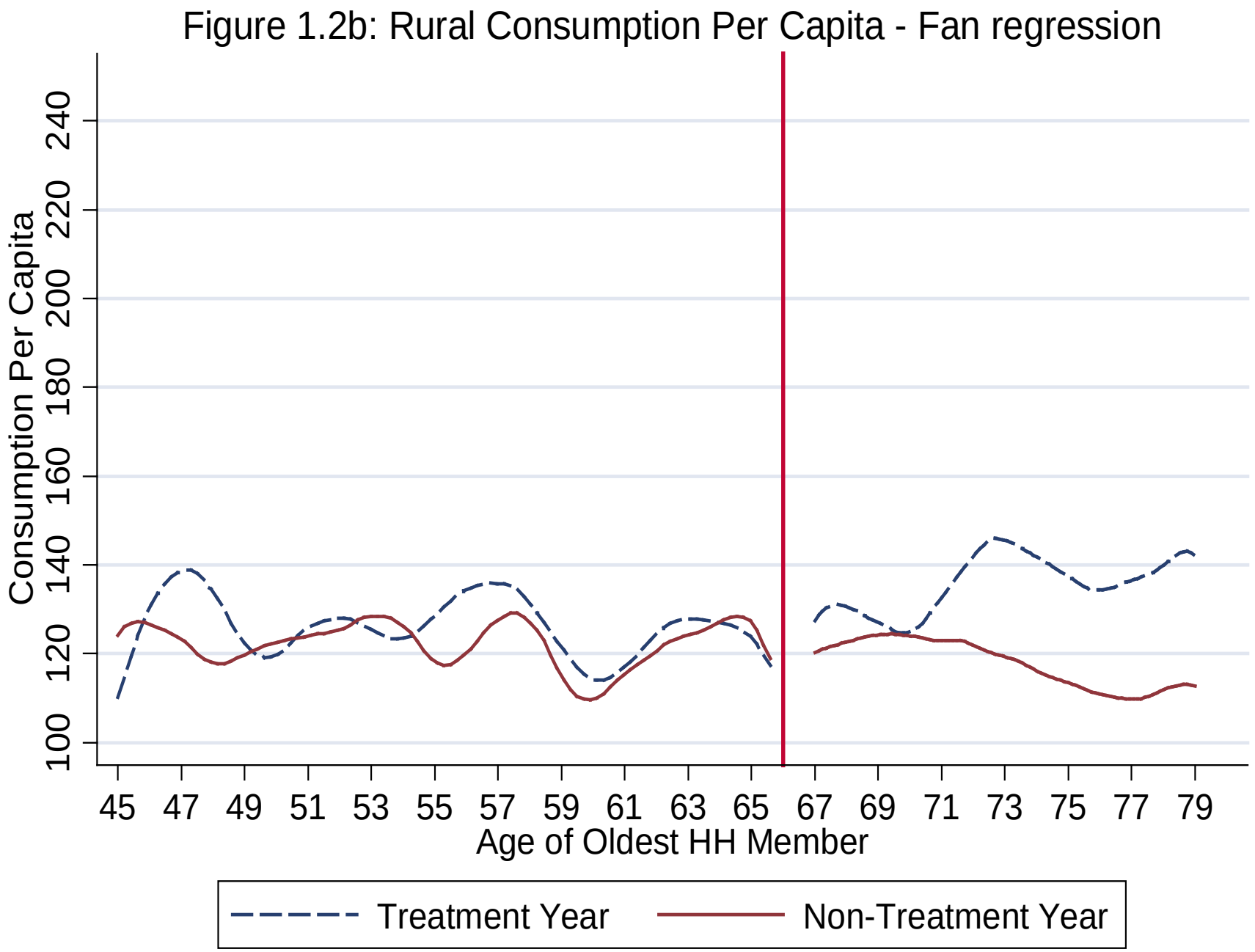


Figure 1.2b: Rural Consumption Per Capita - Fan regression
Consumption Per Capita
100
120
140
160
180
200
220
240
45
47
49
51
53
55
57
59
61
63
65
67
69
71
73
75
77
79
Age of Oldest HH Member
Treatment Year
Non-Treatment Year

Potential Disadvantages of RD

- Local average treatment effects
  - We estimate the effect of the program around the cut-off point
  - This is not always generalizable .
- Power:
  - The effect is estimated at the discontinuity, so we generally have fewer observations than in a randomized experiment with the same sample size
- Specification can be sensitive to functional form: make sure the relationship between the assignment variable and the outcome variable is correctly modeled, including:
  - Nonlinear Relationships
  - Interactions

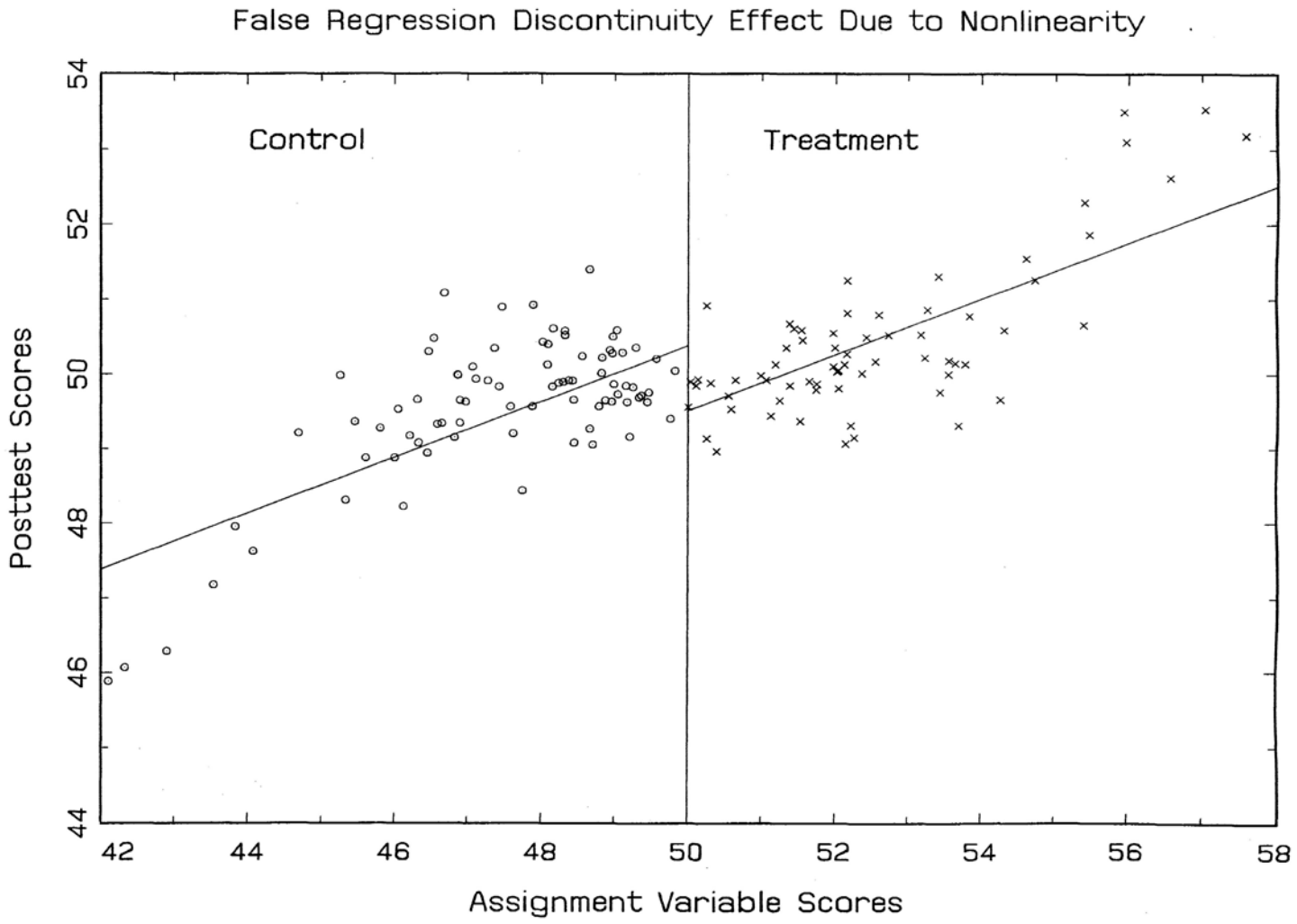

False Regression Discontinuity Effect Due to Nonlinearity
Control
Treatment
Posttest Scores
Assignment Variable Scores
54
52
50
48
46
44
42
44
46
48
50
52
54
56
58

Fig 7-9

Advantages of RD for Evaluation

- RD yields an unbiased estimate of treatment effect at the discontinuity

- Can take advantage of a known rule for assigning the benefit
  - This is common in the design of social interventions
  - No need to “exclude” a group of eligible households/ individuals from treatment

Example 3: Free schooling program, Colombia

- **Goal**: estimate impact (causal!) of school fee reduction on school enrollment
- **Method**: Regression Discontinuity
- **Paper:** "The Effects of User Fee Reductions on Enrollment: Evidence from a quasi-experiment" (Barrera, Linden y Urquiola)

Context and *Free schooling* Program

- Each year the government issues a resolution that stipulates
  - which items schools may charge for
  - the maximum fee they can set for each of those items
- These expenses are between 7 and 29 monthly dollars,
  (between 6 and 25 percent of the minimum wage)

- The *Gratuidad* program reduces some of these fees.
- The program is targeted using the *Sisben* index.
- *Sisben* identifies the most vulnerable households in Colombia.
- The extent to which students benefit from these reductions is a function of their *Sisben* level

What is *Sisben*?

- *Sisben* is an instrument used to focalize social assistance.
- First implemented in 1994
- Based on a survey about households'
  - infrastructure,
  - demographics and
  - human capital
- Each household receives an score between 0 and 100
- Using the score, each households is assigned to one of six "levels", with 1= the poorest , and 6= richest.
  - Scores below a cutoff score of 11 → Level 1
  - Scores between 11 and 22 → Level 2.
  - Scores between 22 and 43 → Level 3

Free schooling Program Benefits

- **Basic education (grades 1-9)**
  - *Sisben* 1 children: 100 percent reduction of complementary service fees
  - *Sisben* 2 and above: no reduction.

- **High school (grades 10-11),**
  - *Sisben* 1 children: elimination of both academic and complementary services fees
  - *Sisben* 2: approximately a 50 percent reduction
  - *Sisben* 3 and above: no reduction

Regression discontinuity analysis

- Where is the discontinuity in the regression?
  - Whether or not students benefit from the program is a discrete function of their score.
- Characteristics of the household (observable and unobservable) are continuously related to the score at the cutoff points
- They are similar for students just above and below the cutoff scores.
- Discrete differences in attendance rates between treated and untreated students close to the cutoff can be attributed to the fee reductions.
  - Students with scores of 21.5 might provide an adequate control group for students with scores of 22.5

Estimation

- The basic equation for the estimation, *close to the discontinuity*, is the following:

$$y_i = \alpha + \beta G_i + f(S_i) + \varepsilon_i$$

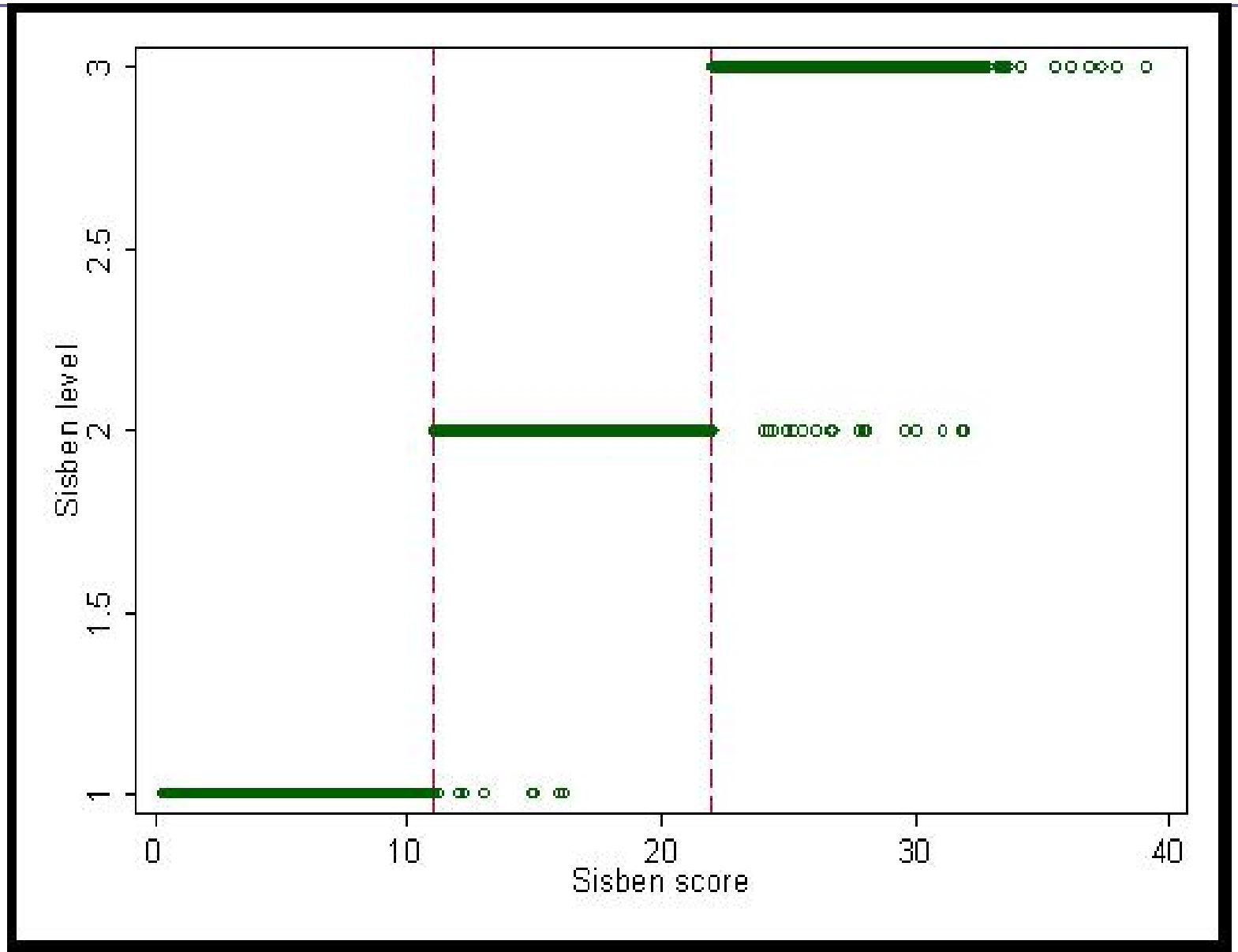
where y is the enrollment variable, G is a dummy that capture the level of *Sisben*, and S is the score of *Sisben*.

- β will consistently estimate the effect of the program.
- It can be estimated within arbitrarily narrow bands close to the cutoff point,

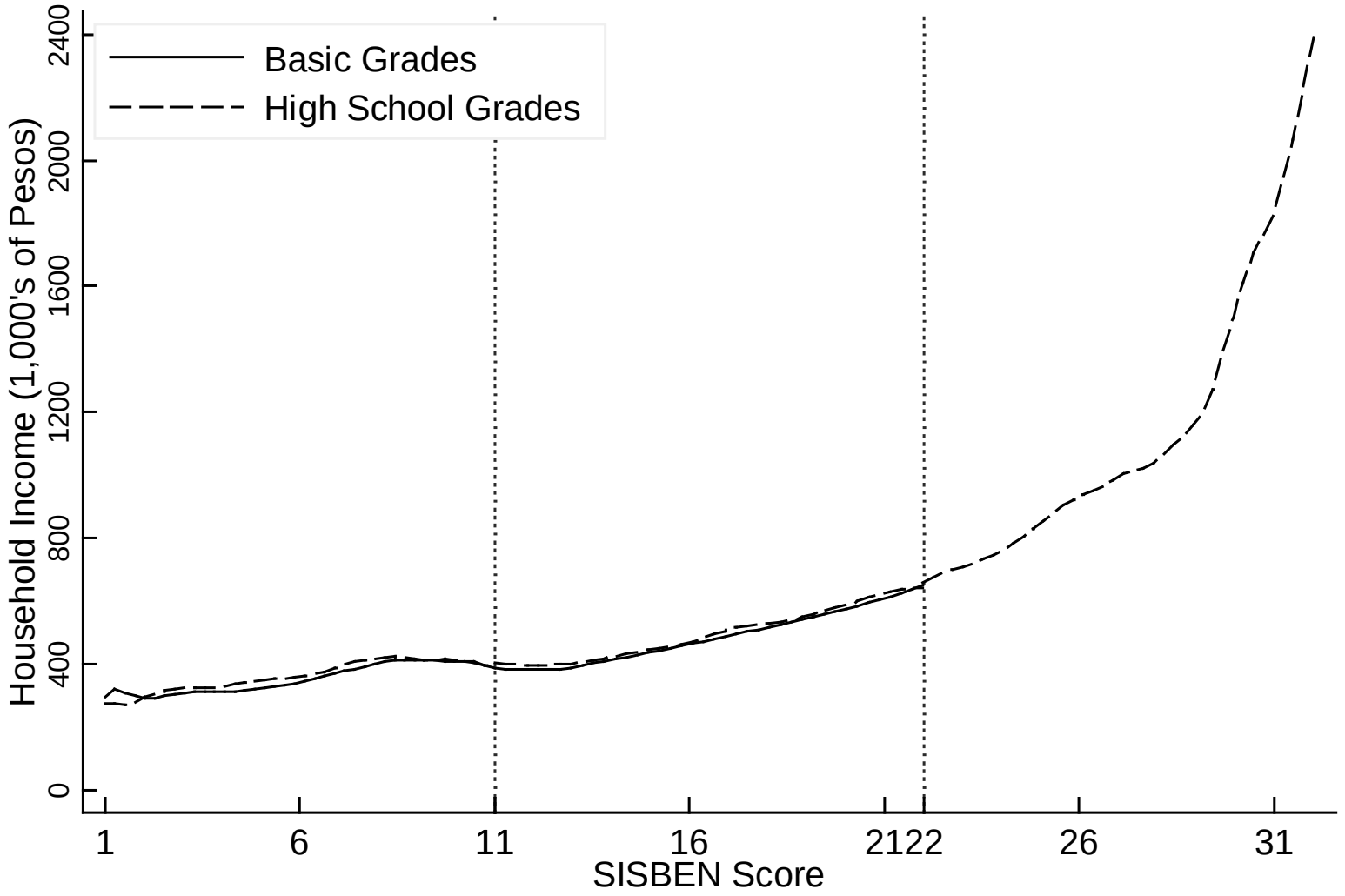
Validation of the RD strategy

- **First:** what are the properties of the assignment variable? Is there a real discontinuity in assignment around the cutoff points of the score?
  - Is students' raw *Sisben* score (0-100) a good predictor of their level of benefits?
  - What is the magnitude of exclusion and inclusion errors?
- **Second:** Are the characteristics of individuals smoothly around the cutoff points of the *Sisben* score?
  - E.g., are the beneficiaries and non-beneficiaries similar around the cutoff points?

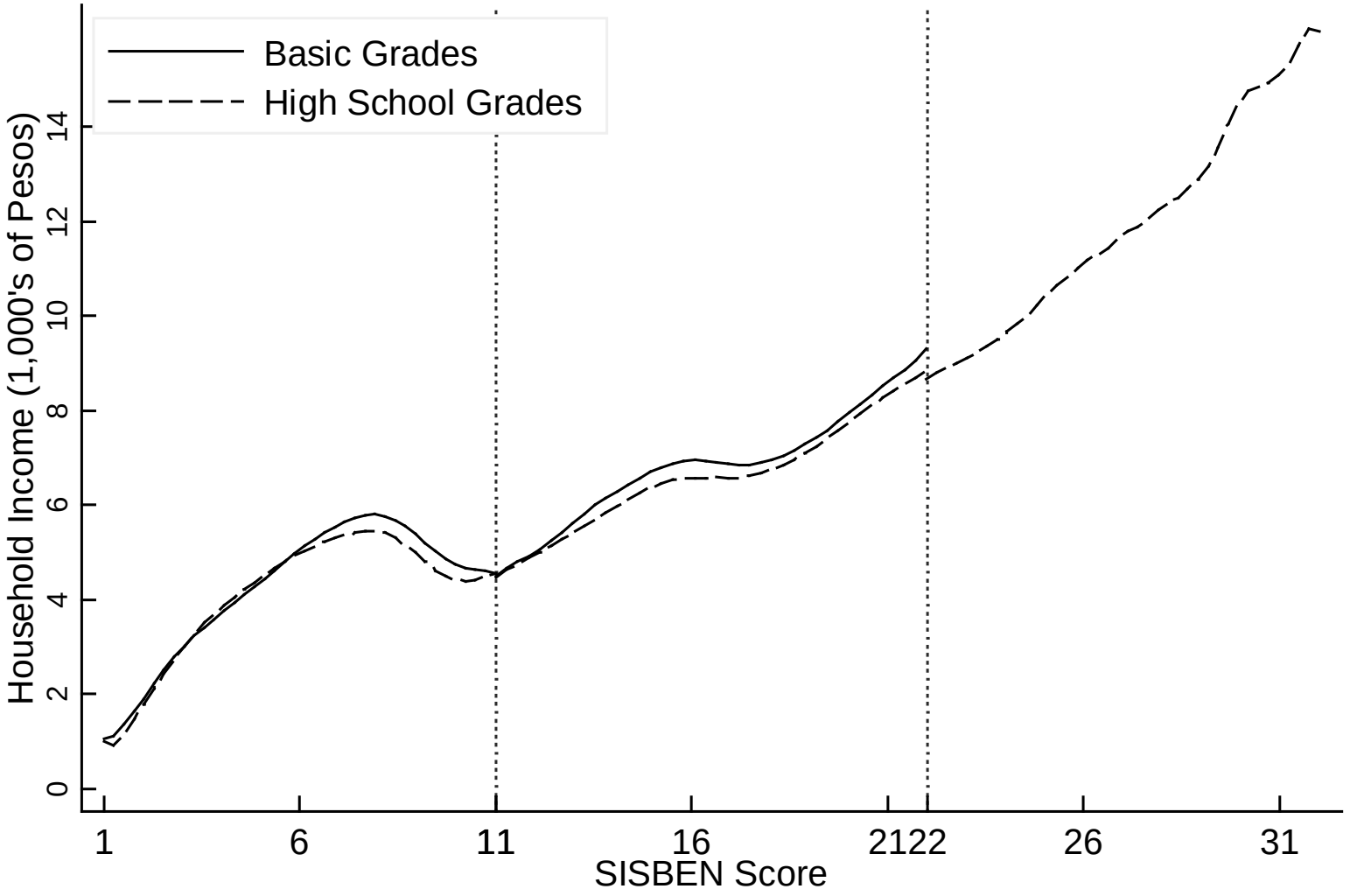
First step validation: *Sisben* score versus benefit level: is the discontinuity sharp around the cutoff points?



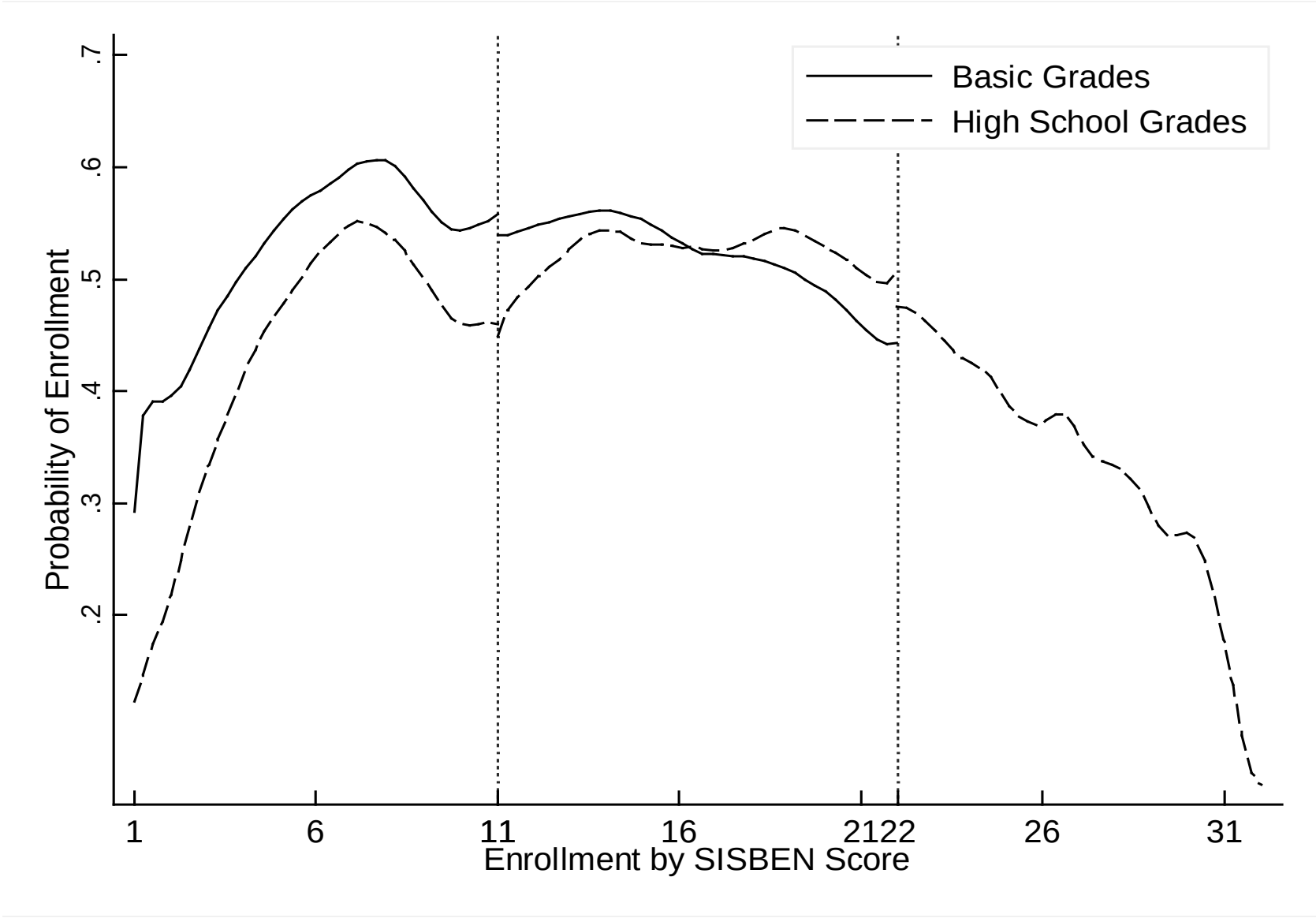
Second Step validation example: Income: Is it smooth around the cutoff points?



Second Step validation example: Years of education of household head : Is it smooth around the cutoff points?



RD Results: *Sisben* vs. school enrollment
Graphic results



References

- Angrist, J. and V. Lavy “Using Maimonodes Rule to Estimate the Effect of Class Size on Scholastic Achievement” *Quarterly Journal of Economics*, 114, 533-575
- Lemieux, T. and K. Milligan “Inentive Effects of Social Assistance: A Regression Discontinuity Approach”. NBER working paper 10541.
- Hahn, J., P. Todd, W. Van der Klaauw. “Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design”. Econometrica, Vol 69, 201-209.
- Barrera, Linden y Urquiola (2006), “The Effects of User Fee Reductions on Enrollment: Evidence from a quasi-experiment”