



THE WORLD BANK



# **Technical Track**

## **Session V**

# **Regression Discontinuity (RD)**

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# Reminder: main objective of an evaluation.....

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- 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

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- 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

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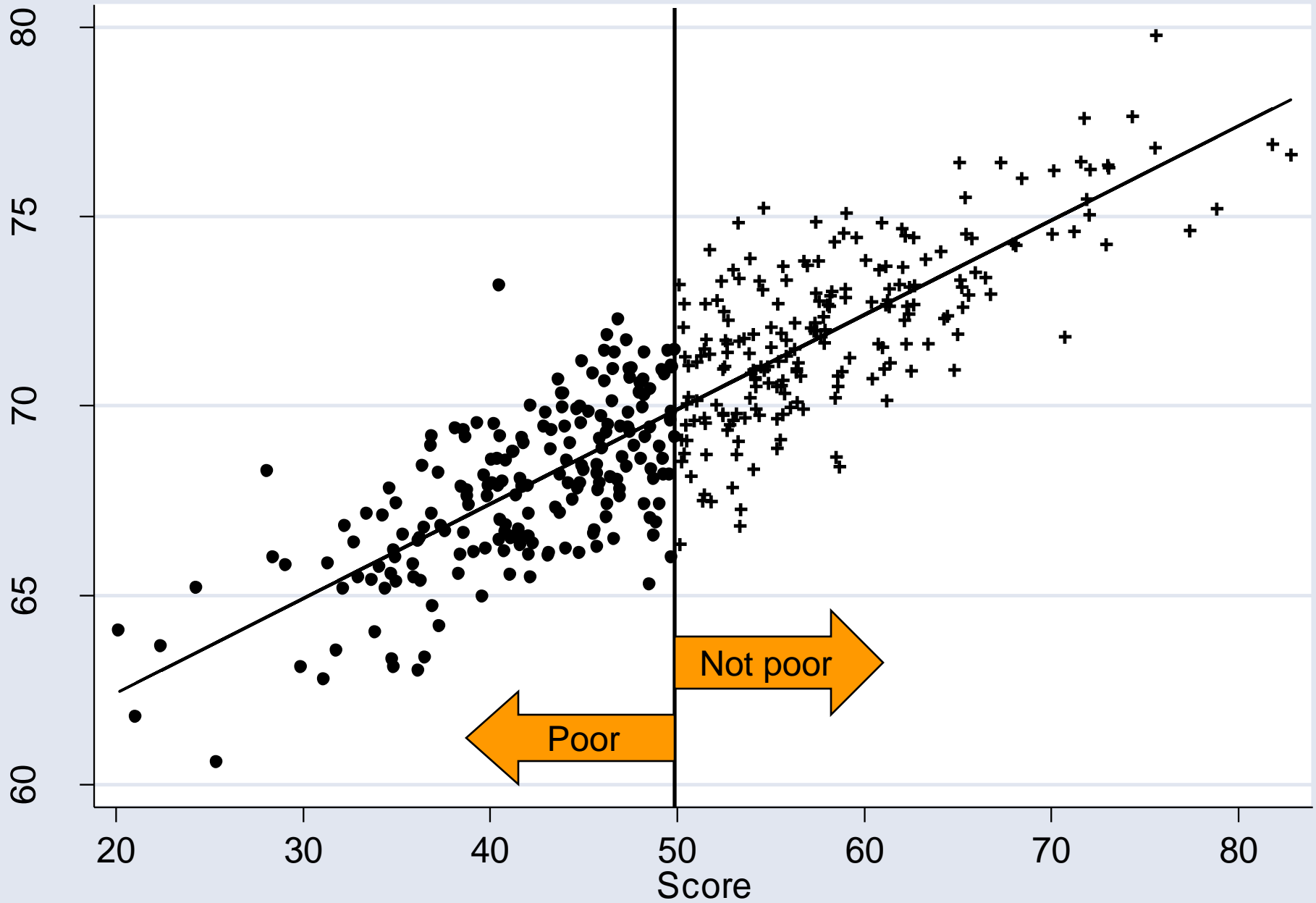
- When to use this method?
  - The beneficiaries/non-beneficiaries can be ordered along a quantifiable dimension.
  - This dimension can be used to compute a well-defined index or parameter.
  - The index/parameter has a cut-off point for eligibility.
  - The index value is what drives the assignment 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

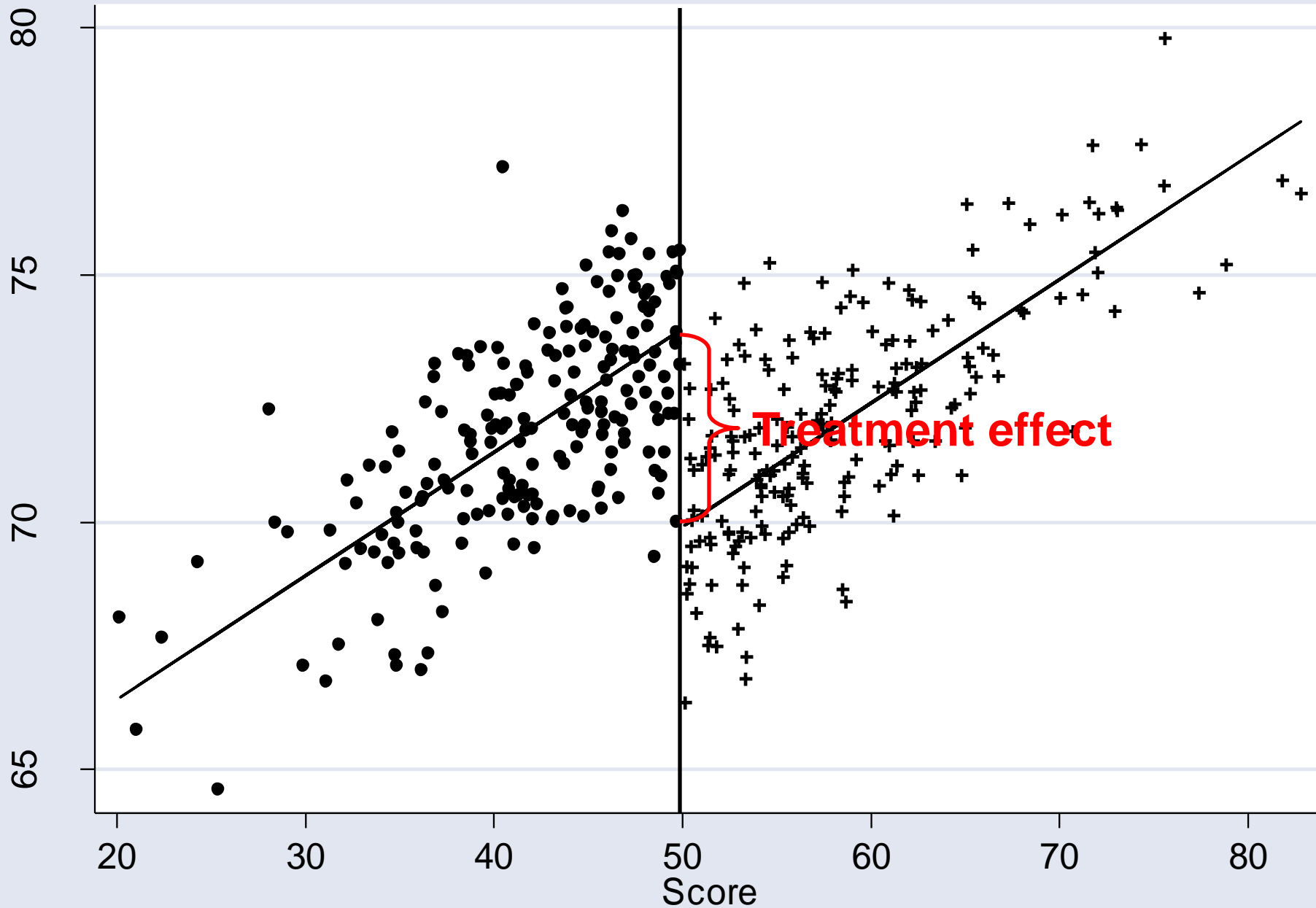
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- **Goal:** Target transfer to poorest households
- **Method:**
  - Construct poverty index from 1 to 100 with pre-intervention characteristics
  - Households with a score  $\leq 50$  are poor
  - Households with a score  $> 50$  are non-poor
- **Implementation:**
  - 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



# Regression Discontinuity Design - Post Intervention



# Sharp and Fuzzy Discontinuity

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## □ 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

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$$y_i = \beta_0 + \beta_1 D_i + \delta(\text{score}_i) + \varepsilon_i$$

$D_i = 1$  if household  $i$  receives transfer

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

$\delta(\text{score}_i)$  is a function that is continuous around the cut-off point

Assignment rule under sharp discontinuity:

$$D_i = 1 \Leftrightarrow \text{score}_i \leq 50$$

$$D_i = 0 \Leftrightarrow \text{score}_i > 50$$

# Identification for fuzzy discontinuity

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$$y_i = \beta_0 + \beta_1 D_i + \delta(\text{score}_i) + \varepsilon_i$$

Where:

$D_i = 1$  if household receives transfer

$D_i = 0$  if household doesn't receive the transfer

**BUT:**

Treatment depends on - whether  $\text{score}_i > < 50$

**AND** - endogenous factors

# Identification for fuzzy discontinuity

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$$y_i = \beta_0 + \beta_1 D_i + \delta(\text{score}_i) + \varepsilon_i$$

IV estimation:

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

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

# Examples

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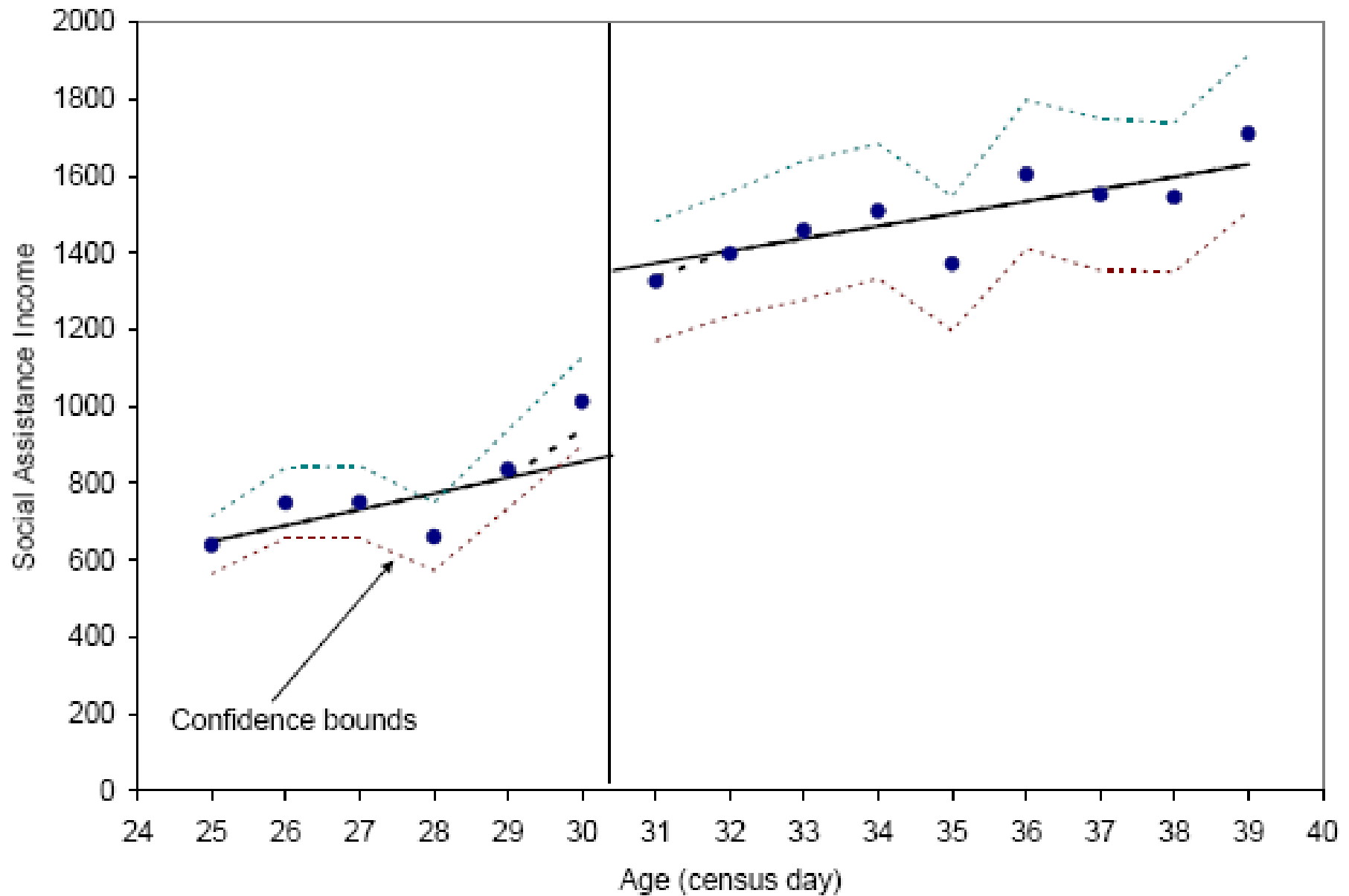
- ❑ Effect of transfers on labor supply  
(Lemieux and Milligan, 2005)
- ❑ Effect of old age pensions on consumption -  
BONOSOL in Bolivia  
(Martinez, 2005)
- ❑ The Effects of User Fee Reductions on School  
Enrollment  
(Barrera, Linden and Urquiola, 2006)

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

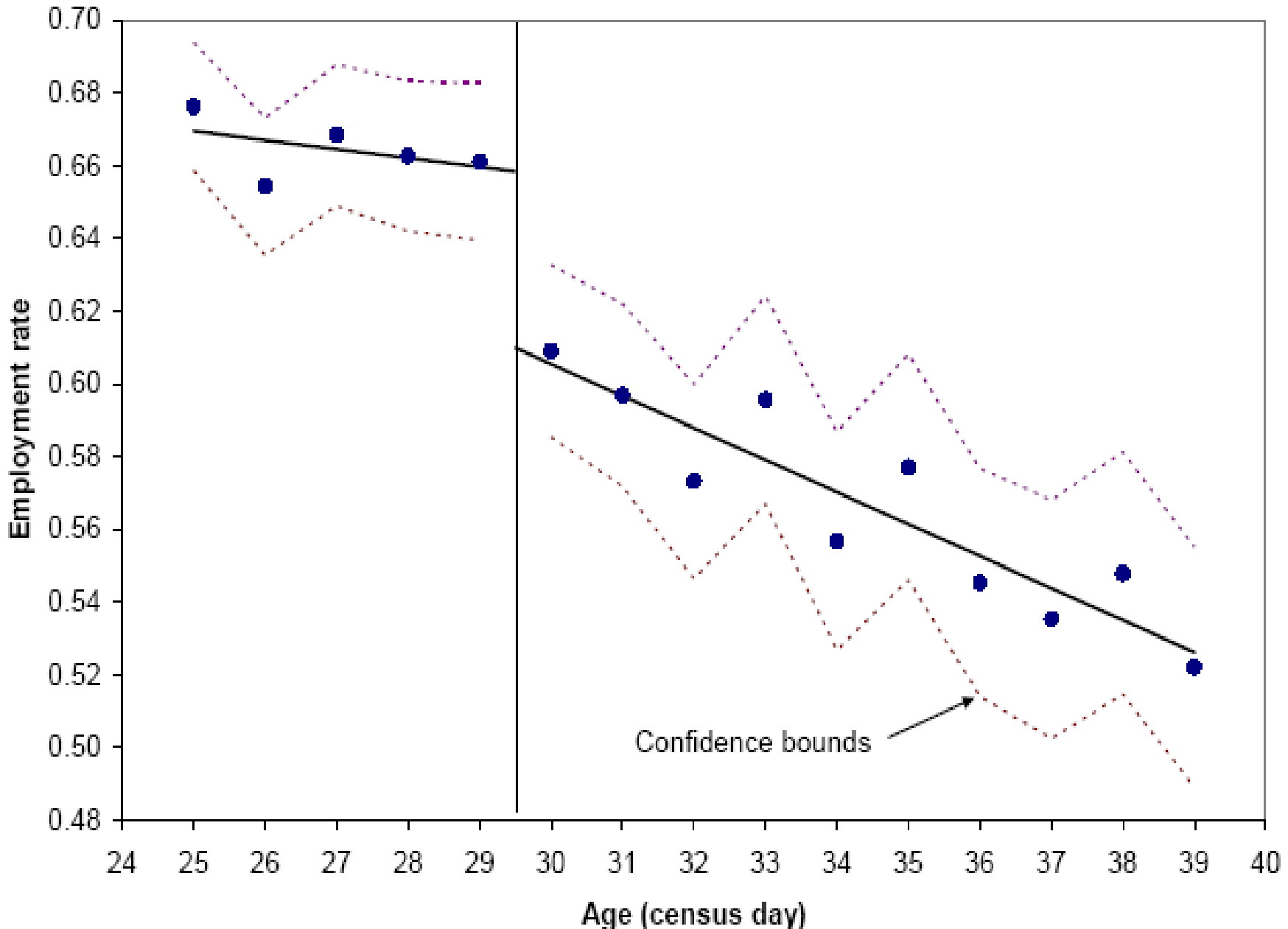
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- Social assistance to the unemployed:
  - Low social assistance payments to individuals under 30
  - Higher payments for individuals 30 and over
  
- What is the effect of increased social assistance on employment?

**Figure 6: Social Assistance Income, Quebec 1986**



**Figure 3: Employment Rate in Census Week, Quebec 1986**

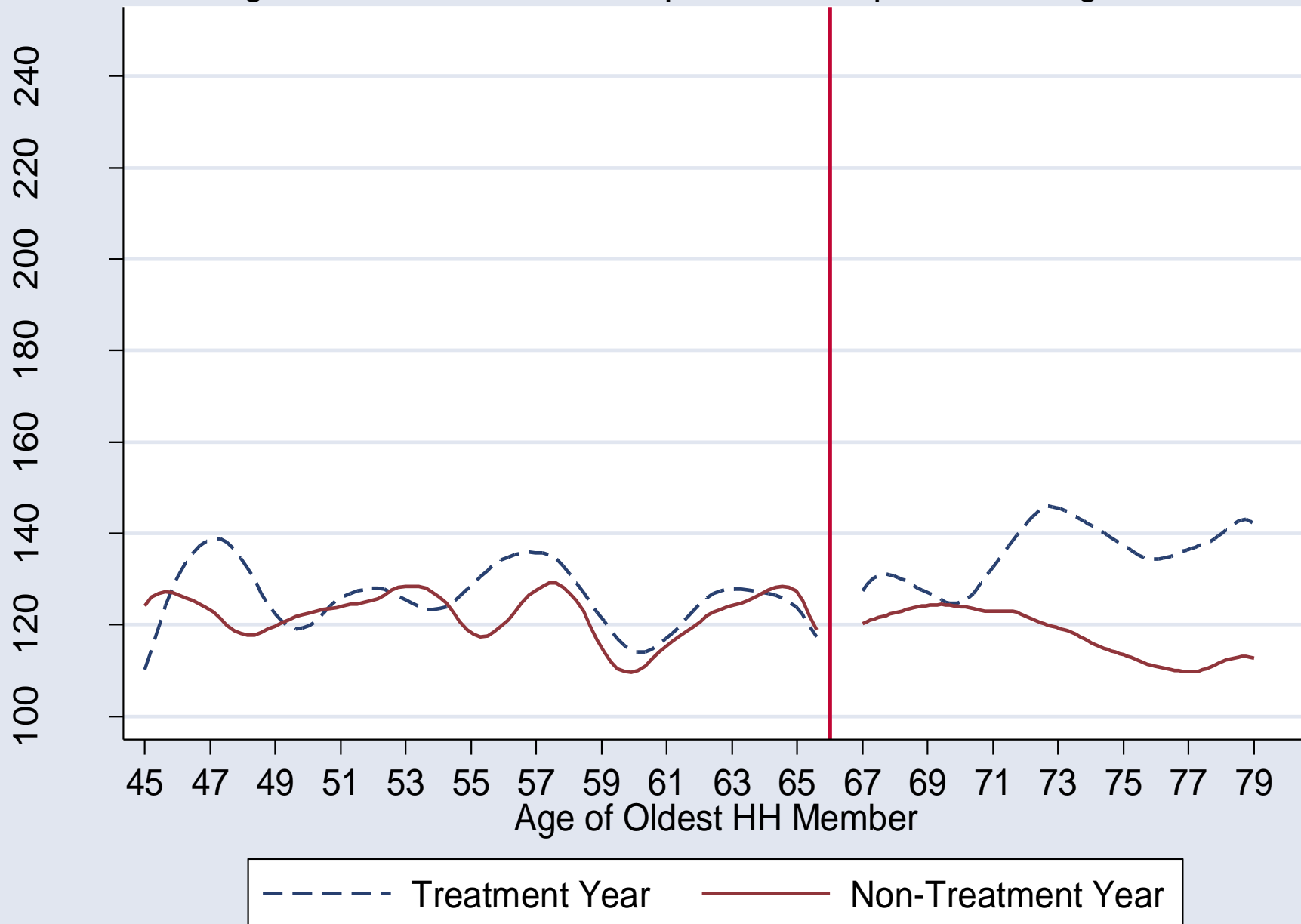


# Example 2: Martinez: BONOSOL

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- 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

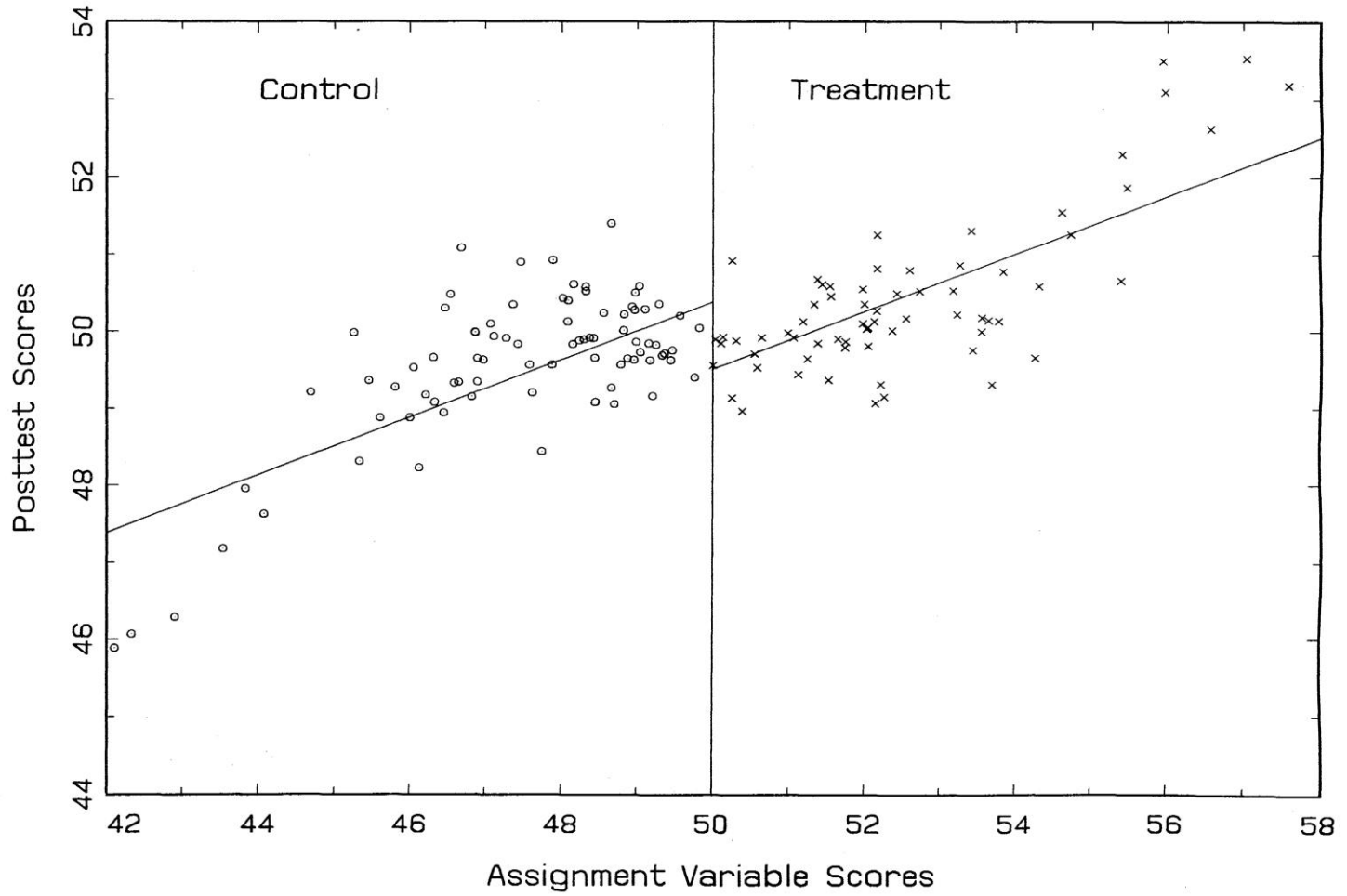


# Potential Disadvantages of RD

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- 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



7.5 7-9

# Advantages of RD for Evaluation

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- 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

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- **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

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- 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*?

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- ❑ *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

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## □ **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

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- 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

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- 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*.

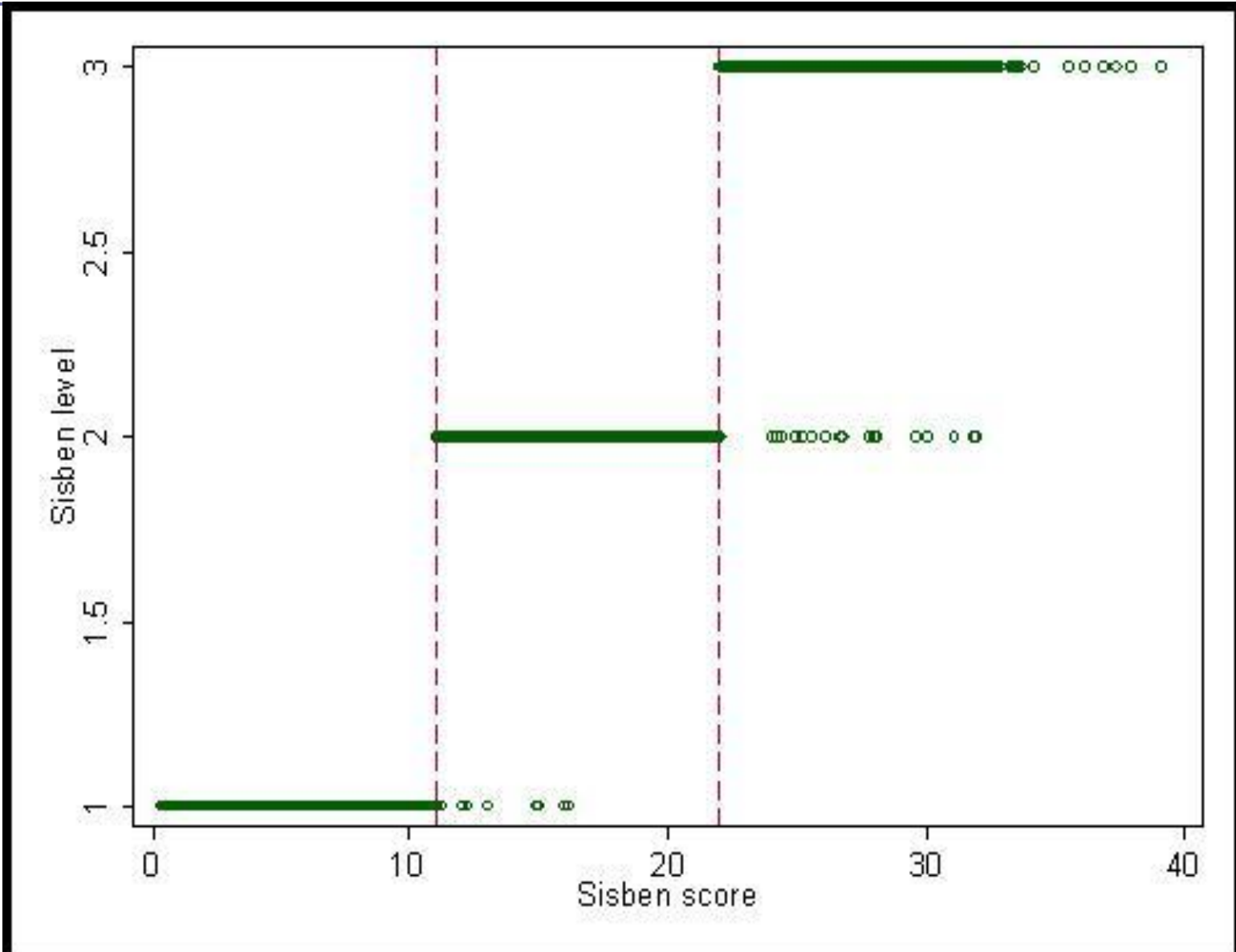
- $\beta$  will consistently estimate the effect of the program.
- It can be estimated within arbitrarily narrow bands close to the cutoff point,

# Validation of the RD strategy

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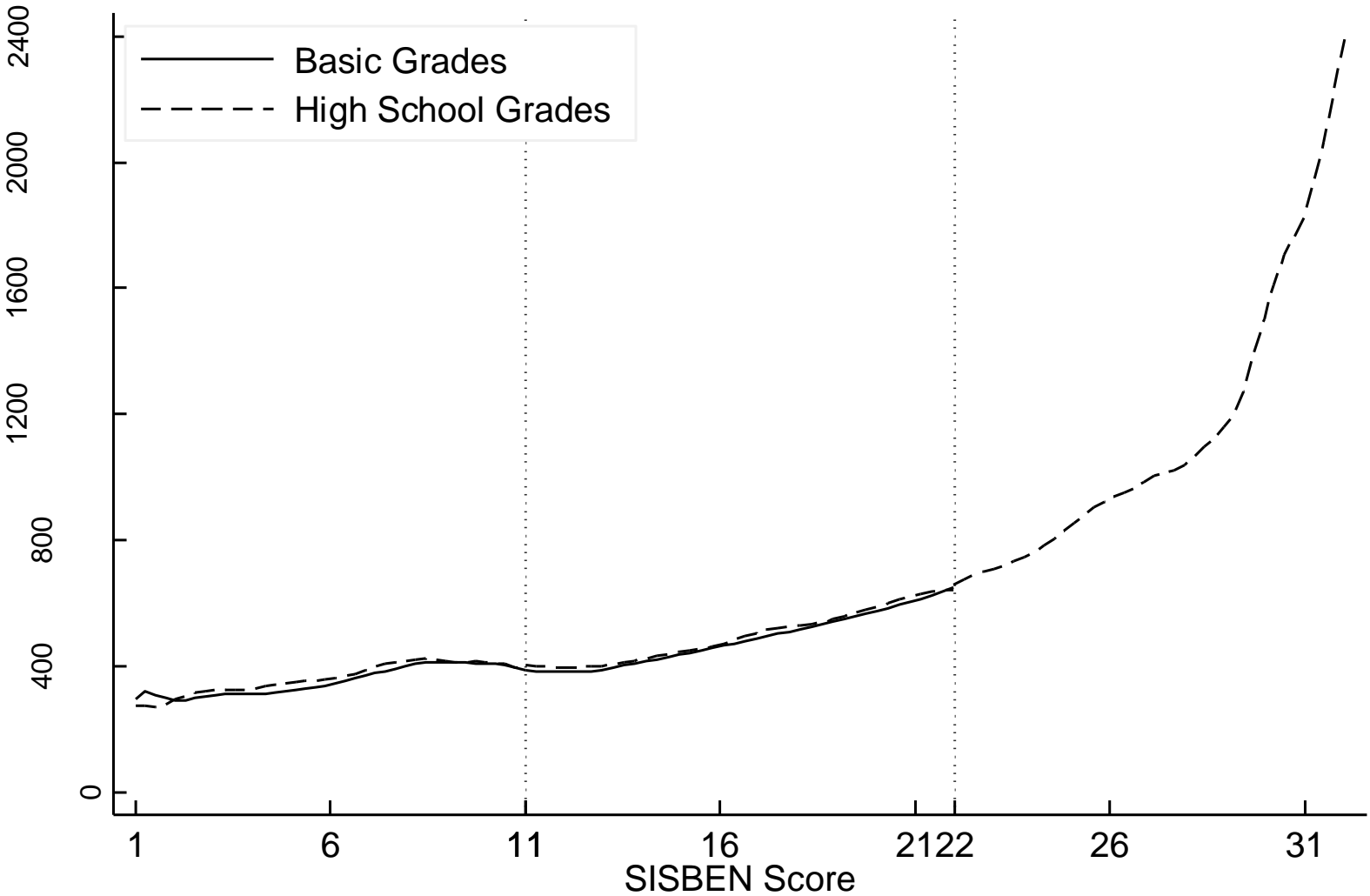
- **First:** what are the properties of the assignment variable?  
Is there a real discontinuity in assignment around the cutoff points of the score?
  - Is students' raw *Sisben* score (0-100) a good predictor of their level of benefits?
  - What is the magnitude of exclusion and inclusion errors?
  
- **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?

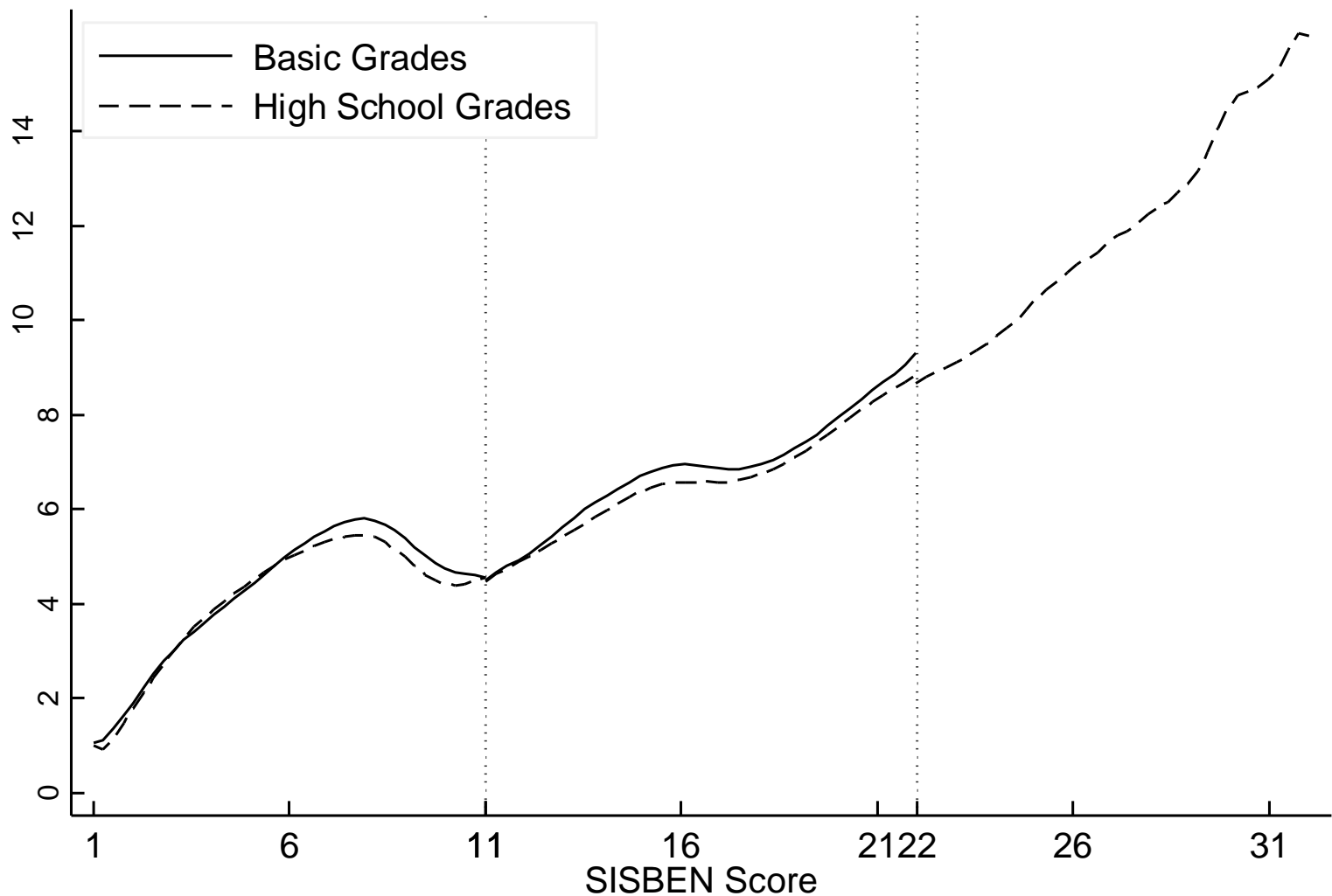


# Second Step validation example: Income:

## Is it smooth around the cutoff points?

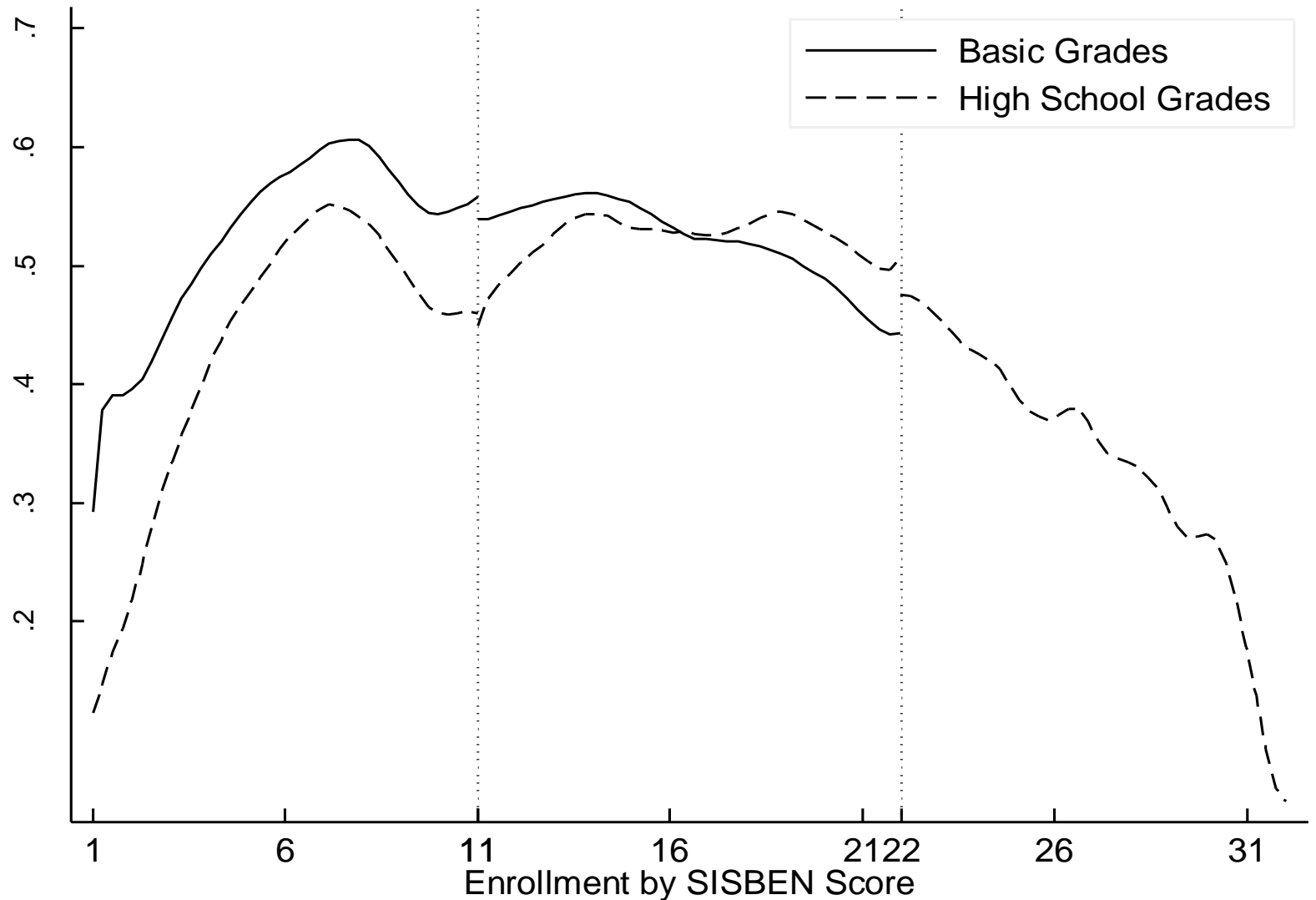


# Second Step validation example: Years of education of household head : Is it smooth around the cutoff points?



# RD Results: *Sisben* vs. school enrollment

## Graphic results



# References

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- ❑ 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”