Technical Track
Session V
Regression Discontinuity (RD)

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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 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

- **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

Outcome vs Score plot with a discontinuity at 50. Points representing 'Not poor' and 'Poor' categories are shown.
Regression Discontinuity Design - Post Intervention

Outcome vs. Score plot with a discontinuity highlighting the 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:
\( D_i = 1 \iff score_i \leq 50 \)
\( D_i = 0 \iff score_i > 50 \)
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 \( score_i > < 50 \)
- endogenous factors
Identification for fuzzy discontinuity

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

**IV estimation:**

**First stage:** \[ D_i = \gamma_0 + \gamma_1 I(\text{score}_i > 50) + \eta_i \]

**Second stage:** \[ y_i = \beta_0 + \beta_1 D_i + \delta(\text{score}_i) + \varepsilon_i \]
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

Confidence bounds

Social Assistance Income vs. Age (census day)
Figure 3: Employment Rate in Census Week, Quebec 1986

Confidence bounds
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
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
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
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

- **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