# Regression Discontinuity: A Causal Modeling Approach to Non-randomized Interventions

**Ryan Johnson, Ph.D.**
**Principal Research Analyst**
**University of California, Riverside**

LMU | LA
Loyola Marymount University

# Agenda

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  - Useful references for the Regression Discontinuity (RD) method
  - Conceptual fundamentals of RD
  - Comparison of RD vs. other common quasi-experimental methods
  - Description of steps involved in RD
  - 10-15-minute break
  - Guided data analysis activity
- After the conference, I will e-mail you the slides, Stata scripts, log files, and graphs

# History

- RD approach first proposed by Thistlethwaite & Campbell (1960)
- RD only became notably popular the last two decades
- For a detailed academic review of RD and list of published economic studies using the method, see Lee and Lemieux (2010)
- For a more practical review of RD, see William Trochim's demonstration at: http://www.socialresearchmethods.net/kb/quasird.php

# Useful References

Hahn, J., Todd, P., & van der Klaauw, W. (2001). Identification and estimation of treatment effects with a regression-discontinuity design. *Econometrica, 69*(1), 201–209.

Lee, D.S. & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature*, *48*(June 2010), 281-355.

Thistlethwaite, D. L., & Campbell, D. T. (1960). Regression-discontinuity analysis: An alternative to the ex post facto experiment. *Journal of Educational Psychology, 51*(6), 309–317.

Trochim, W. (1984). *Research design for program evaluation: The regression-discontinuity approach*. Beverly Hills: Sage.

# Random Assignment Method

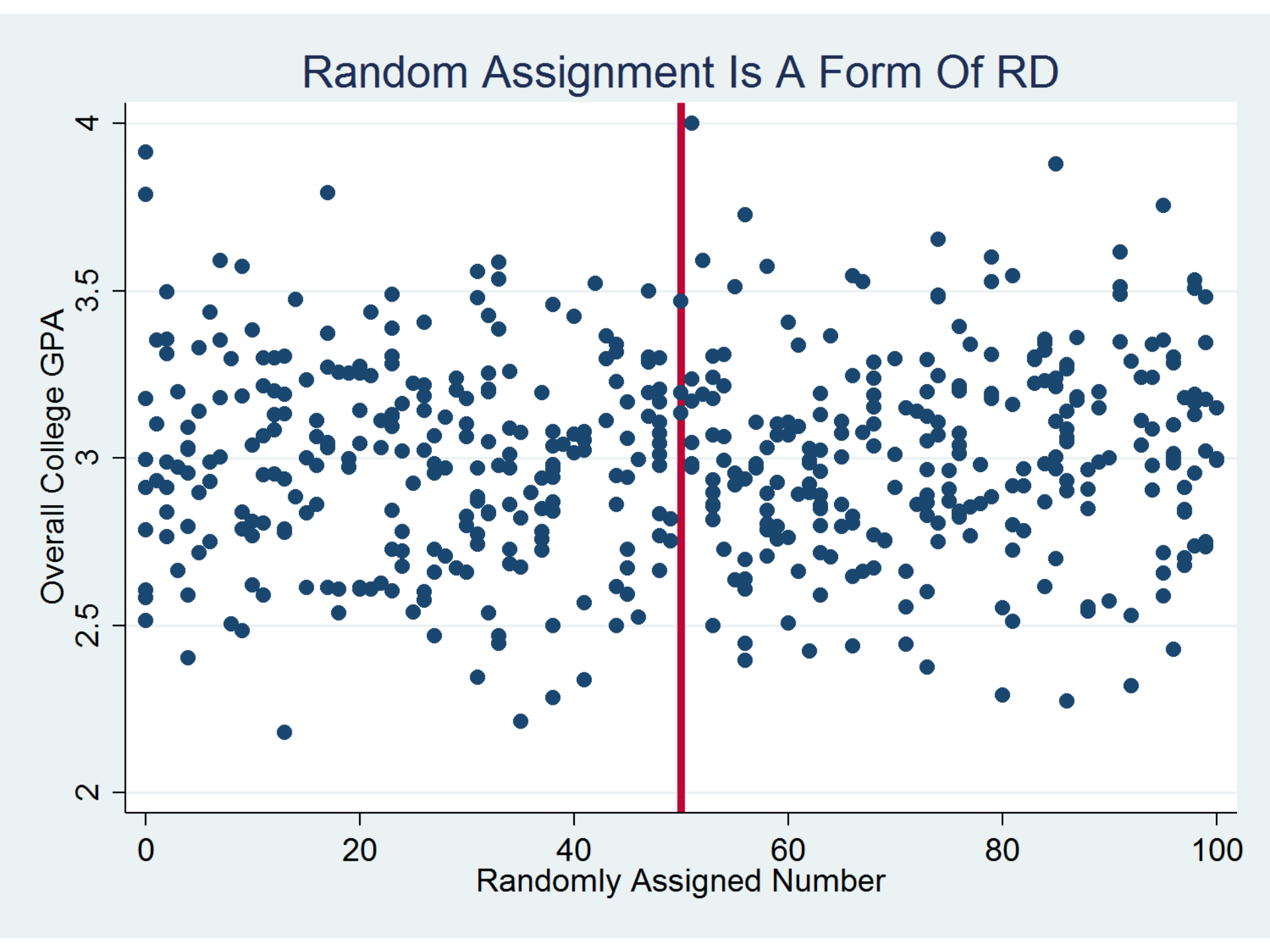
- The gold standard for internal validity
- When using a method that is inherently random (e.g., coin flip) to assign members of a sample into groups, those groups will be equal on all possible characteristics
- If a treatment is applied to one group, any post-treatment differences must have been caused by the treatment or something related to that treatment

# Non-randomized Methods

- Necessary because randomization is often not ethical or even desirable in higher education research
- Goal
  - Without random assignment, determine if a manipulation caused a change in some outcome
- Example non-randomized methods
  - RD
  - Multiple Regression/Matching on Observables
  - Instrumental Variables
- Of the methods above, only RD is comparable in internal validity to true random assignment

# Underlying Premise of RD

- Random assignment still works regardless of the degree of sample heterogeneity, assuming sufficient sample size
- Those close to each side of an arbitrary cutoff are functionally randomly assigned to their side
- Body weight example
  - 150.0000000 lbs vs. 150.0000001 lbs
  - Imprecise measurement
    - Scales are not perfect (e.g., +/- 1 lb)
  - Individual variation
    - Countless random variables affect true scores (e.g., how recently last meal was eaten)


Random Assignment Is A Form Of RD
Overall College GPA
2
2.5
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3.5
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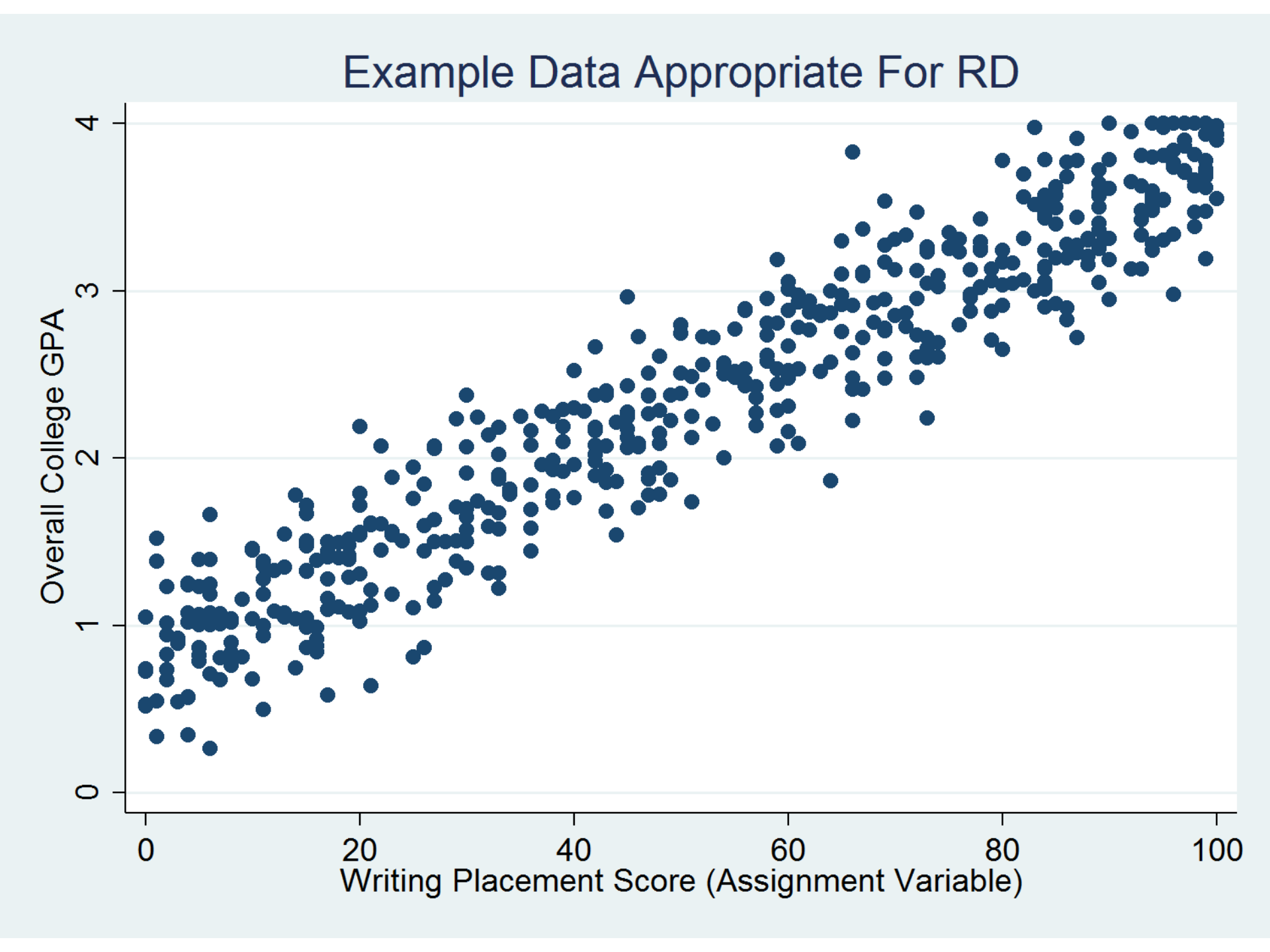
60
80
100
Randomly Assigned Number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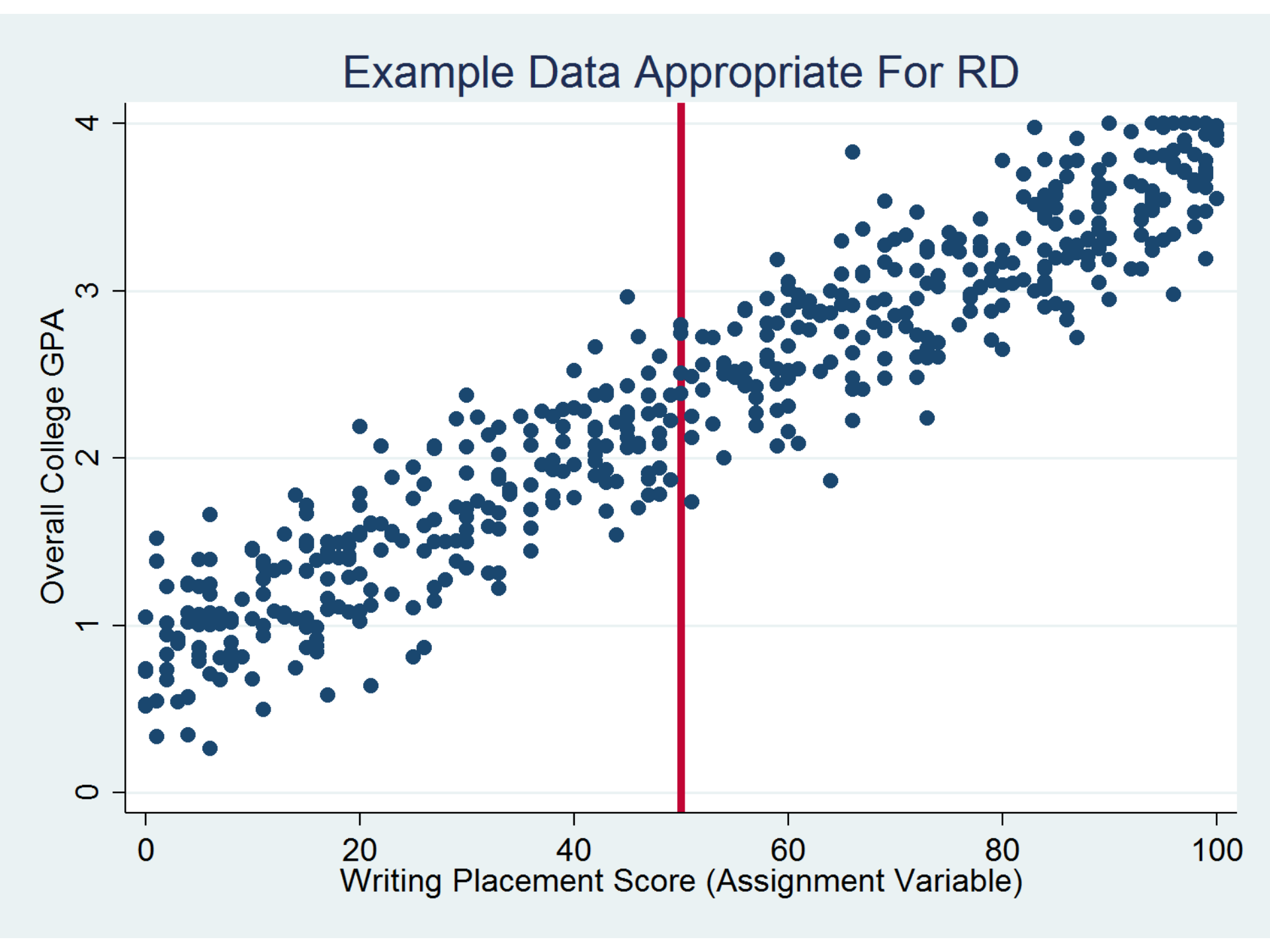
Writing Placement Score (Assignment Variable)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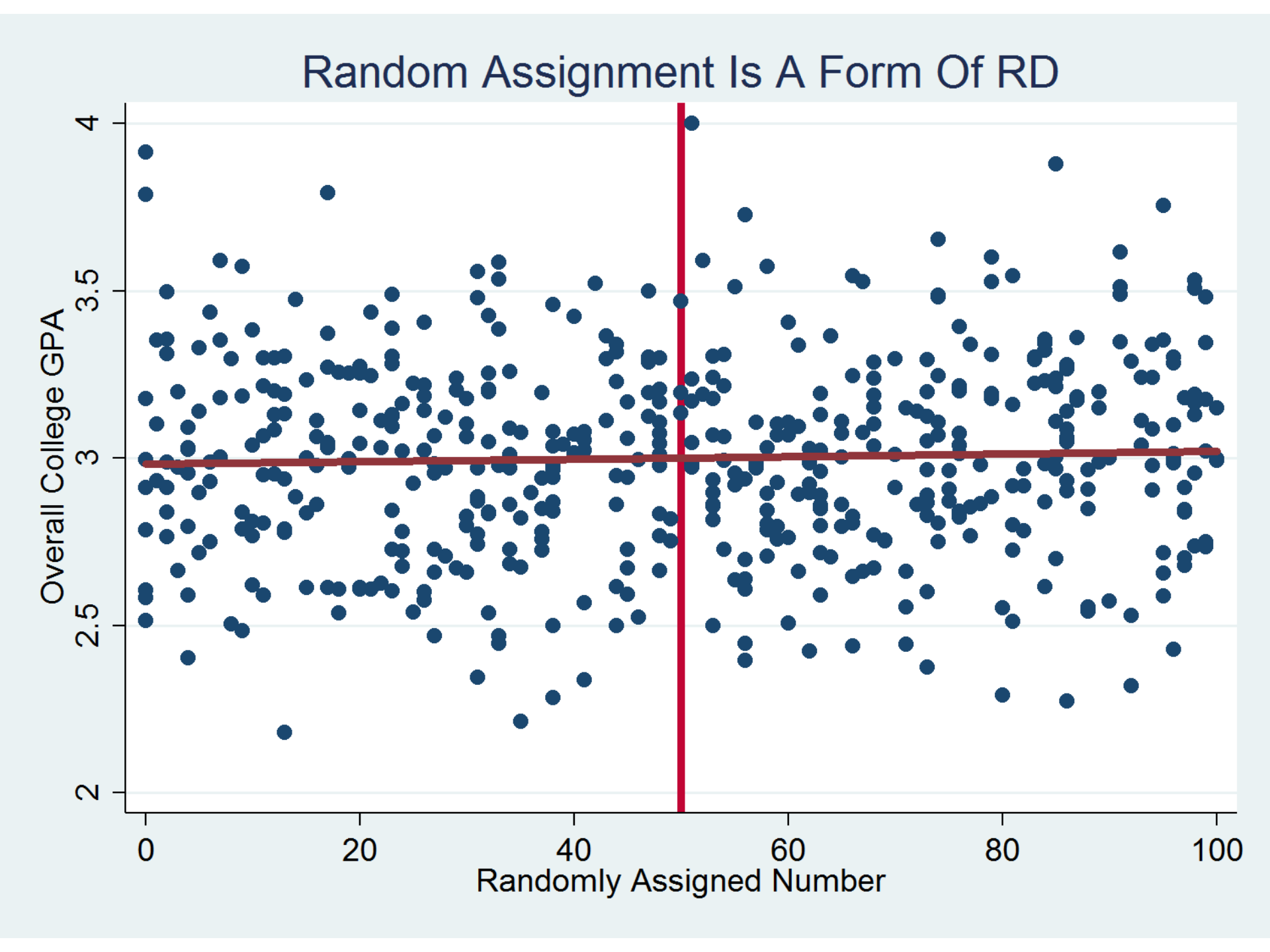
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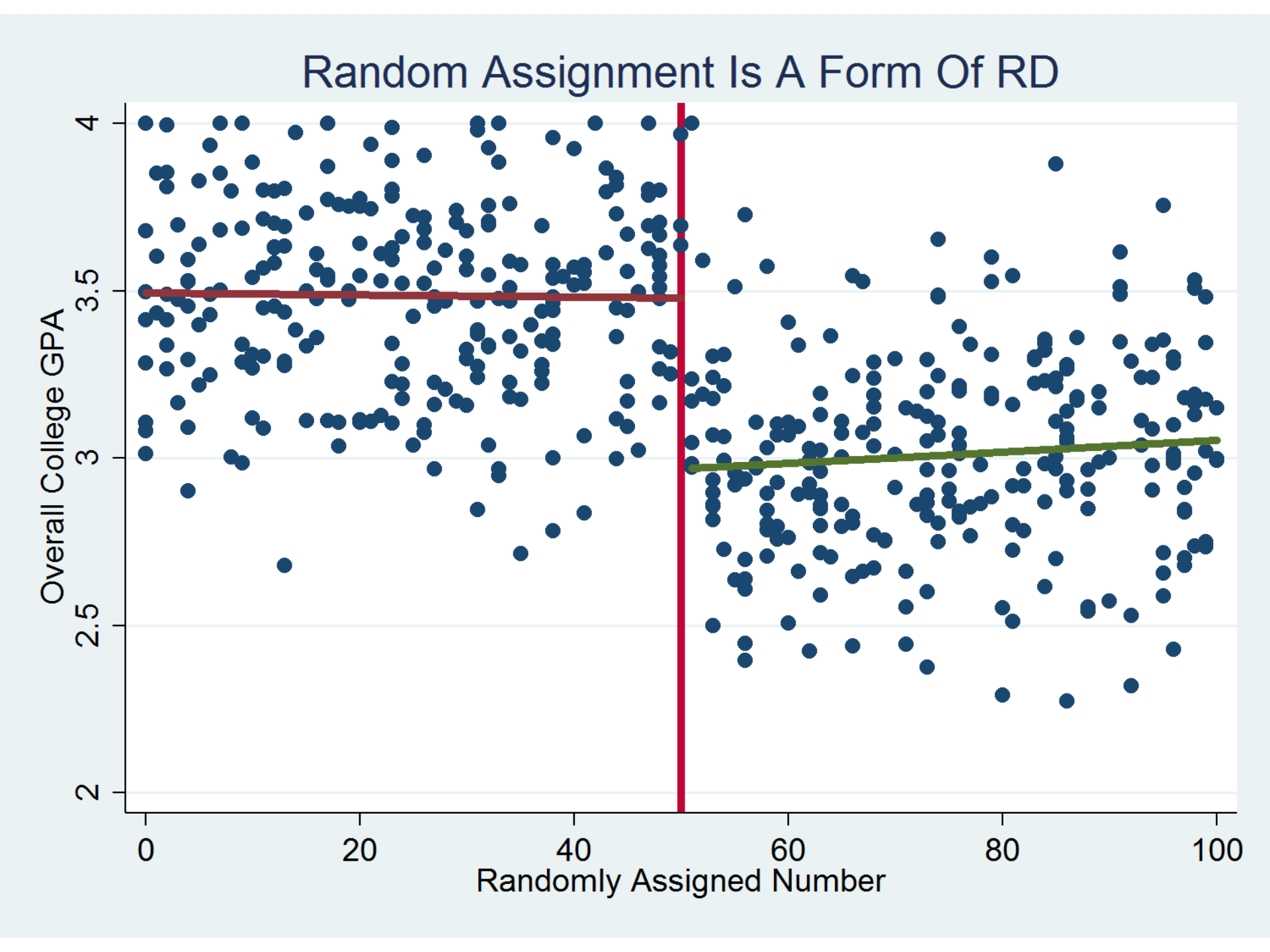
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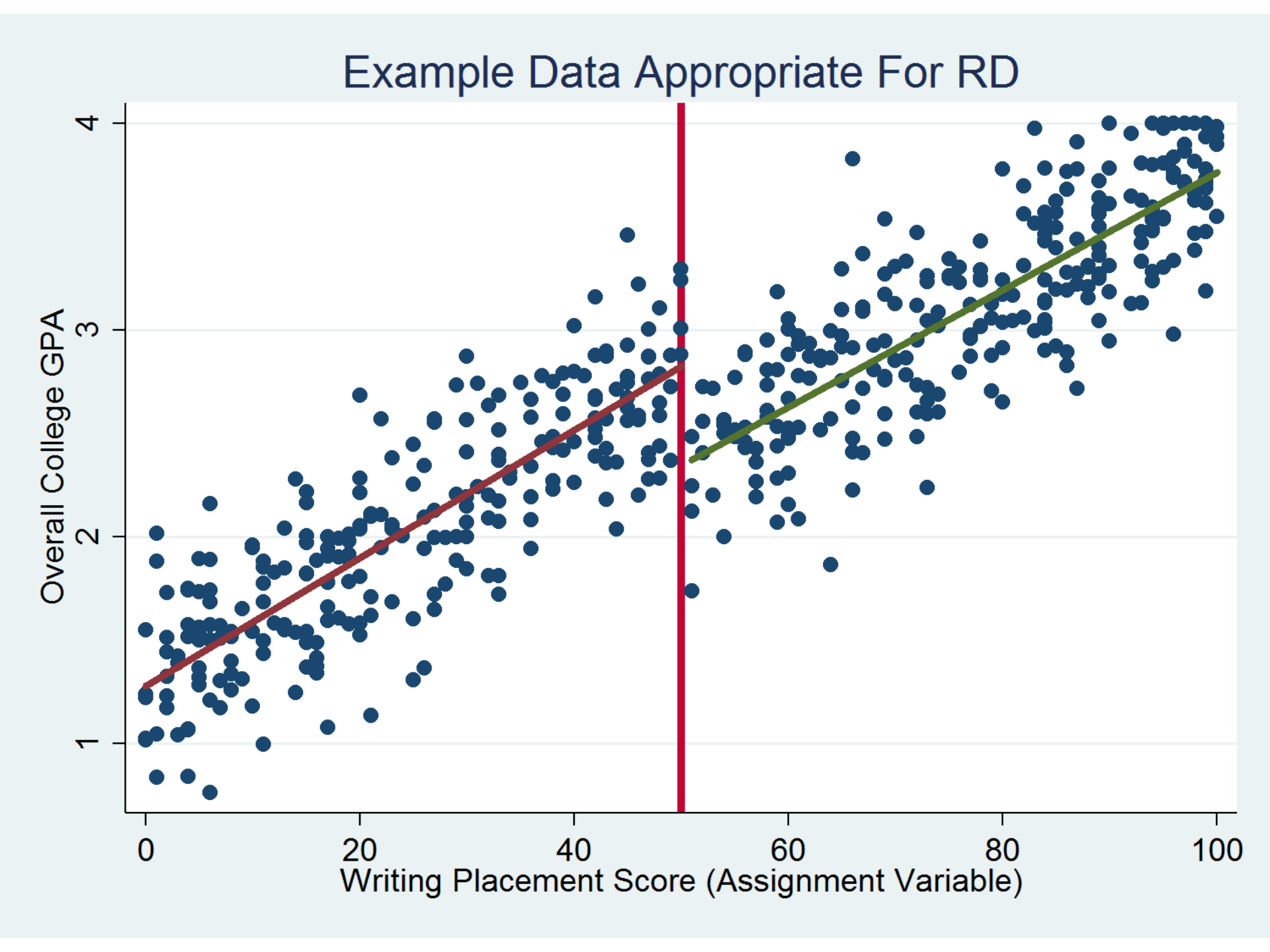
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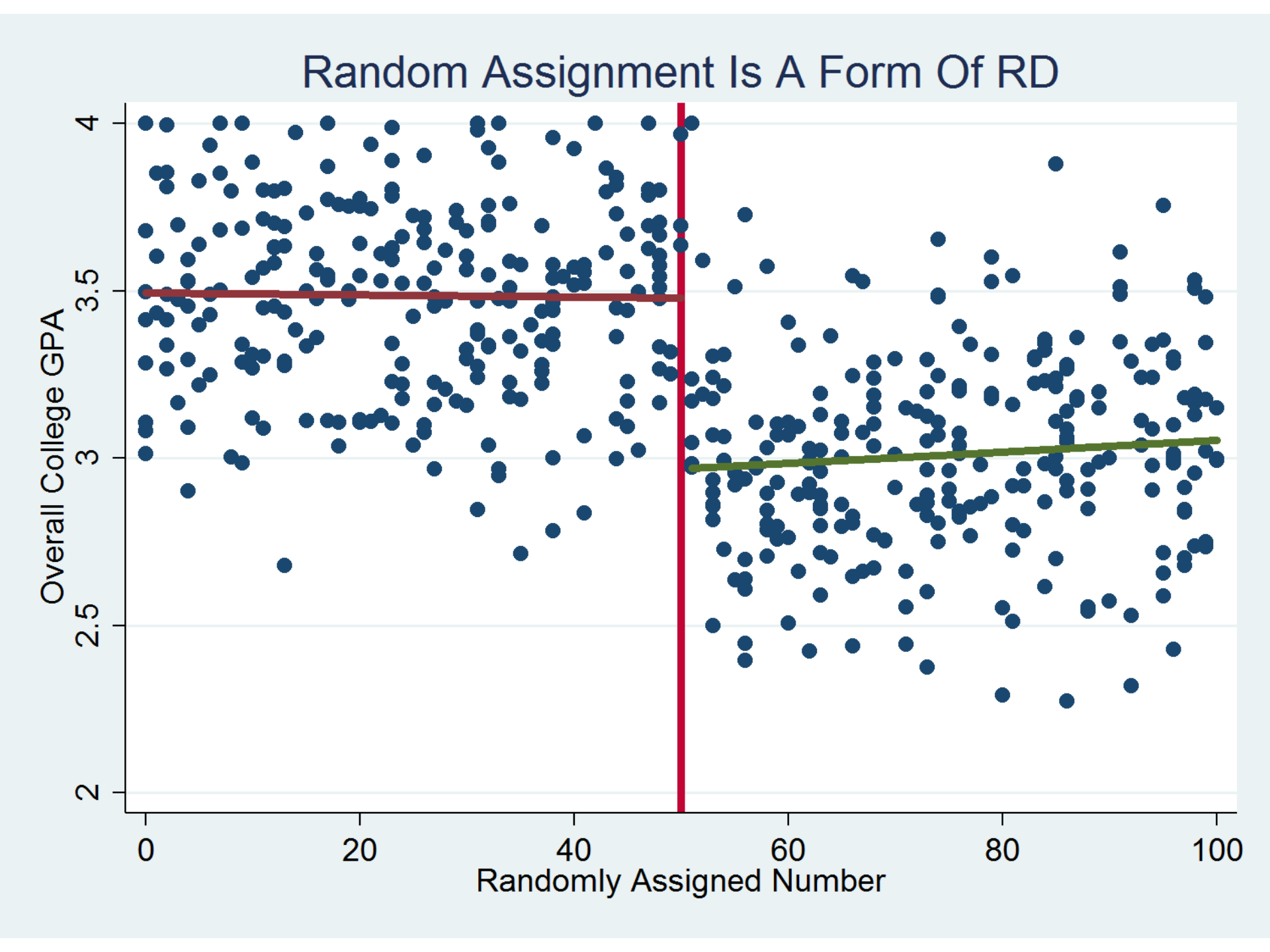
# Interpretation of RD Effect at Cutoff

- A model that compares two regression lines at the cutoff does not compare two groups of actual people (or units) close to the line on either side….
- It compares the trends of the entire treatment and control groups for **predicted** people who are literally equal on the assignment variable and only ended up as treated or control due to randomness
- This is an important distinction, because it highlights why large samples directly on top of the cutoff are not necessary to draw valid conclusions

# Interpretation of RD Effect at Cutoff

- The effect at the cutoff is a weighted average effect for the entire sample
  - The average is weighted on the probability that each individual is close to the cutoff
  - The more random the assignment variable, the more generalizable the effect at the cutoff
- Although RD has internal validity equivalent to random assignment, the weighted average effect issue gives RD potentially lower external validity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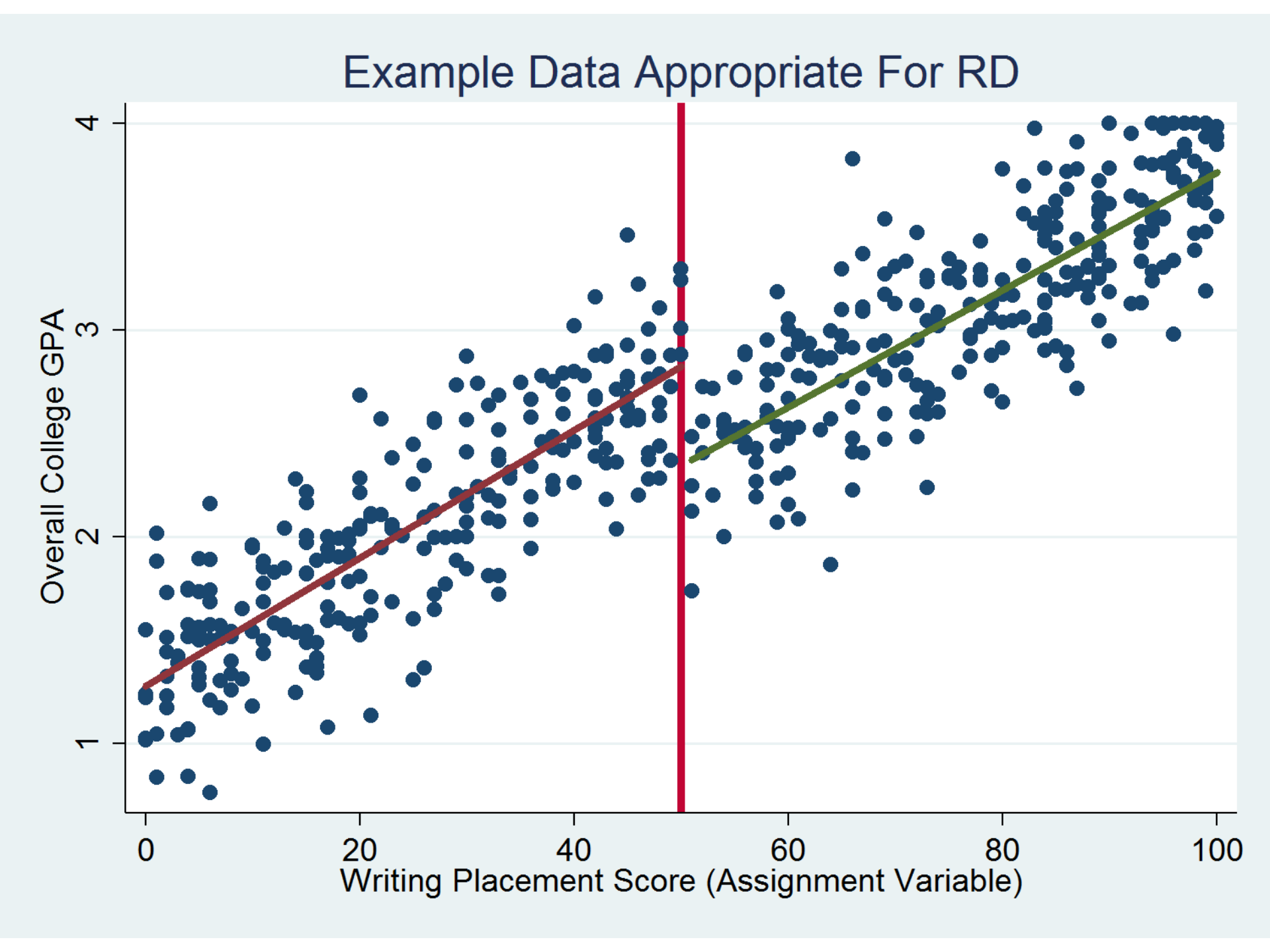
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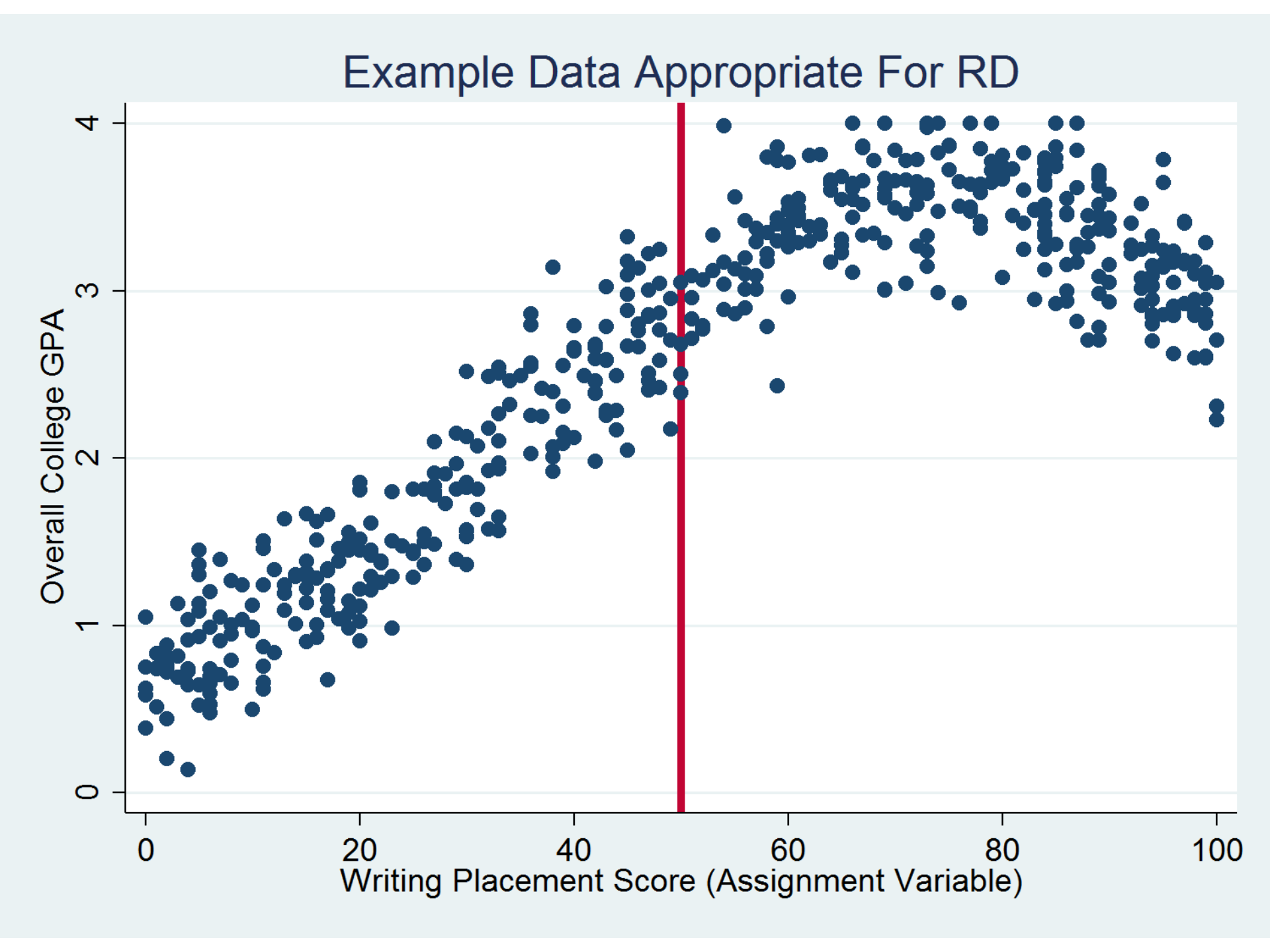
# Necessary Conditions for Basic RD

- Treatment group must be assigned based on a specific cutoff in a previously measured continuous variable (the "assignment variable")
  - No exceptions for those above or below the cutoff to switch groups after the assignment variable is measured
  - It must be impossible for the people in the study to **precisely** manipulate the assignment variable in an attempt to gain (or avoid) treatment
- The cutoff for the assignment variable must be "arbitrary" (i.e., no natural gaps at the cutoff)

# Necessary Conditions for Basic RD

- Data distribution must be able to be described as a polynomial function.
- Intervention must be uniformly delivered
- Model must be correctly specified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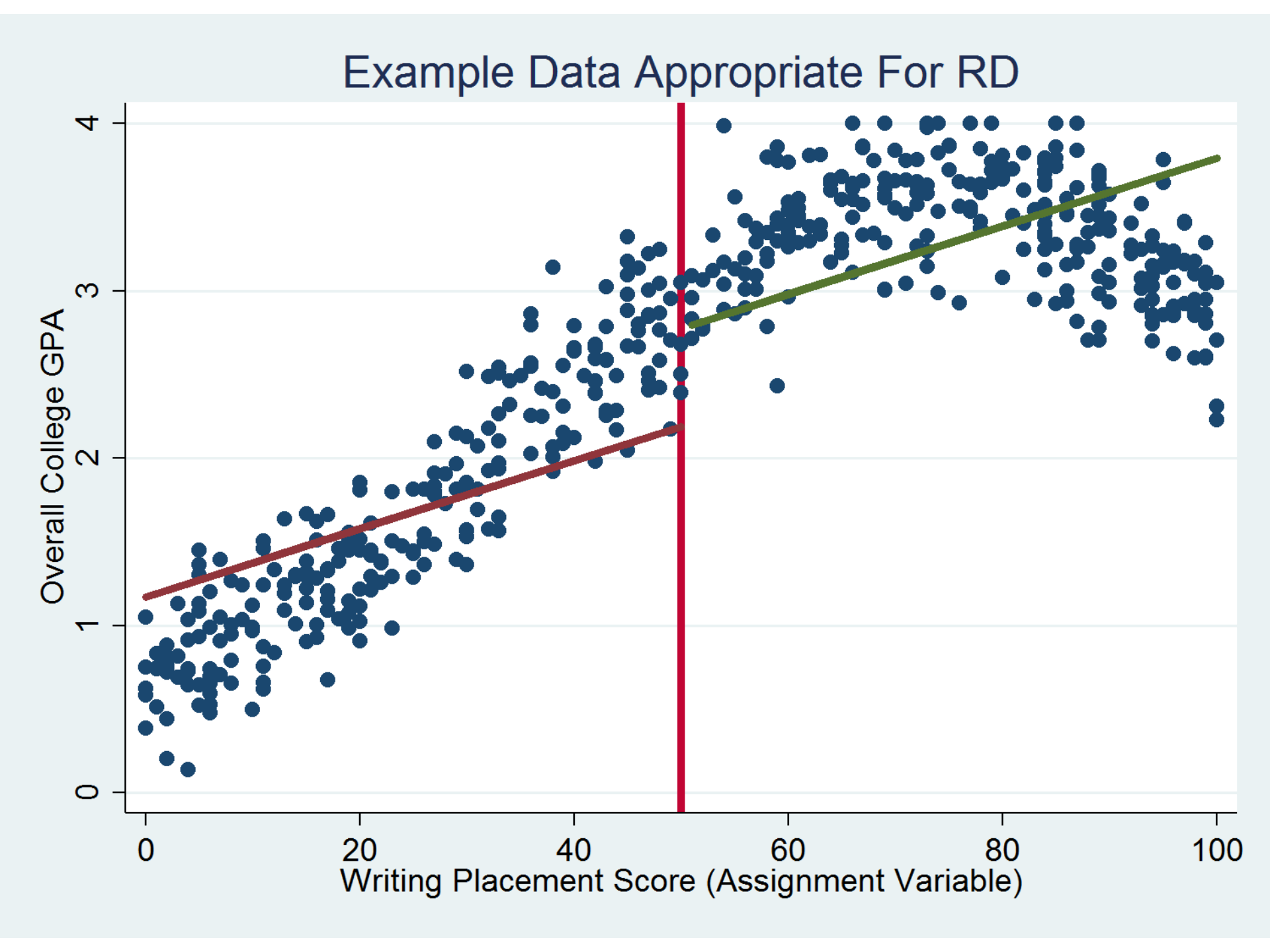
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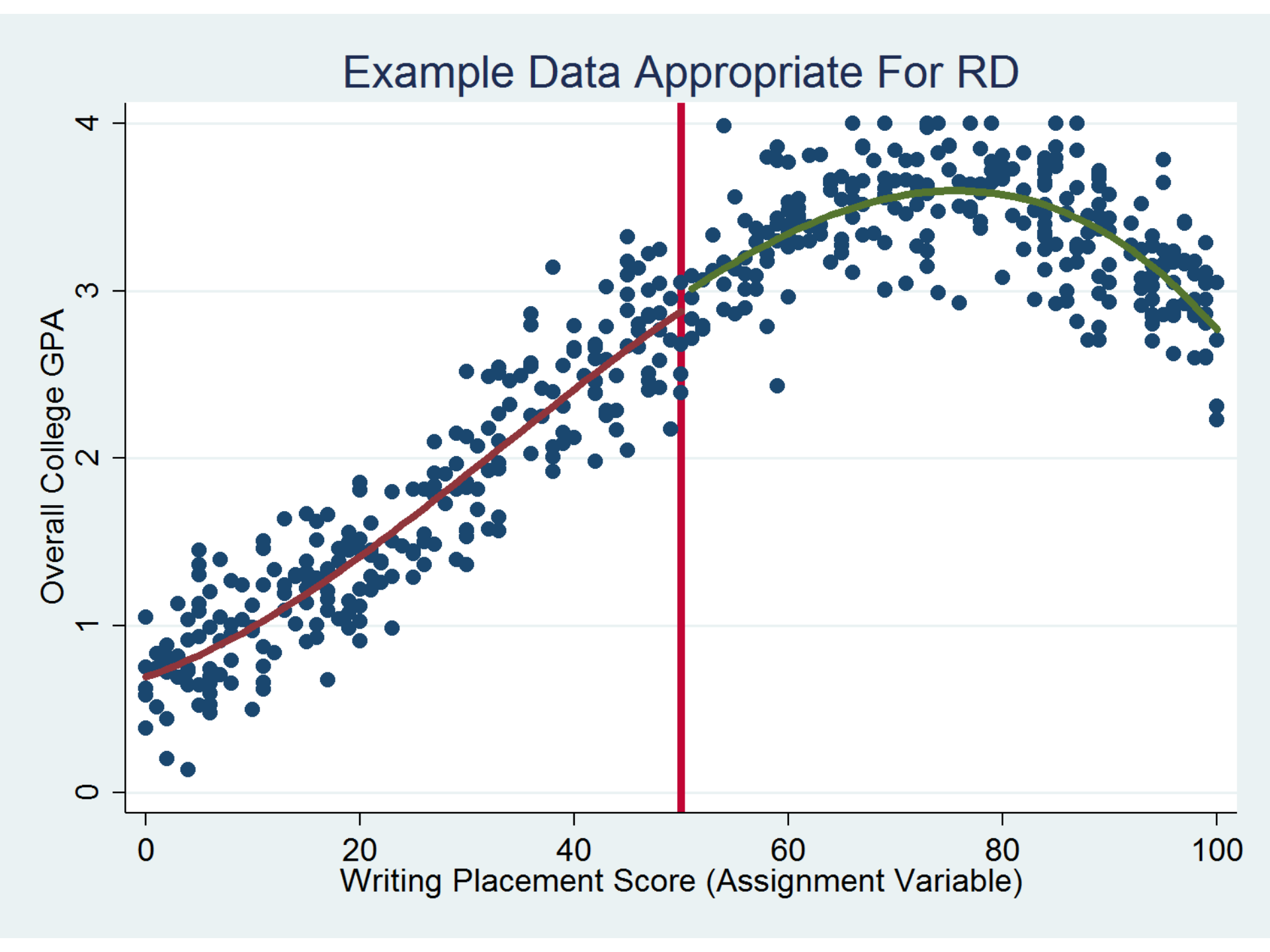
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# RD vs. Multiple Regression/Matching (MR/M)

- Goal with MR/M is to control for differences in characteristics between those in treated and control groups
- MR/M assumes the unlikely premise that all causal covariates are accounted for in the model
- RD requires no assumptions regarding covariates. In fact, inclusion of covariates does not even improve RD estimates, although they can be used to test certain assumptions about RD

# RD vs. Instrumental Variables (IV)

- The IV method assumes that the chosen IV is uncorrelated with unobserved variables
- Unobserved variables are irrelevant to well-designed RD studies

# Steps in RD Design and Analysis

- Design
  - Ensure all assumptions are met. Proper study design is more important than which analytic method you use
- Analysis
  - Center the assignment variable at the cutoff
  - Graph the relationship
    - Graph all points to get a sense of total distribution/outliers
    - Use a binned approach if there is too much noise to see patterns clearly
  - Specify higher-order terms and interactions
  - Estimate initial full model
  - Refine the model to include only essential parameters

# Optional Additional Steps

- If there is concern about manipulation of the assignment variable:
  - Look for irregular frequency distributions above and below the cutoff
  - Conduct an RD analysis on baseline covariates
  - Include baseline covariates in the original RD analysis

# Data Analysis Example

- Scenario 1 based on real data collected at LMU
- Scenario 2 based on data manipulated by me for a particular purpose
- Loyola Law School (LLS) wanted to help struggling students perform better in their second year
- Those with first-semester GPAs below 2.75 were required to take an additional course in Spring designed to build skills
- All students with low GPAs were required to take the course, and no students with higher GPAs were allowed
- The outcome was GPA in Fall of their second year

# If you still need the data…

- Stata data: http://goo.gl/qTM0IR
- CSV data: http://goo.gl/0InuGJ

For questions, e-mail ryan.johnson@ucr.edu

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