

# Using Big Data To Solve Economic and Social Problems

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Photo Credit: Florida Atlantic University



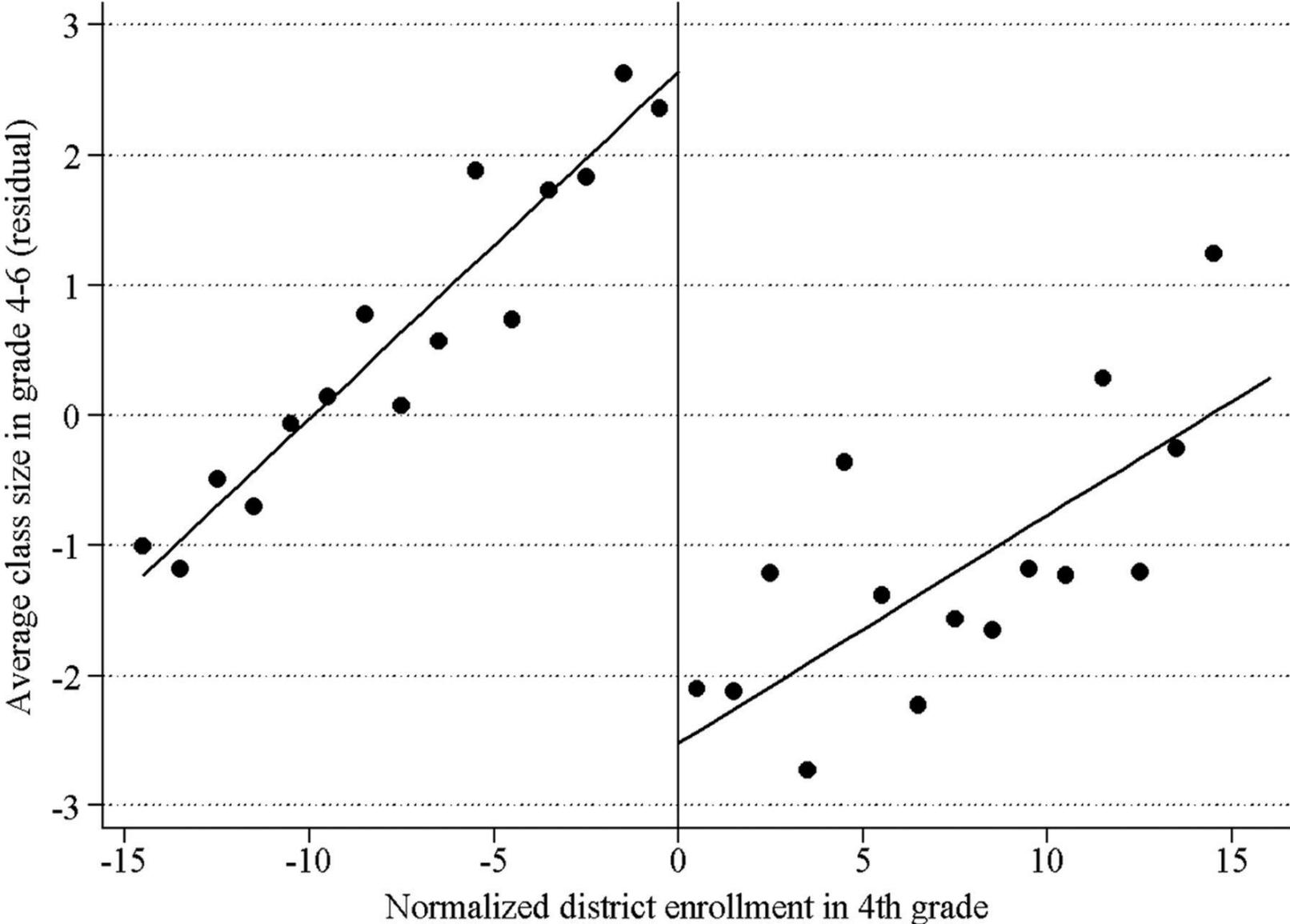
# Effects of Class Size: Quasi-Experimental Evidence

- How does the number of students in a classroom affect children's earnings?
- STAR experiment: insufficient data to estimate impacts of class size on earnings precisely
- Fredriksson et al. (2013) use administrative data from Sweden to obtain more precise estimates
  - No experiment here; instead use a quasi-experimental method:  
*regression discontinuity*

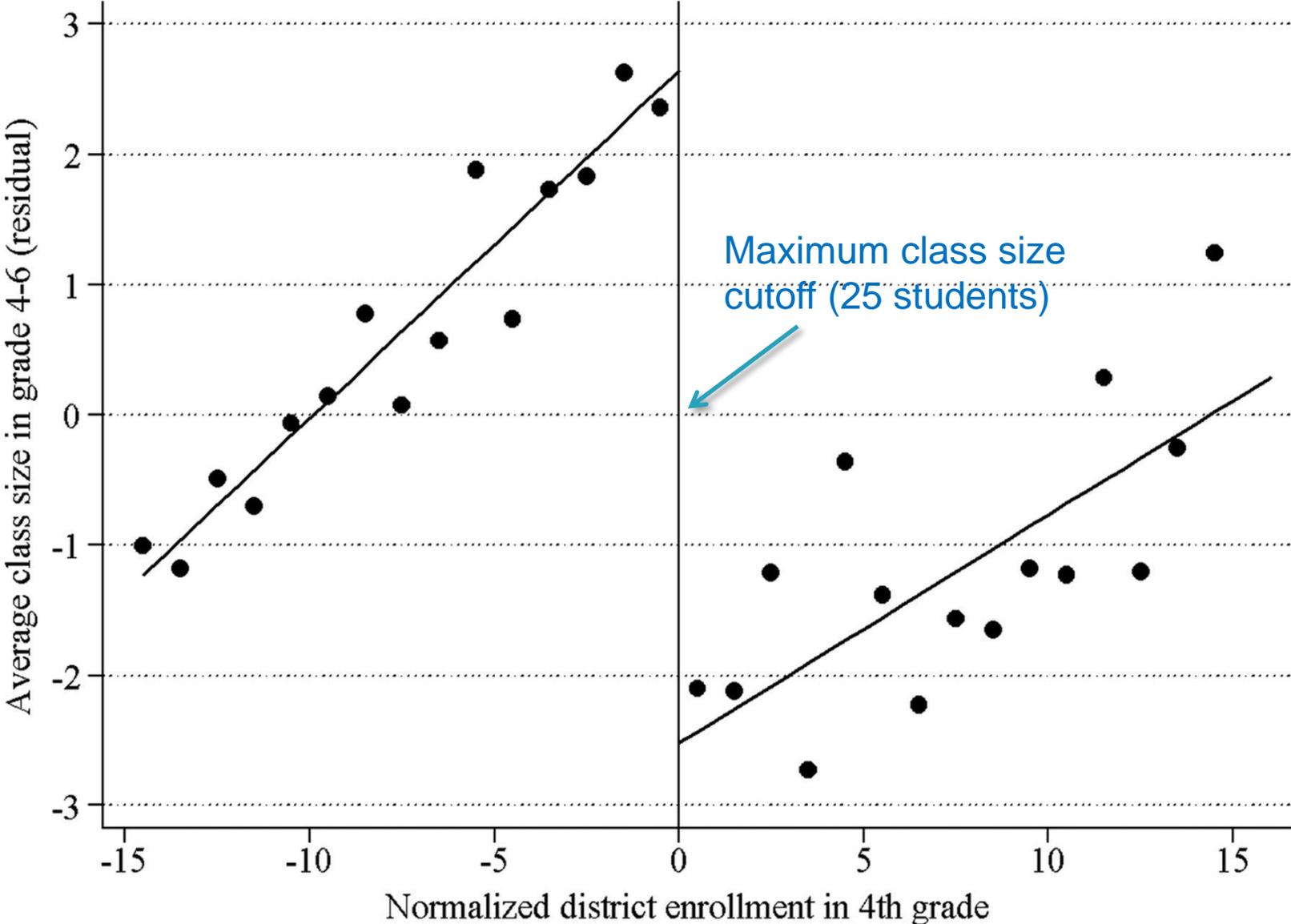
# Regression Discontinuity Using Class Size Cutoffs

- Sweden imposes a maximum class size of 25 students
  - School that has 26 students in a given grade will therefore have two classes of 13 students each
  - School that has 25 students may have one class of 25 students
- School that have 26 students in a grade are likely to be comparable to those that have 25 students
  - Can identify causal effects of class size by comparing outcomes in schools with 26 vs. 25 students in a given grade

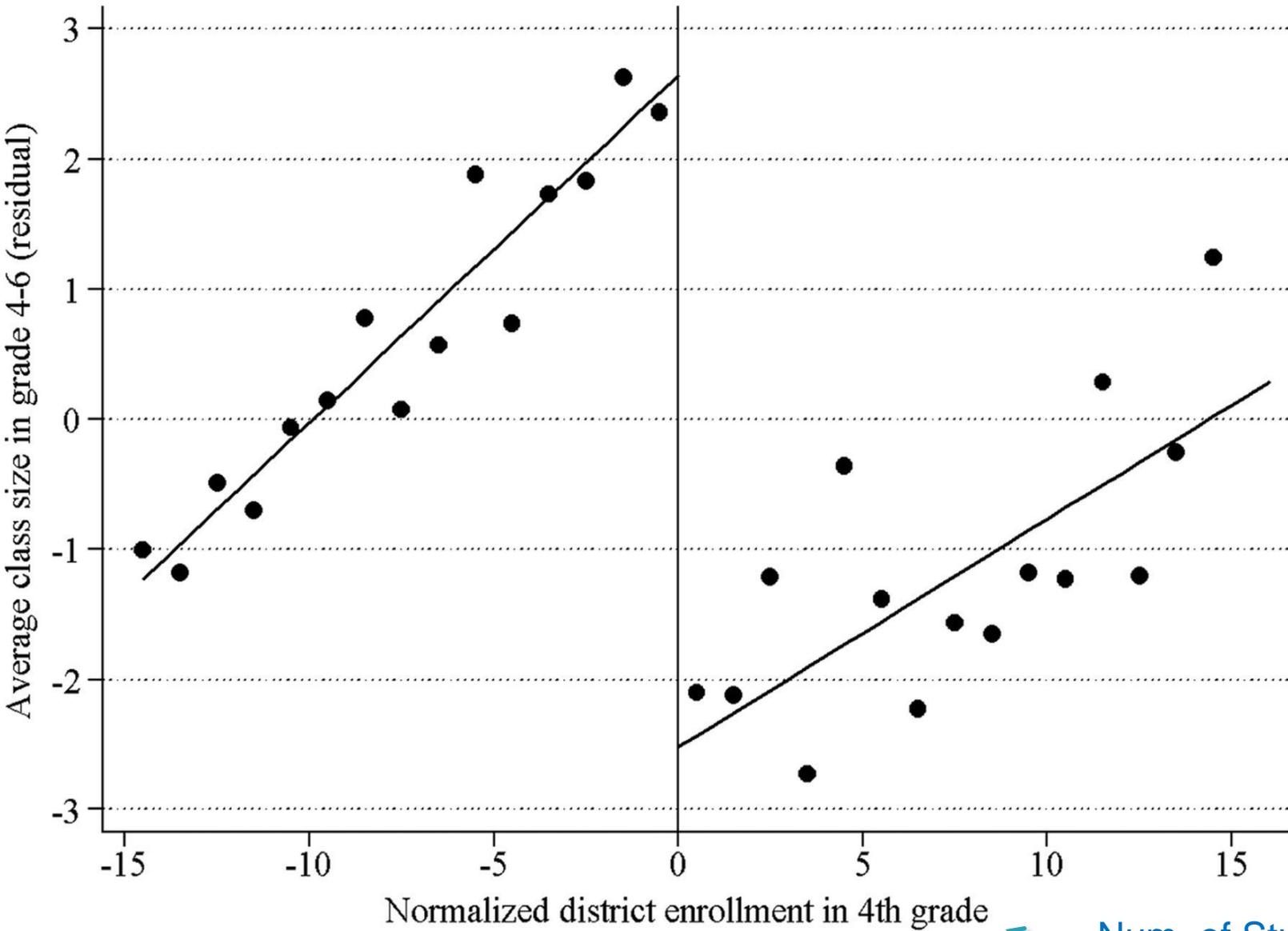
# Discontinuities in Class Size Created by Maximum Class Size Rule



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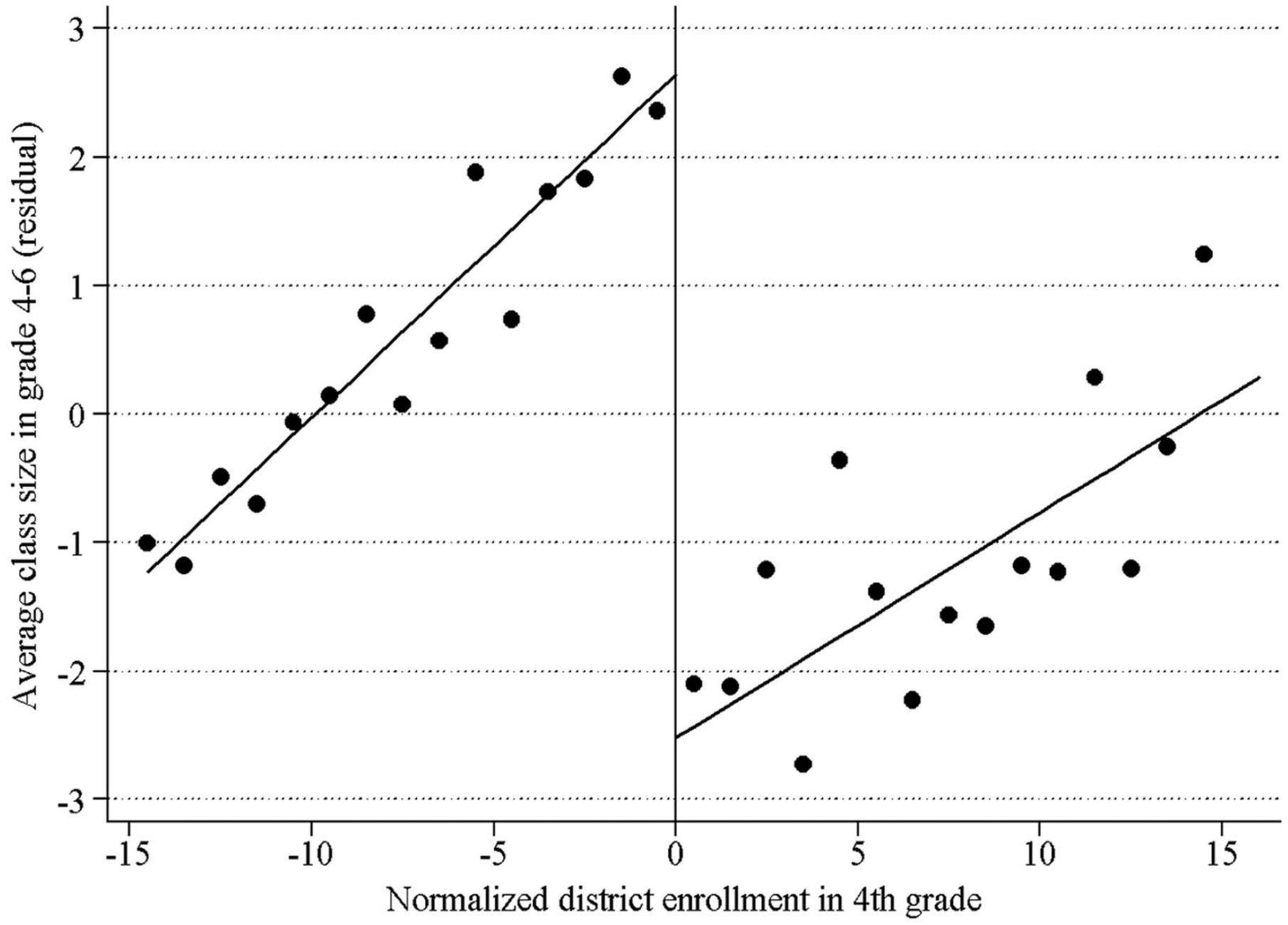
# Discontinuities in Class Size Created by Maximum Class Size Rule



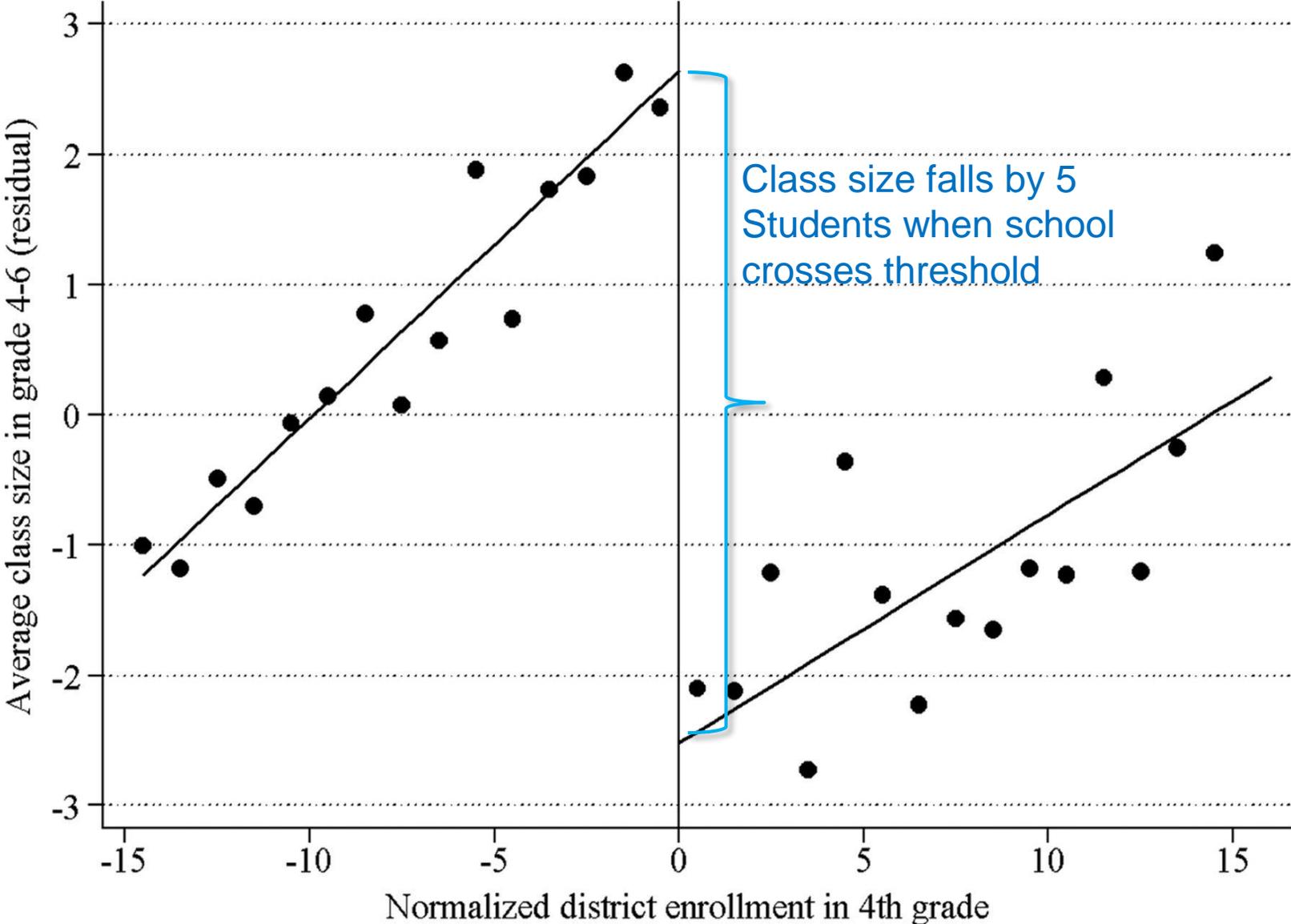
← Num. of Students in School Relative to Cutoff

# Discontinuities in Class Size Created by Maximum Class Size Rule

Average Class Size



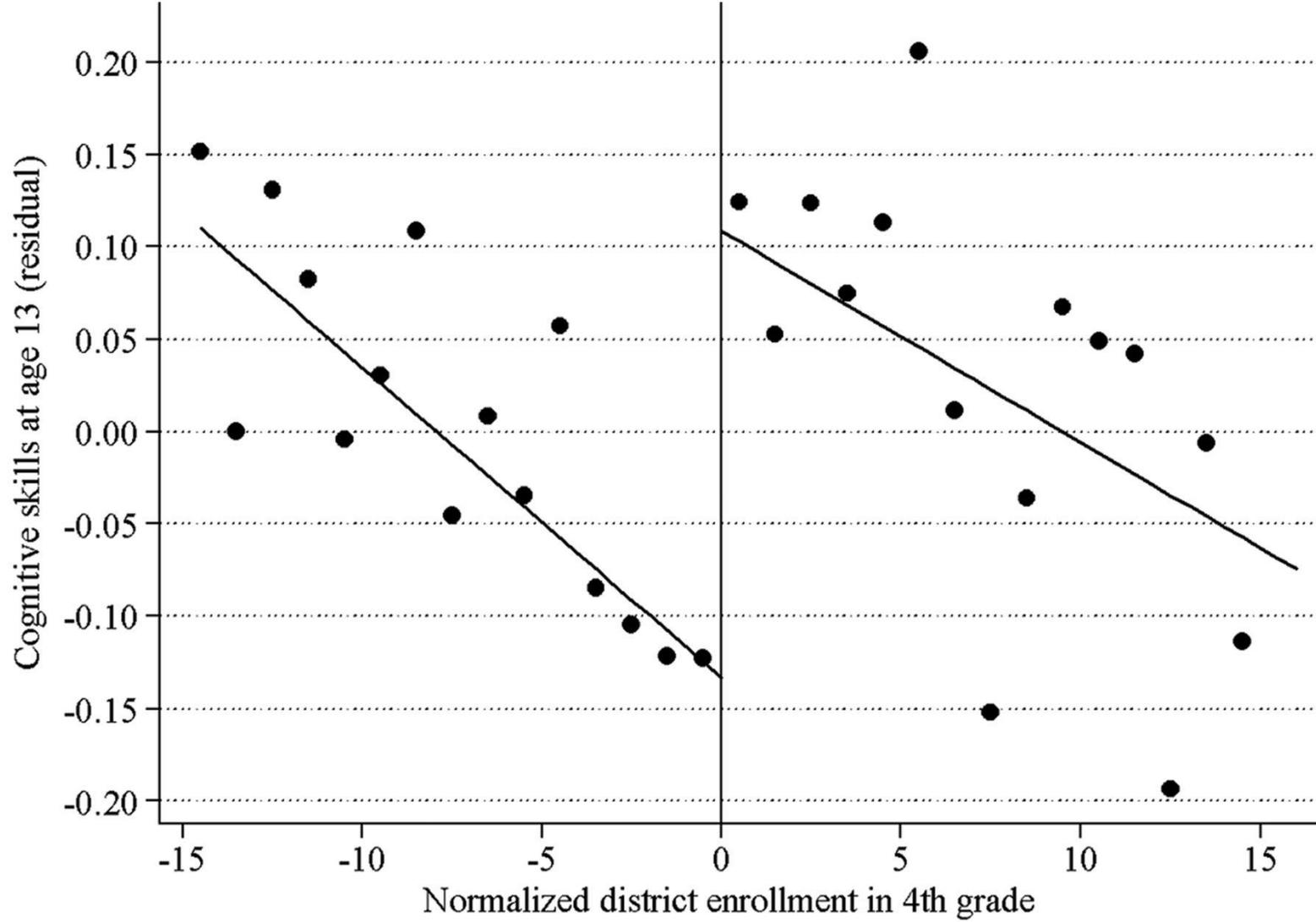
# Discontinuities in Class Size Created by Maximum Class Size Rule



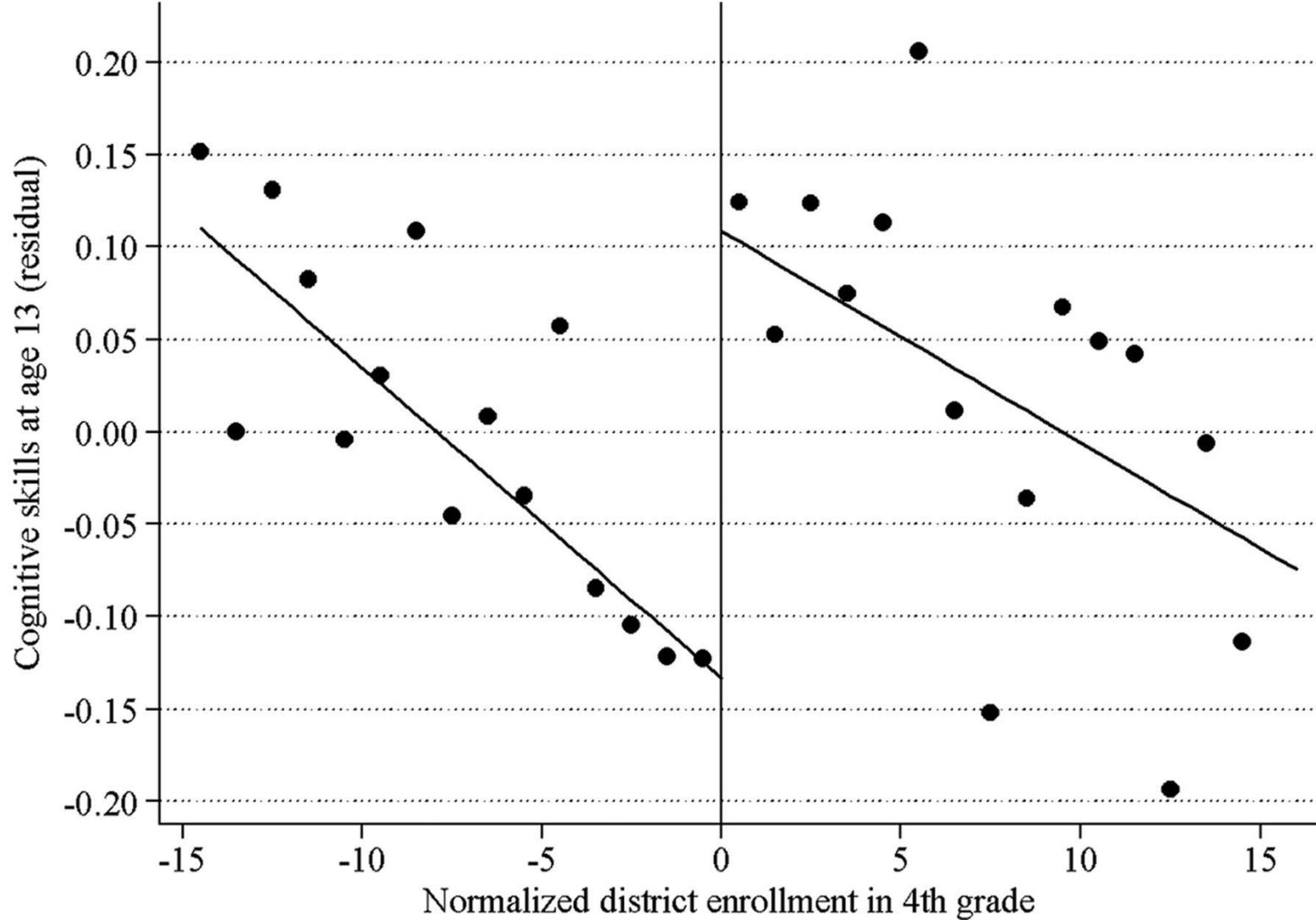
# Regression Discontinuity Methods

- Recall that any quasi-experimental approach requires an “identification assumption” to make it as good as an experiment
- For regression discontinuity (RD), the assumption is that other student characteristics do not jump discontinuously at cutoff point
  - Suppose everything else (parents, students’ abilities, etc.) changes continuously (smoothly) with size of the school
  - Then the only discrete change at the max size cutoff is the size of the class
  - This makes groups above and below the cutoff comparable → like an experimental comparison

## Test Score Achievement: Regression Discontinuity Estimates

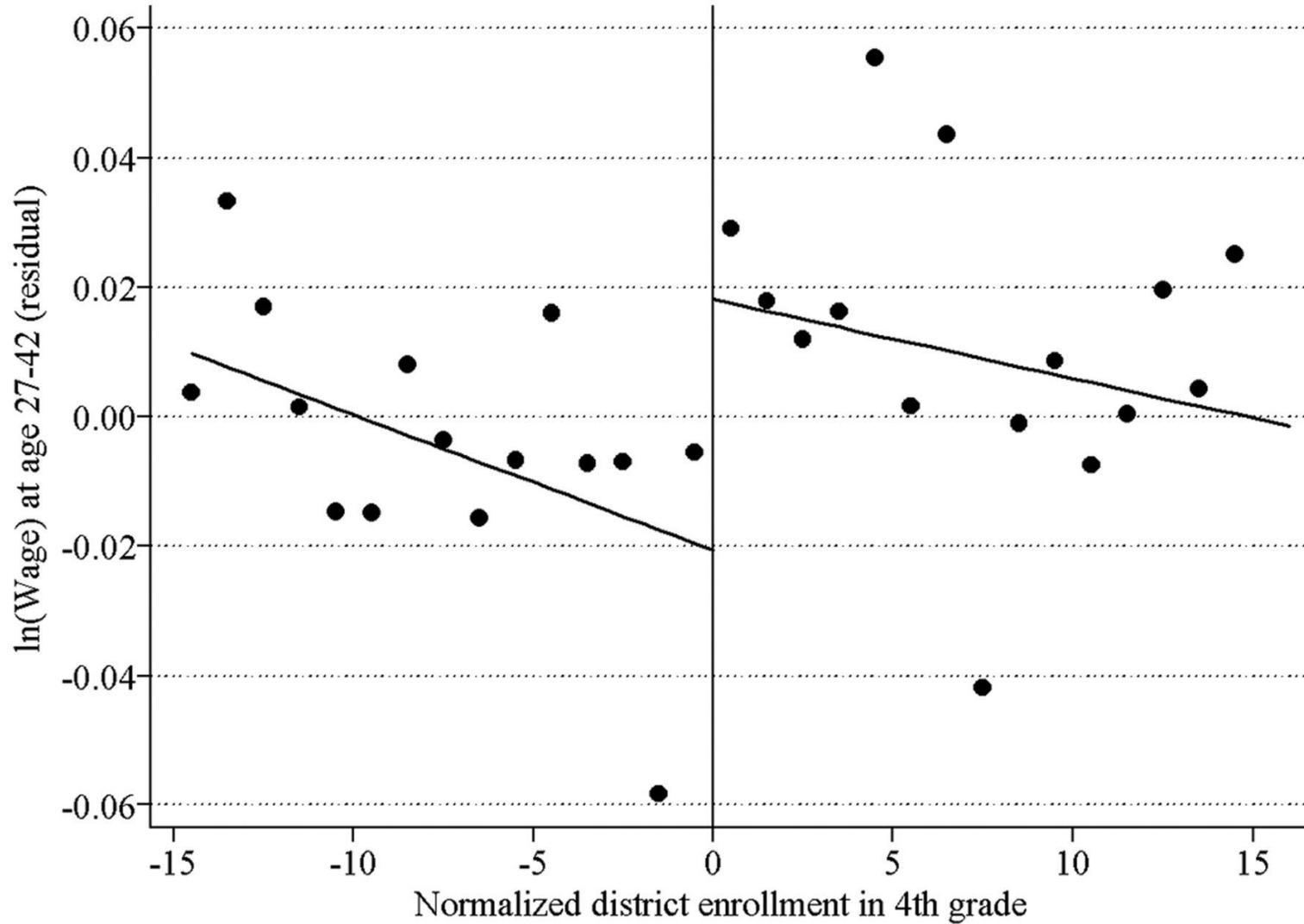


## Test Score Achievement: Regression Discontinuity Estimates



*Test scores jump by 0.2 standard deviations (8 percentiles) at cutoff  
→ Reducing class size by 5 students causes 8 percentile increase in scores*

## Earnings Impacts: Regression Discontinuity Estimates



*Earnings jump by 0.04 log points (4 percent) at cutoff*

*→ Reducing class size by 5 students causes 4% increase in earnings*

# Lessons on Class Size

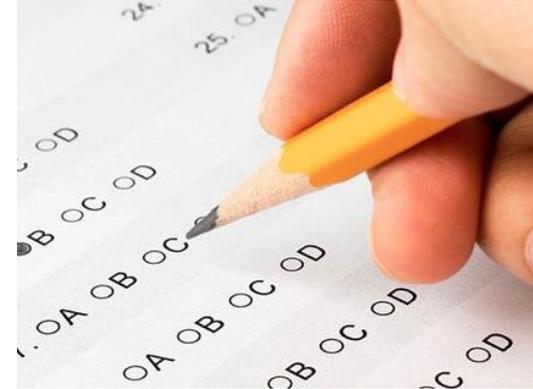
- Reducing class sizes in primary school by hiring more teachers can have large returns
  - Present value of lifetime earnings of a child growing up in a family at 25<sup>th</sup> percentile is about \$500,000 on average
  - 4% earnings gain from smaller class = \$20,000
  - Dividing a class of 30 students into two would increase total earnings of students by more than \$600,000
  - Costs (hiring another teacher and an additional room) likely to be well below \$600,000

# Teacher Quality

- But need to hire new teachers carefully when reducing class sizes...
  - Next topic: how does teacher quality affect students' outcomes?

# Using Big Data to Study Teachers' Impacts

**School district records**  
2.5 million children  
18 million test scores



**Tax records**  
Earnings, College  
Attendance, Teen Birth



# Measuring Teacher Quality: Test-Score Based Metrics

One prominent measure of teacher quality:  
teacher *value-added*

How much does a teacher raise her/his students' test scores on average?



# Debate About Teacher Value-Added Measures

- Controversial and highly politicized debate about using teacher value-added (VA) measures to evaluate teachers
- At its core, debate revolves around three statistical issues:
  1. Potential for bias in VA estimates
    - Do differences in test-score gains across teachers capture causal impacts of teachers or are they driven by student sorting?

# Debate About Teacher Value-Added Measures

- Controversial and highly politicized debate about using teacher value-added (VA) measures to evaluate teachers
- At its core, debate revolves around three statistical issues:
  1. Potential for bias in VA estimates
  2. Lack of evidence on teachers' long-term impacts
    - Do teachers who raise test scores improve students' long-term outcomes or are they simply better at teaching to the test?

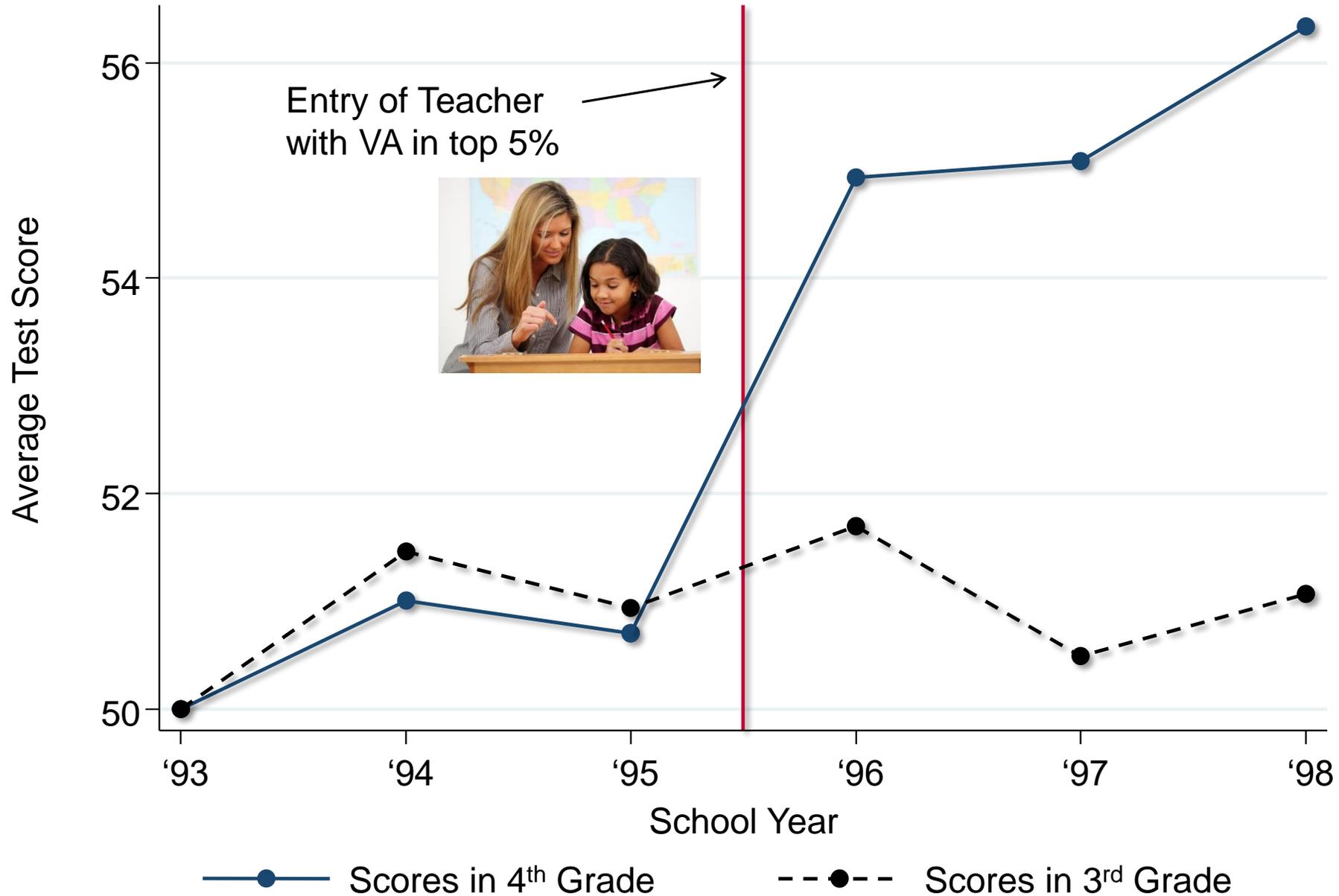
# Debate About Teacher Value-Added Measures

- Controversial and highly politicized debate about using teacher value-added (VA) measures to evaluate teachers
  
- At its core, debate revolves around three statistical issues:
  1. Potential for bias in VA estimates
  
  2. Lack of evidence on teachers' long-term impacts
  
  3. Instability of VA estimates
    - Are estimates of teacher quality based on a few years of data too unstable to be useful for policy?

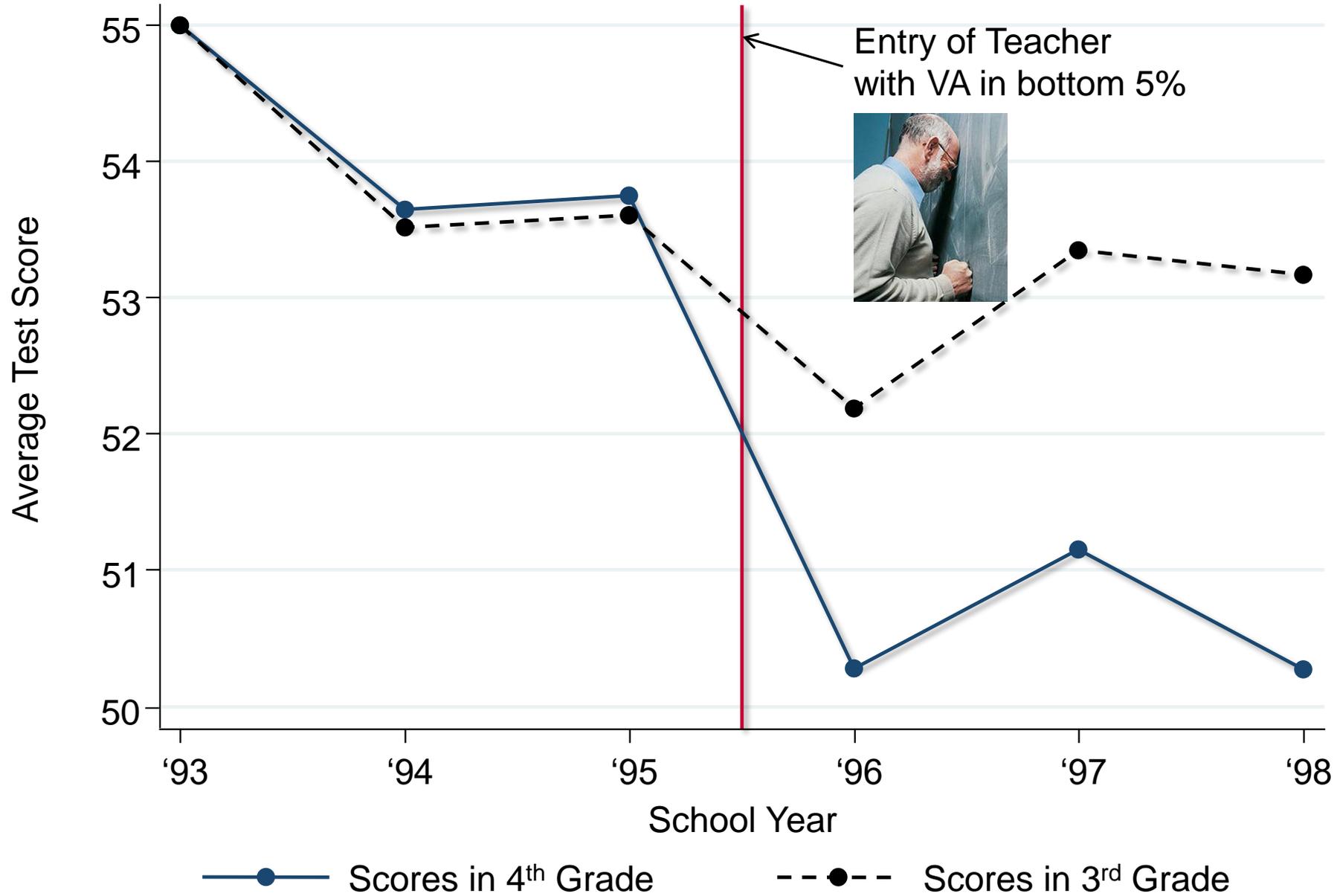
# Measuring the Impacts of Teachers

- Ideal experiment to answer these questions: randomly assign students to teachers with different value-added
- Test whether those with high value-added teachers have higher test scores and earnings
- We use a quasi-experimental approximation to this experiment
  - Exploit the fact that there is a lot of turnover in teachers across school years
  - When high VA teachers arrive at new schools, do scores go up?

# A Quasi-Experiment: Entry of High Value-Added Teacher



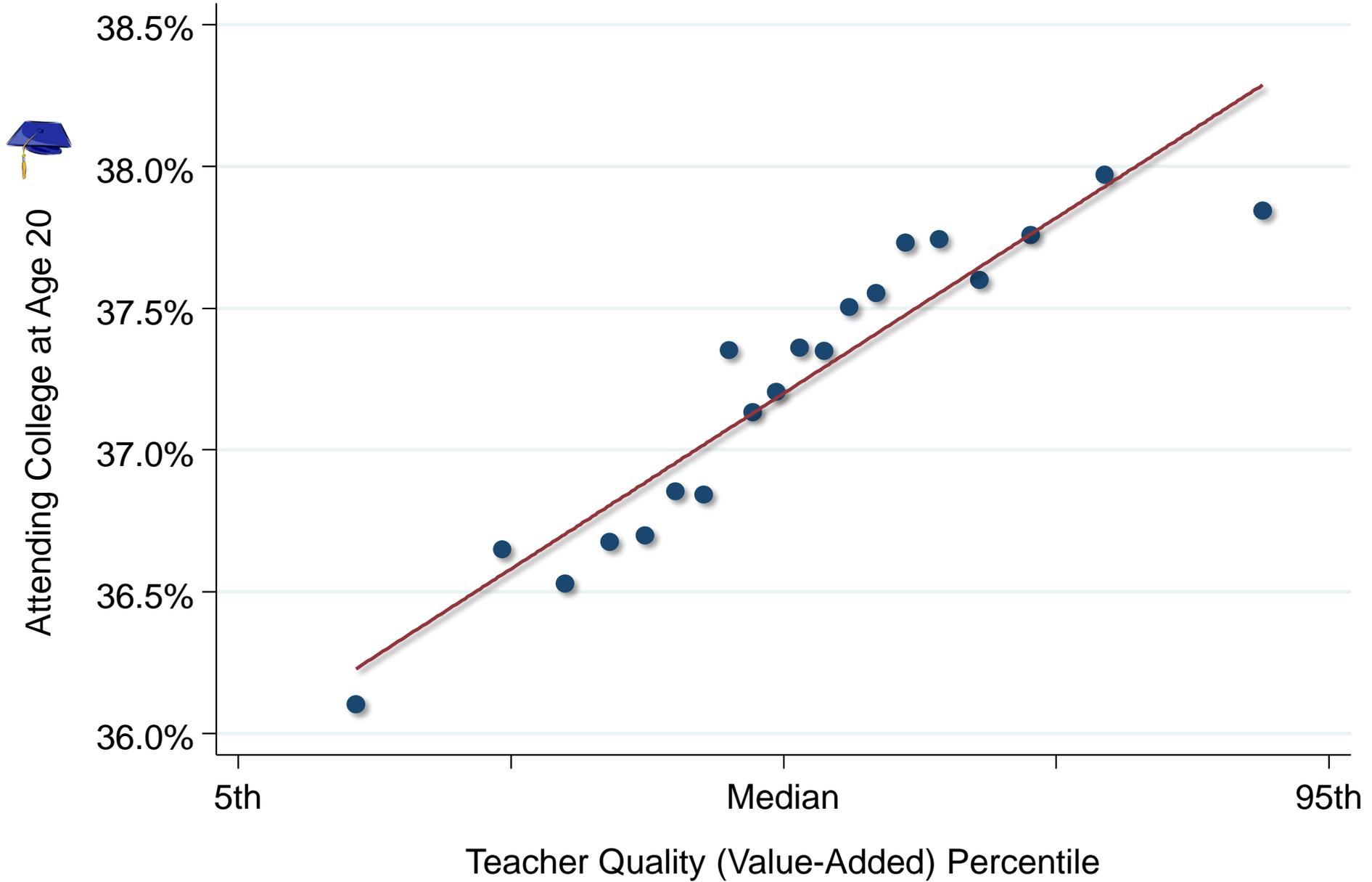
# A Quasi-Experiment: Entry of Low Value-Added Teacher



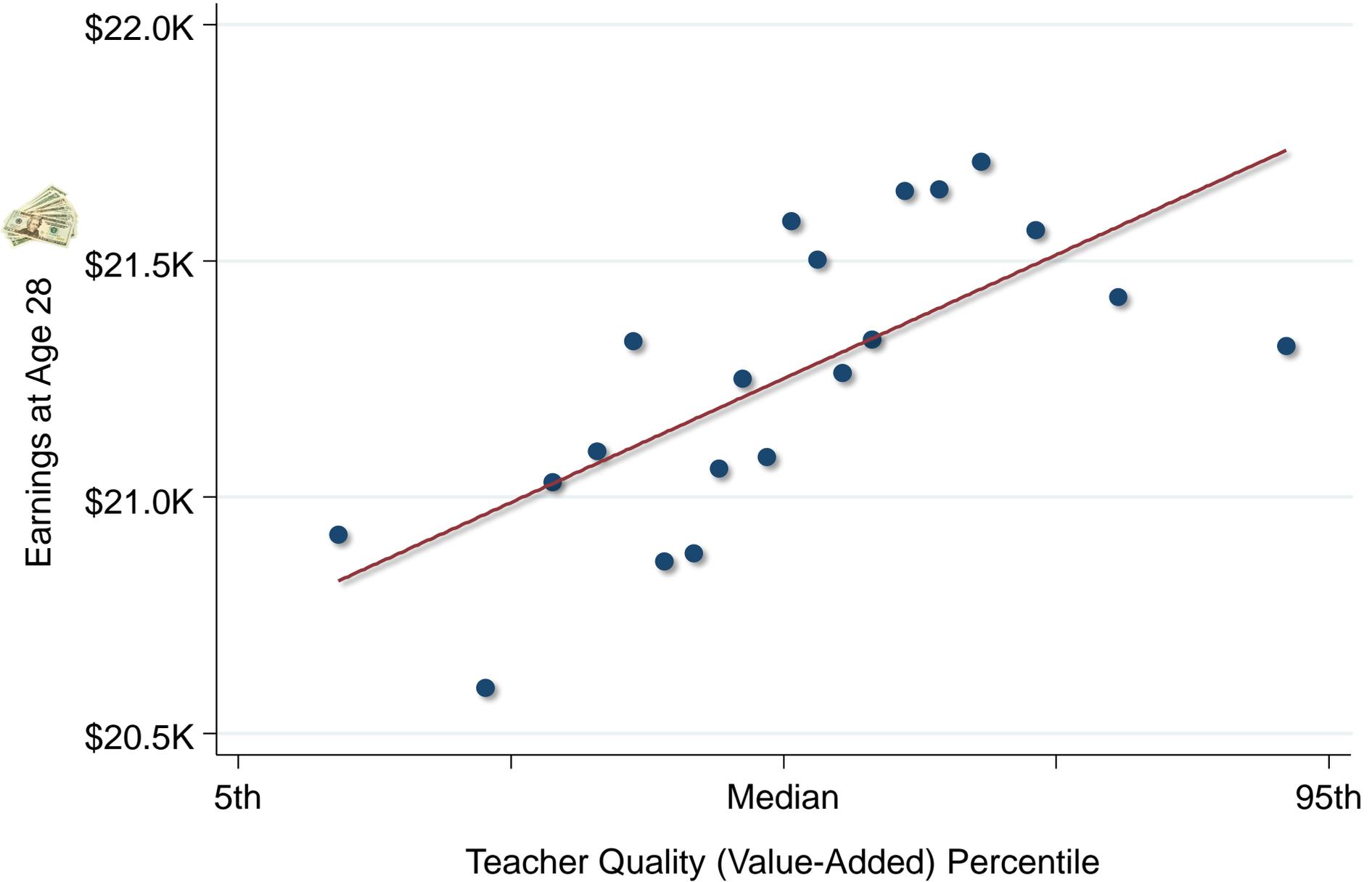
# Lesson 1: VA Estimates Are Unbiased Measures of Teacher Effectiveness

- Students assigned to higher value-added teachers have higher test scores
  - Being assigned to a teacher who is predicted to raise test scores by 10 percentiles increases a given student's score by ~10 percentiles
  - Differences in VA measures largely capture *causal effects* of teachers, not differences in types of students they are assigned (selection)

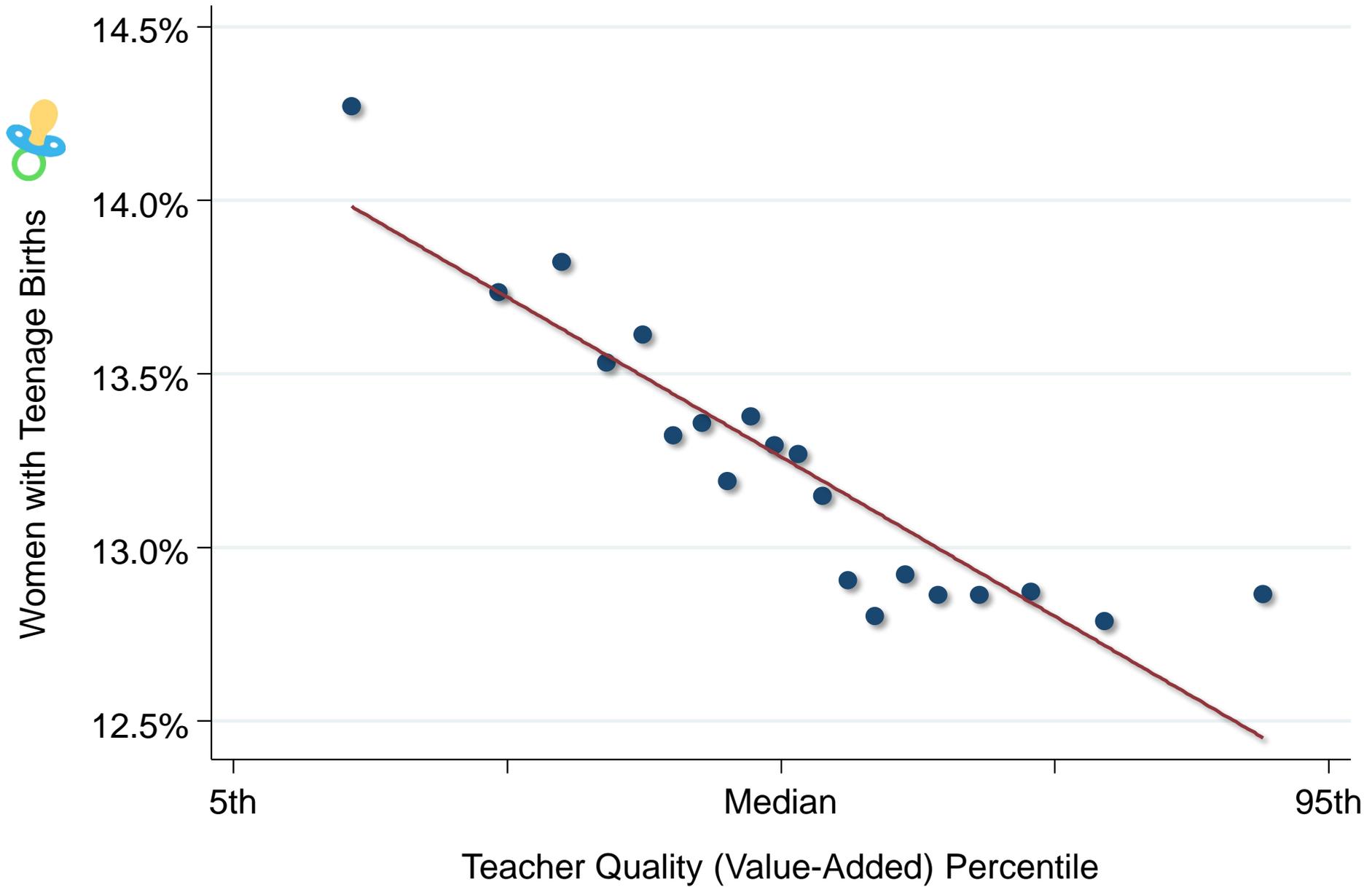
# Effect of Teacher Quality on College Attendance Rates



# Effect of Teacher Quality on Earnings



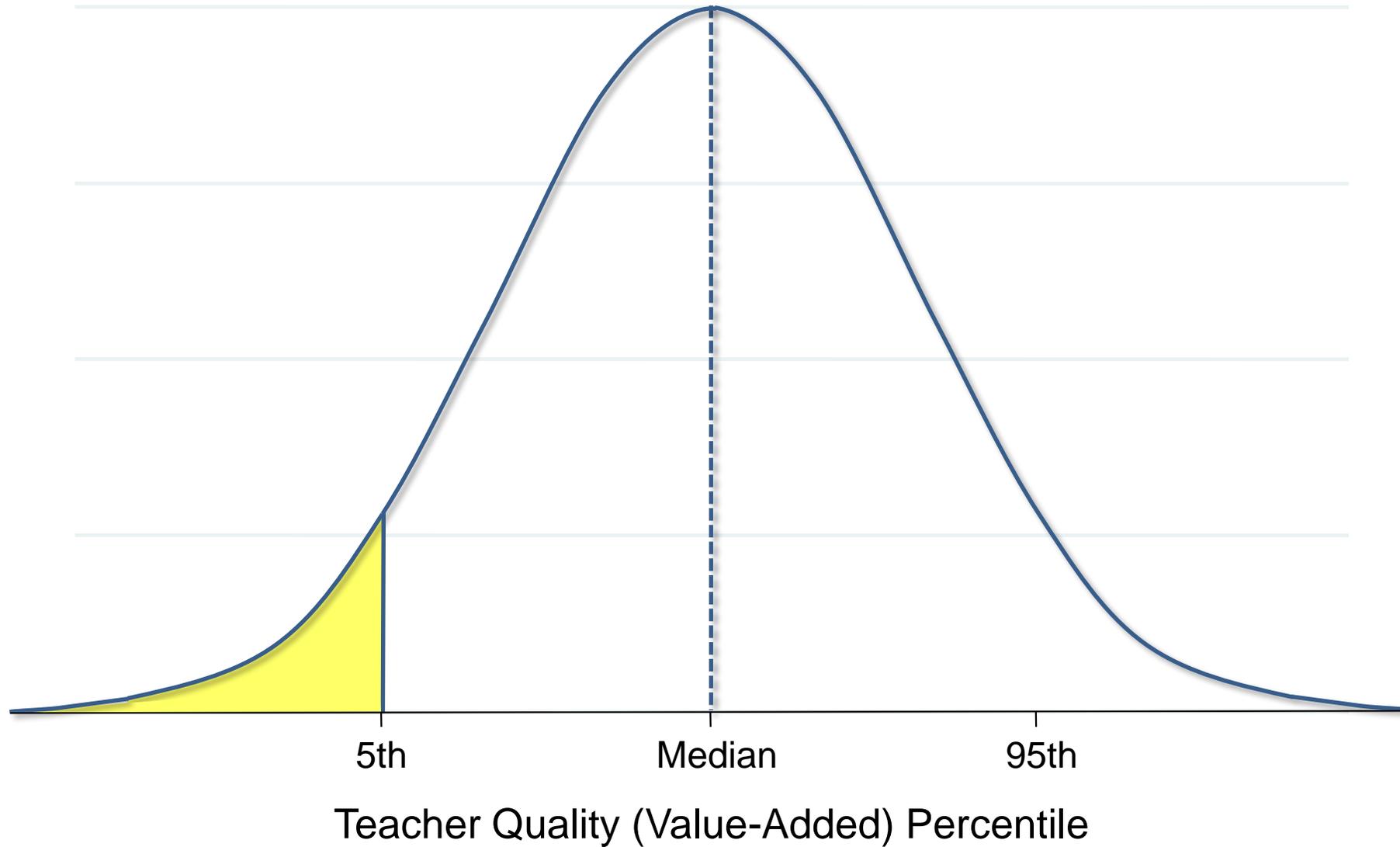
# Effect on Teacher Quality on Teenage Birth Rates



## Lesson 2: VA Estimates Based on Test Scores Predict Teachers' Long-Term Impacts

- Assigning a student to a higher value-added teacher raises not just test scores but long-term outcomes
  - Teachers who generate high test scores are not just “teaching to the test”

# The Value of Improving Teacher Quality



## The Value of Improving Teacher Quality

**+\$80,000** lifetime earnings per child  
**= \$2.2 million** per classroom of 28 students  
**= \$407,000** in present value at 5% int. rate

5th

Median

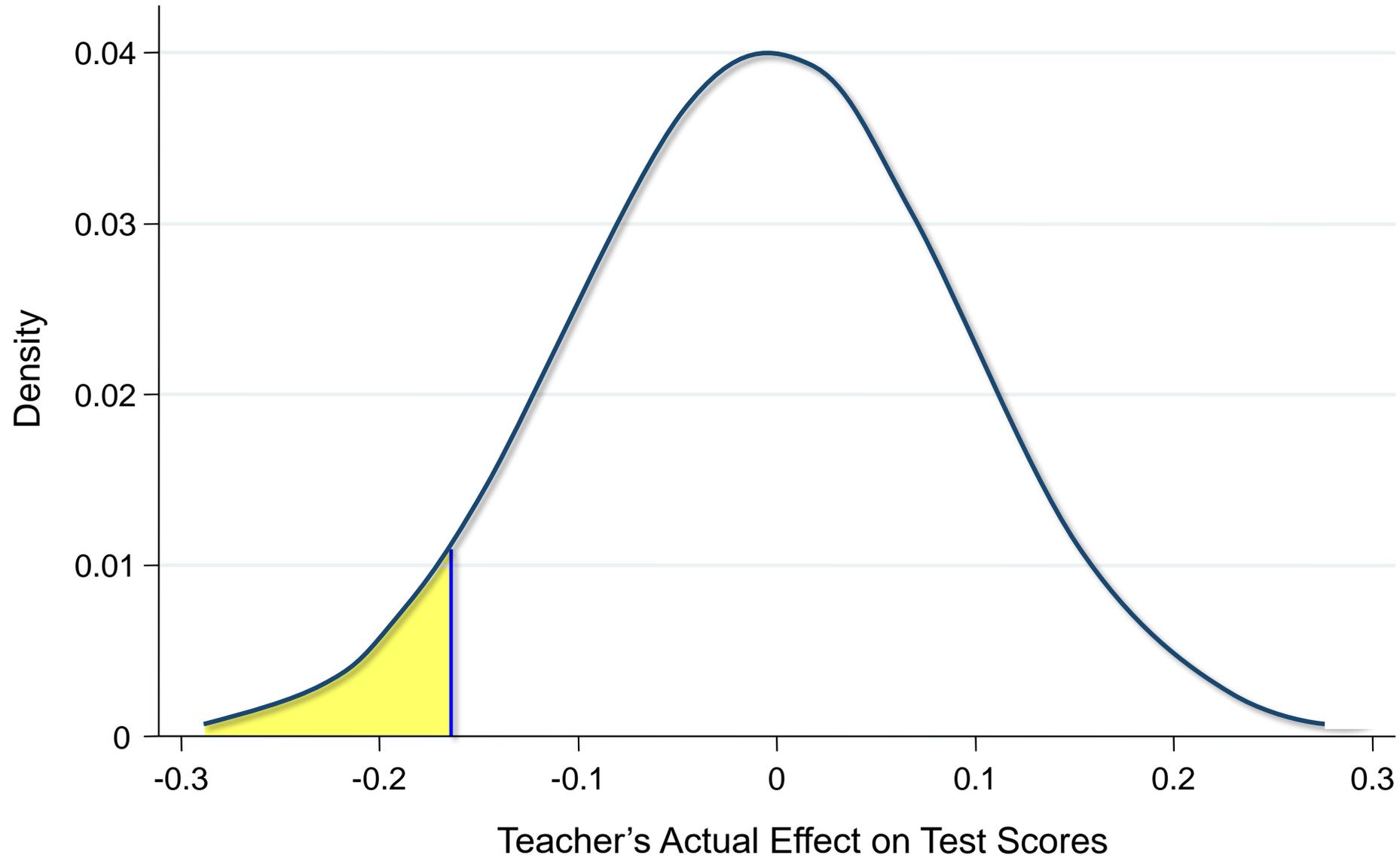
95th

Teacher Quality (Value-Added) Percentile

# Reliability of Teacher Value-Added Estimates

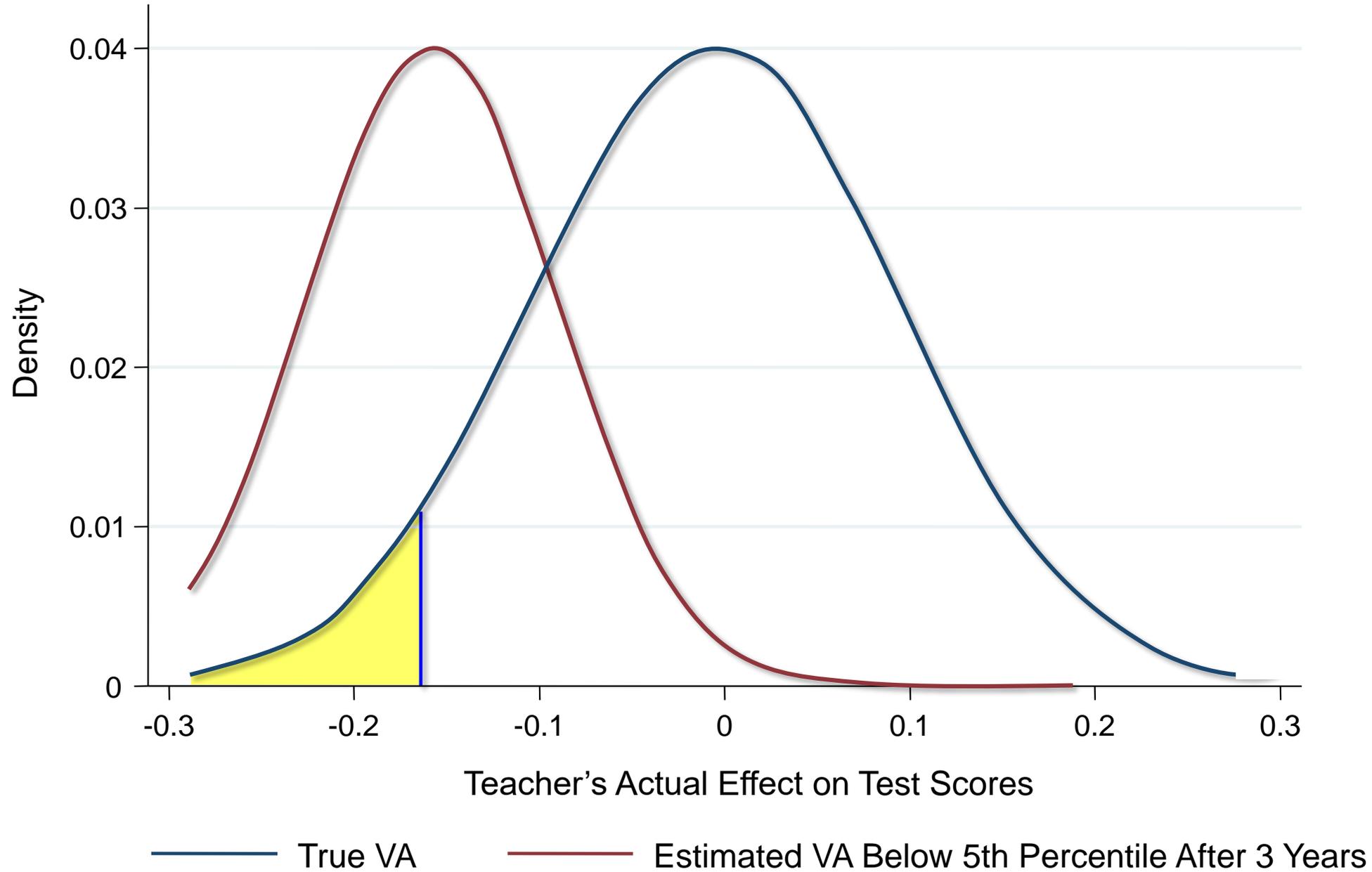
- Previous calculation overstates feasible gain because we do not observe each teacher's value-added perfectly
- In practice, we usually have performance data for just a couple of years before we need to make personnel decisions
  - VA estimates based on a couple of classes are statistically imprecise
  - Teachers who happen to have students who do well by chance will get a high VA score
- Does this estimation error in VA reduce gains from previous exercise?

# Selecting Teachers on the Basis of Value-Added Estimates

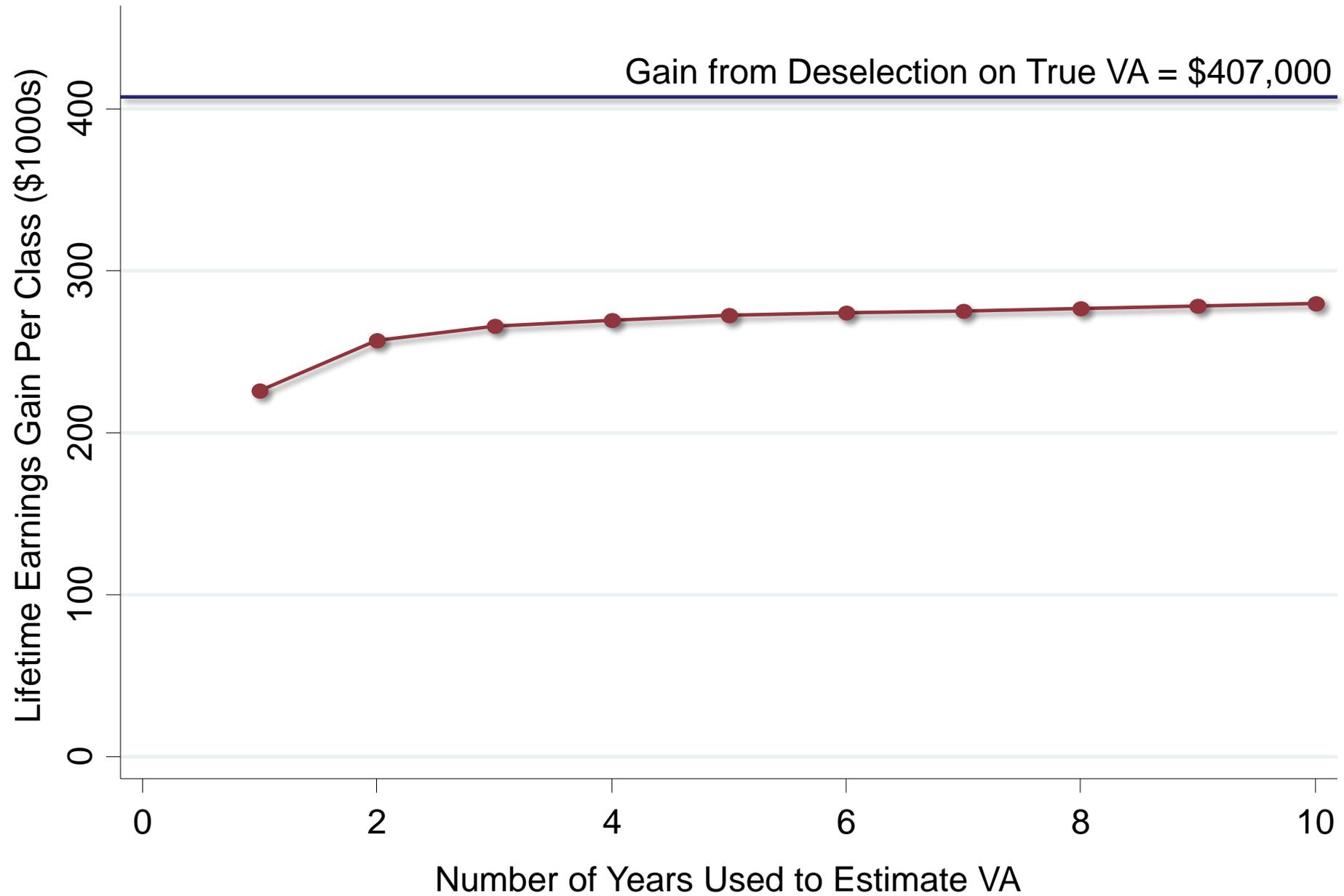


— True VA

# Selecting Teachers on the Basis of Value-Added Estimates



## Earnings Gain from Teacher Replacement Based on Estimated VA



## Lesson 3: VA Estimates Based on a Few Years of Data Are Sufficiently Reliable to Generate Large Gains on Average

- VA estimates do fluctuate depend upon which students teachers get
- But even taking this into account, gains from replacing teacher with estimated VA in bottom 5% with teacher of average quality is \$250,000
  - Less than \$400,000 gain we'd achieve if there were no measurement error in VA, but still substantial

# Relevance of Findings to Current Policy Debate

- Most school districts in the U.S. do not use any performance metrics to evaluate teachers
  - In many districts, 98%+ of teachers get tenure within 3 years
  - Pay set purely based on experience, not performance
- New evidence on VA metrics has sparked interest in changing this system

# Policy Impacts



“We know a good teacher can increase the lifetime income of a classroom by over \$250,000.... Every person in this chamber can point to a teacher who changed the trajectory of their lives”

- Barack Obama, *State of the Union*, 2012



“A recent study by Harvard and Columbia economists found that students with effective teachers are less likely to become pregnant, more likely to go to college and more likely to get higher-paying jobs....Ineffective teachers are hurting our students’ futures – we can’t allow that.”

- Michael Bloomberg, *State of the City*, 2012

# Policy Impacts

## *Vergara v. California* | Legal Claims

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### *Civil Rights*

- Under longstanding California Supreme Court precedents, Plaintiffs have a fundamental right to equal educational opportunity.

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### *Harm to Students*

- **Teacher quality is the key determinant of educational effectiveness and has a profound impact on students' lifetime achievement.**
- **The problem is worse for students who attend schools that serve predominantly minority and lower-income populations** because those schools are staffed by a disproportionate share of grossly ineffective teachers.
- In some school districts, **students of color are two to three times more likely to have bottom-quartile teachers than their white and Asian peers.**

# Summary: Improving Public Schools

- New data show that changing public schools in certain specific ways can have large long-term returns
- Reducing class size can be very valuable
  - But critical to hire highly effective new teachers when doing so
- There are large, measurable differences in teacher quality,
  - We should do more to attract and retain top teachers in public schools (not just using value-added metrics but also other tools)

# **Marked-Based Solutions: Charter Schools**

# Market-Based Solutions to Improving Education

- Alternative approach to improving education: leverage market forces
- Permit school choice → best schools will attract more students and other schools will improve their performance to stay in business
- Two ways we currently take such an approach in the U.S.
  1. Charter schools: schools that are publicly funded but independent of public school system
  2. Vouchers that students can use for private schools instead of their local public school

# Do Charter Schools Work?

- Question: are private schools/charter schools better than public schools?
- Cannot simply compare outcomes at charters and public schools
  - Charters tend to be concentrated in lower-income, urban areas → outcomes worse on average

# Do Charter Schools Work?

- Several recent studies estimate effects of charter schools on students' outcomes by exploiting lotteries for admission
  - Charter schools often have more applicants than seats → use lotteries to assign seats
  - Comparing outcomes of winners vs. losers identifies causal effects
- References:

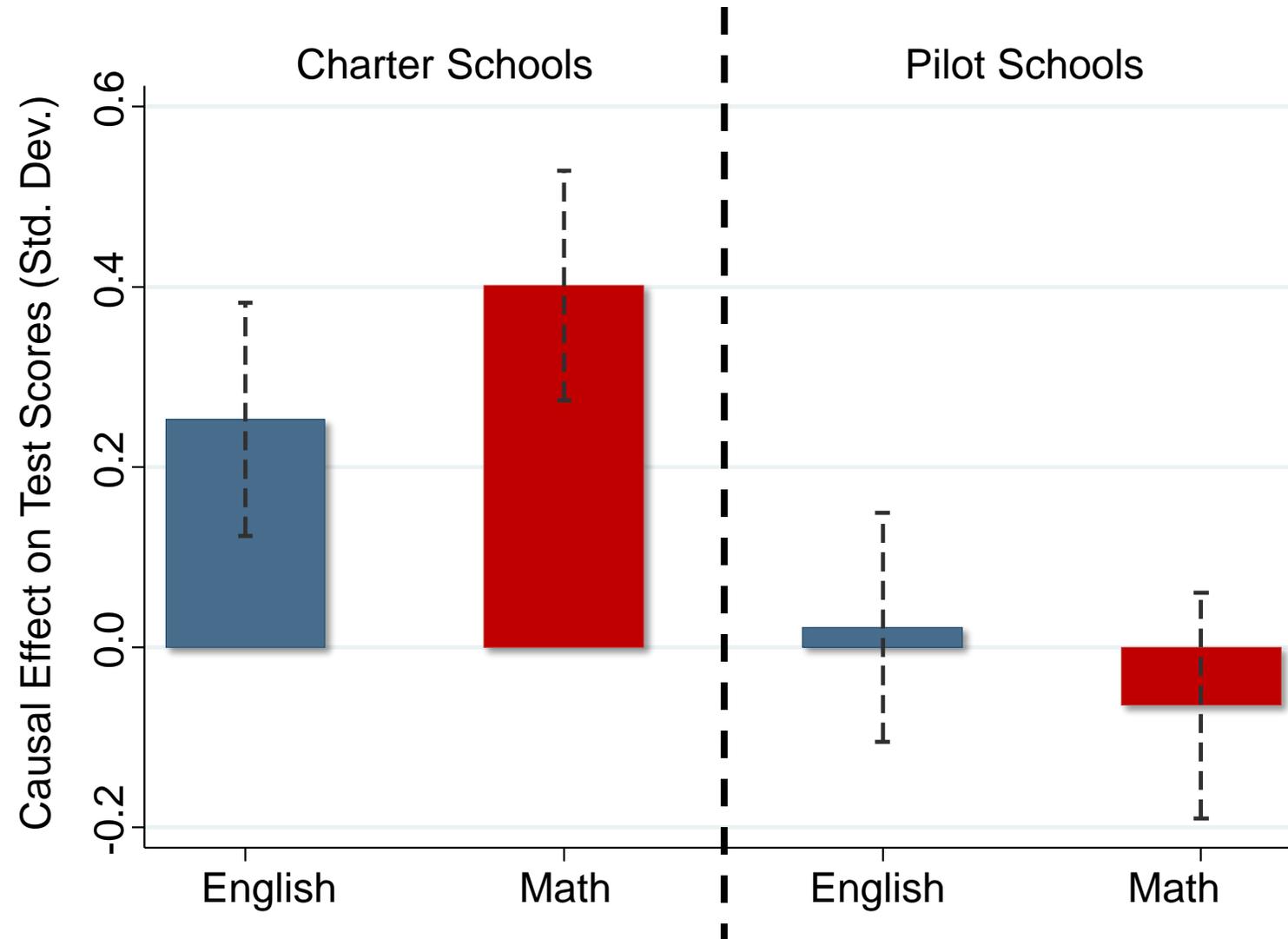
Abdulkadiroğlu, Angrist, Dynarski, Kane, Pathak. "Accountability and Flexibility in Public Schools: Evidence from Boston's Charters and Pilots." QJE 2011.

Chabrier, Cohodes, Oreopoulos. "What Can We Learn From Charter School Lotteries?" JEP 2016

# Effects of Boston Area Charter Schools

- Abdulkadiroglu et al. (2011): compare effects of charter schools and pilot schools in Boston
  - Charter schools are exempt from all public school regulations
  - Pilot schools are like charters but covered by Boston Public School regulations and teachers union contracts
  - Both are financed by payments from students' home district: tax payments transferred to charter/pilot school

# Effects of Boston Charter and Pilot Schools on Test Scores



# Effects of Boston Area Charter Schools

- Subsequent study by Angrist et al. (2013) shows that Boston charters have significant effects on college attendance rates
- Lesson: charters generate positive effects on average; pilots are no better than public schools
  - Suggests that the flexibility obtained by relaxing public school restrictions (e.g., on teacher hiring) is a key driver of positive impacts

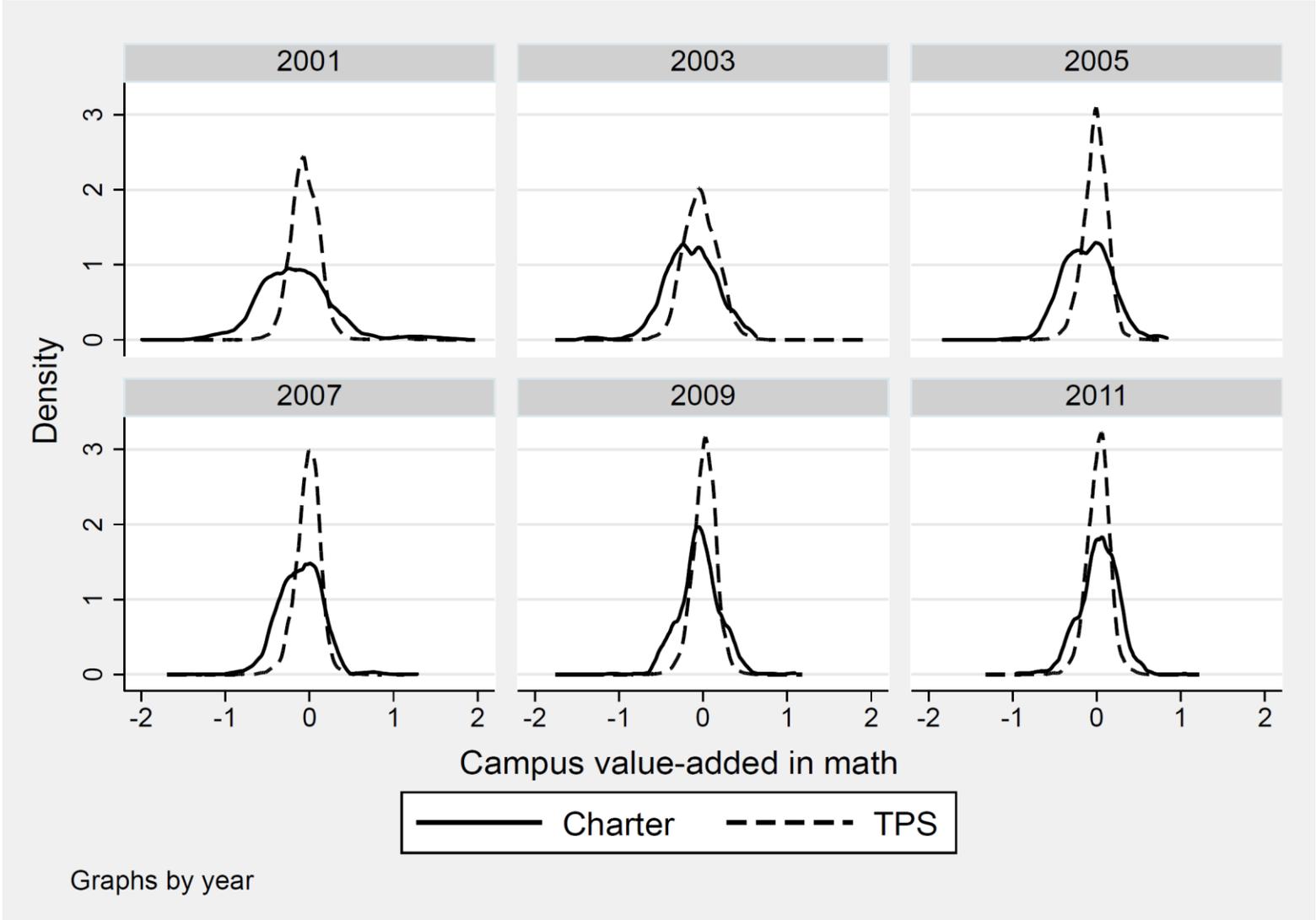
# Effects of Charter Schools: Summary

- Chabrier et al. (2016) summarize literature on charter schools
  - Small positive mean effects on test scores on average
  - In general, “no excuses” schools (extra hours, discipline, academic focus) tend to have positive impacts

# Market Competition and Charter Schools

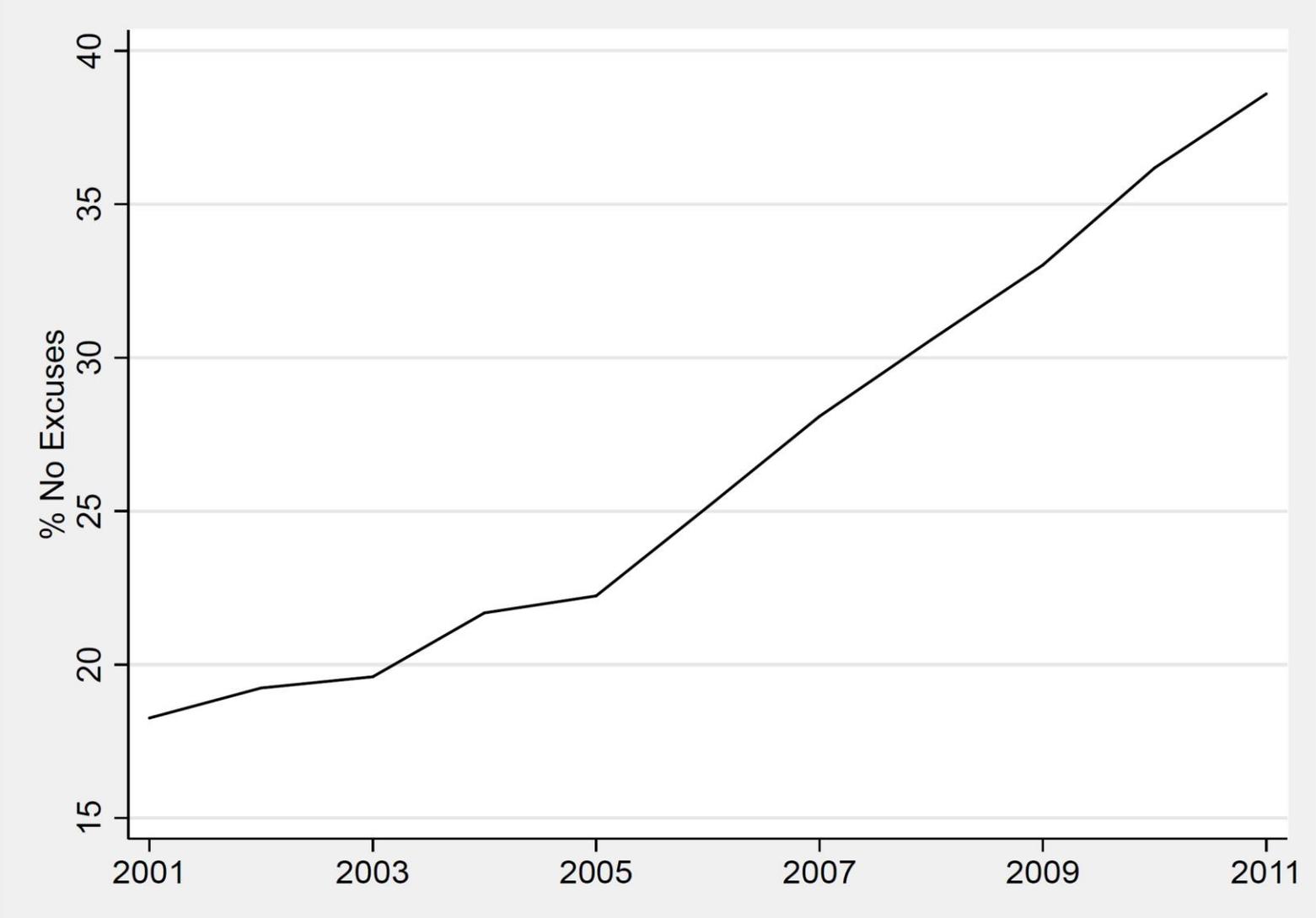
- Does market discipline lead to growth of better schools and improvement in performance over time?
- Baude, Casey, Hanushek, and Rivkin (2014) study how quality of charter schools in Texas changed over time
- Difficult to estimate causal effect of 500 schools using lotteries
- Instead calculate value-added of each school by estimating average test score gains in each school
- Compare distributions of school value-added for charters relative to Texas Public Schools over time

# Distribution of School Math VA by Year: Texas Charters vs. Public Schools



Source: Baude et. al. 2014

# Market Share of "No Excuses" Charter Schools in Texas



Source: Baude et. al. 2014

# Market Competition and Charter Schools

- Charter school market is evolving in a positive direction
  - Better schools gaining enrollment over time
  - But still a number of relatively low-performing schools, even many years after system began

# Limitations of Market Competition

- Three limitations of relying purely on private market competition
  1. Markets may function poorly when quality is not well observed
    - Difficult to gauge value-added, especially when outcomes (e.g. college, earnings) are realized 10+ years after treatment

# Limitations of Market Competition

- Three limitations of relying purely on private market competition
  1. Markets may function poorly when quality is not well observed
  2. Cream skimming of students and teachers
    - Private schools have an incentive to reject less qualified applicants
    - Can exacerbate inequality by leaving less qualified students behind in schools with fewer resources and weaker peers

# Limitations of Market Competition

- Three limitations of relying purely on private market competition
  1. Markets may function poorly when quality is not well observed
  2. Cream skimming of students and teachers
  3. Parents may not make well-informed choices
    - Hastings, Kane, and Staiger (2007) study introduction of school choice in Charlotte, NC in 2002
    - Low income parents are much less likely to choose schools with high test scores than high income parents
    - School choice can *amplify* achievement gaps

# Improving Education: Summary

- We now have simple, empirically proven ways to improve primary education
  - Solutions range across political spectrum: more resources to reduce class size in public schools to expansion of “no excuses” charter schools
- Which approach is better: government or market based?
  - Current constraints in public school system (local property tax funding base, regulations on teacher hiring) limit its effectiveness
  - But unregulated market system likely to deliver highly variable outcomes
- Best system may be a hybrid that preserves flexibility within schools while offering uniform quality and resources across schools