Class Size in Community College

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Presentation for California Association for Institutional Research

CENTER FOR EDUCATION POLICY ANALYSIS
At STANFORD UNIVERSITY
cepa.stanford.edu

Presentation

- Background on class size
- What is a fixed effect? Common ways they are used?
- Common issues and “threats” to my estimation
- Do we have to use fixed effects?

- Most issues of coding reserved for file I can email later: ogurantz@stanford.edu

Background

- Class size changes in higher education tied to both economic conditions and institutional sector

- Recessions reduce state expenditures, which may induce class size increases for cost saving
  - Selective institutions can raise tuition and restrict enrollment to maintain quality
  - Less selective or open-access institutions may find it more difficult to enact policies that alter student enrollment

Figure 2. University of California Admission and Enrollment

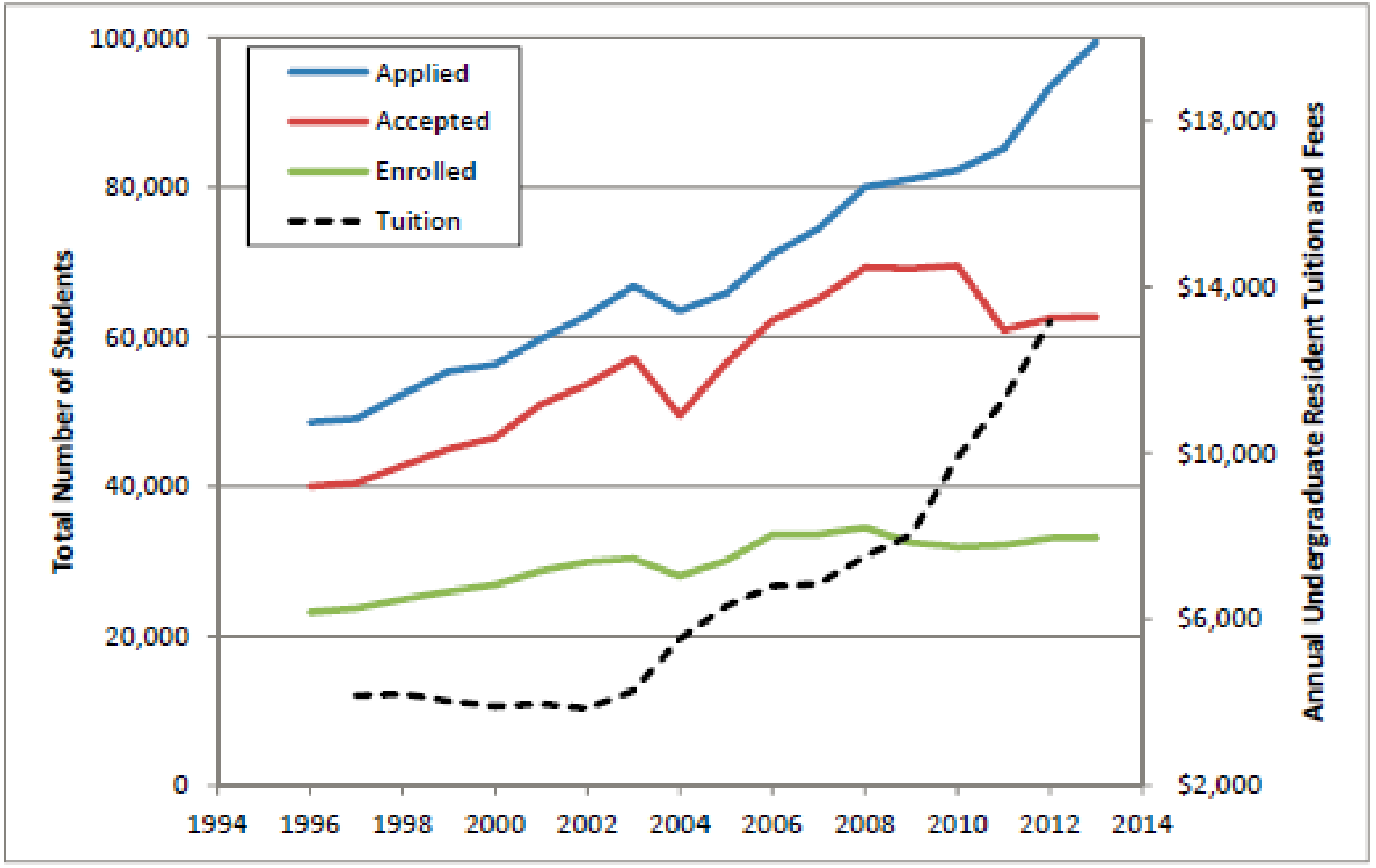
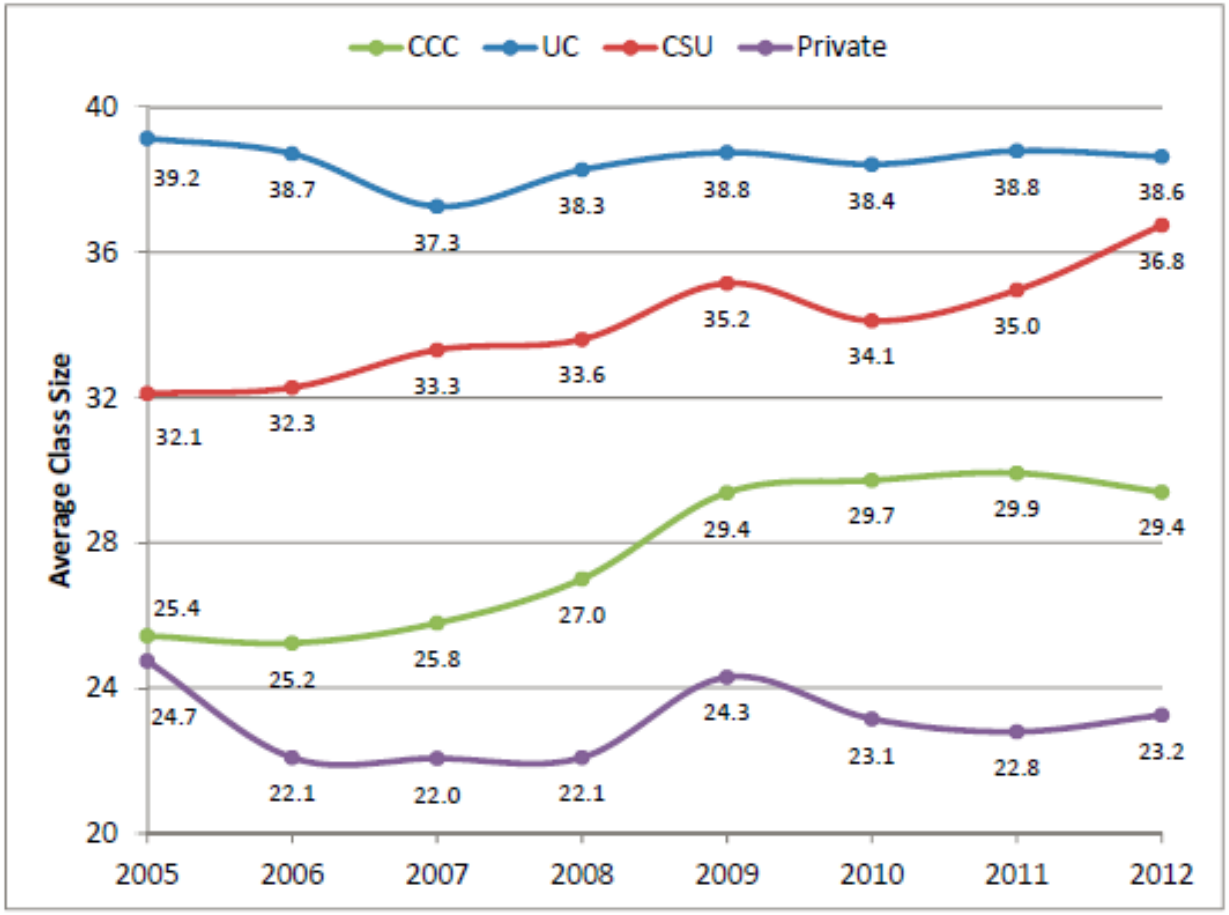


Figure 1. Average class size, by institutional sector



Notes. Community college class size data were computed as total enrollment divided by total sections offered (extracted from (http://datamart.cccco.edu/ on August 25, 2014). Class size data for UC, CSU, and Private derive from colleges that had publically available elements of the Common Data Set (section I) available on their websites for the years between 2005-06 and 2012-13. Included colleges for each sector are: UC (Los Angeles, Berkeley, San Diego, Irvine, Santa Cruz, Davis), CSU (Los Angeles, San Jose, Sacramento (except 2007), Long Beach, Stanislaus, San Marcos, Humboldt, Cal Poly, San Bernardino), and Private (Stanford University, CalTech, St. Mary's College, Santa Clara University, Pomona College, Occidental College). As class section size were binned into categories, midpoints were taken for each section (e.g., 10-19 = 15 students), and sections above 100 were considered as 150 students (results are not sensitive to changes in these definitions).

Study

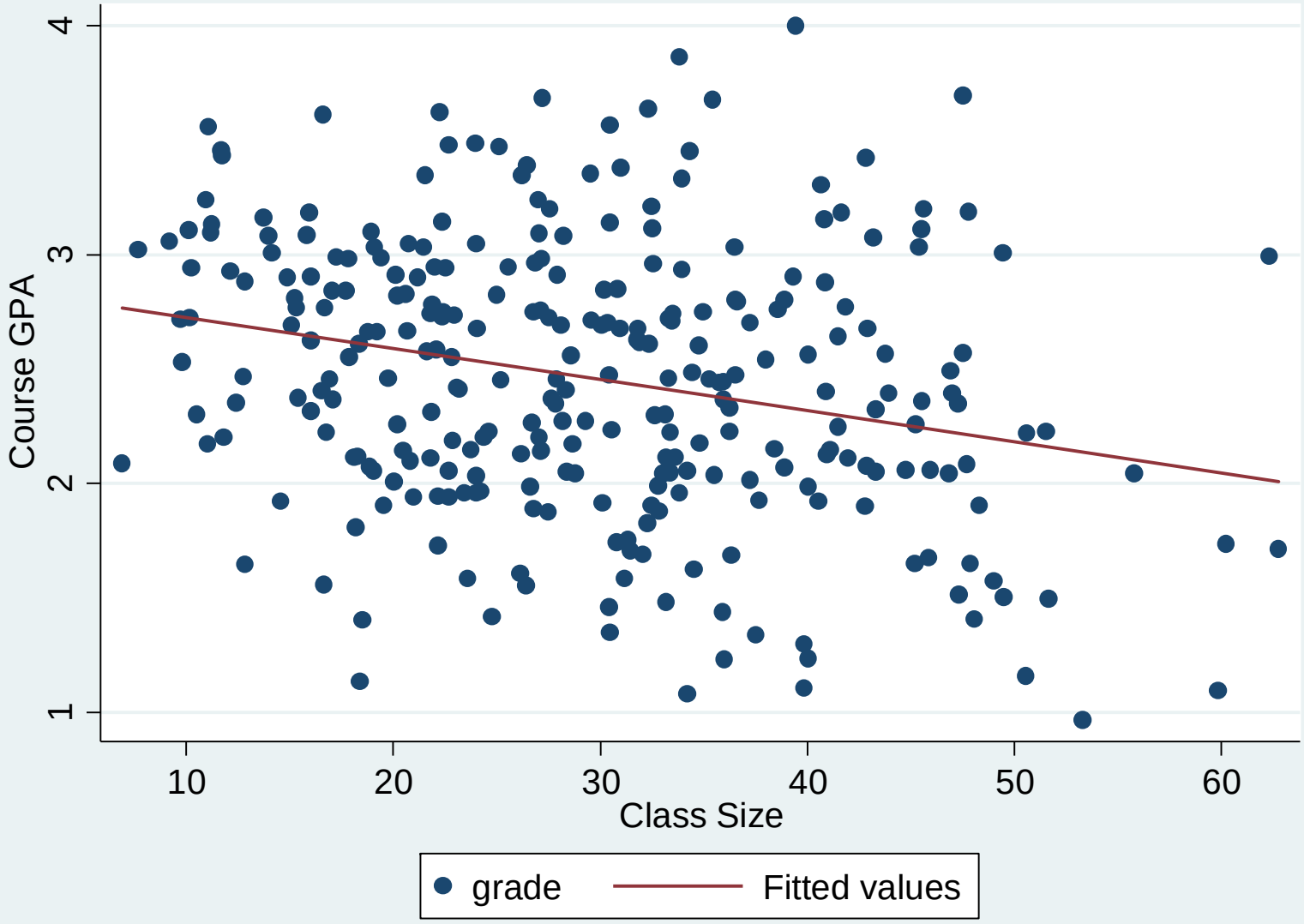
- Question: What is the relationship between class size and academic outcomes in community college
- Setting: Large California community college
  - Slightly older and higher representation of Asian
- Preview of Findings:
  - Robust but small negative effects on course performance
  - Inconsistent effects on persistence
  - Main effects should be thought of as lower bound

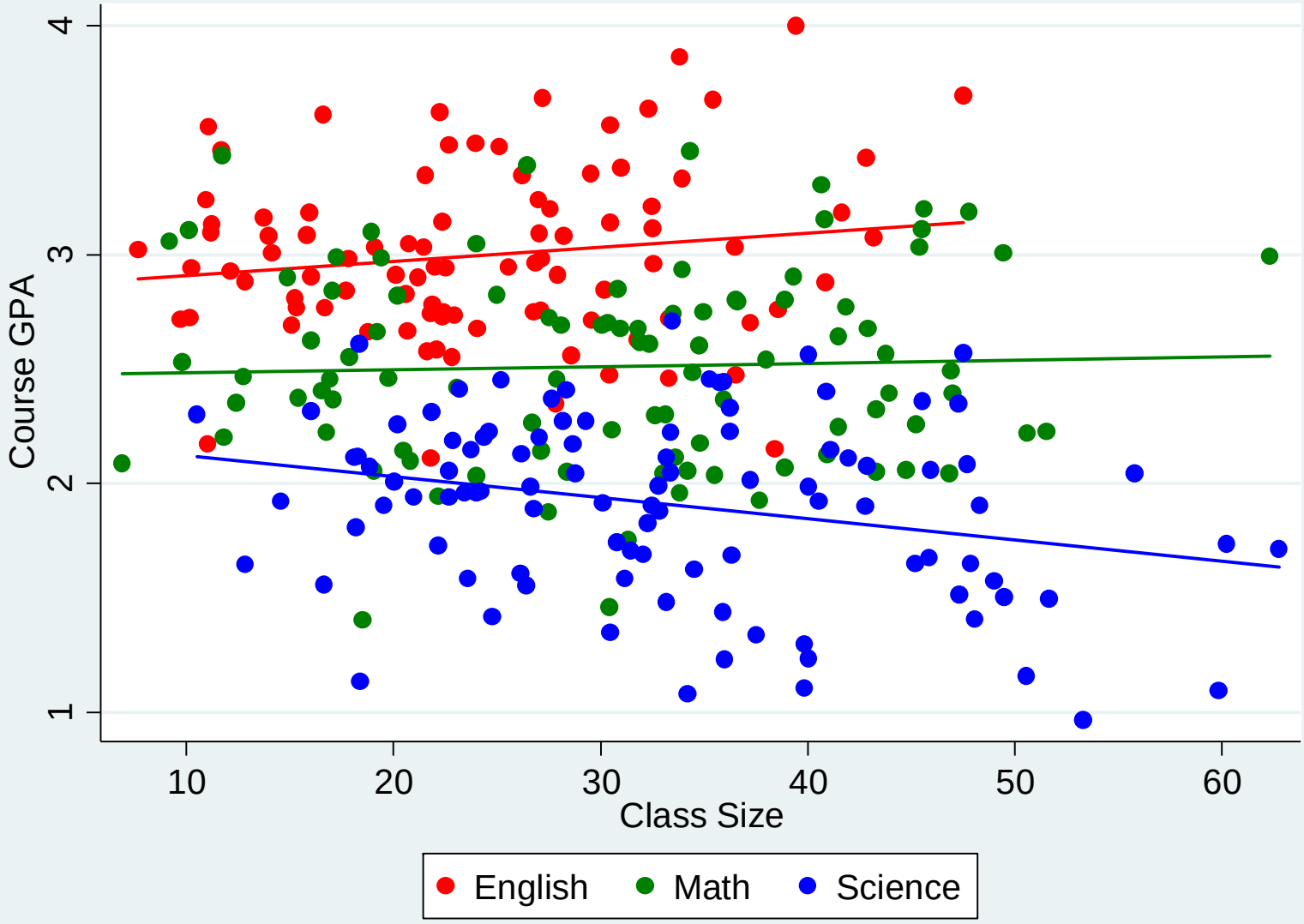
"Hierarchy" of Research

- Randomized Control Trials
- Regression Discontinuity
- Instrumental Variables
- FIXED EFFECTS
- Matching
- Regression

Benefits:

- Data available
- Can have strong internal validity
- Can have strong external validity
- Underlies many other techniques
- Non-parametric


Course GPA
1
2
3
4
10
20
30
40
50
60
Class Size
grade
Fitted values


Course GPA
1
2
3
4
10
20
30
40
50
60
Class Size
English
Math
Science

Estimating Class Size Effects

- Courses are graded differently
- Teachers grade differently
- Non-random sorting of students to teachers:
  - A good teacher or easy grader may have larger classes, biasing effects downwards

- Good use of fixed effects can remove some of these sources of omitted variable bias

Fixed Effects

- Ex: Data on math performance and class size

$$Y_1 = Size_1$$
$$\ldots$$
$$Y_4 = Size_4$$

$$Y_1 = Size_1 + Teacher_1$$
$$Y_2 = Size_2 + Teacher_1$$
$$Y_3 = Size_3 + Teacher_2$$
$$Y_4 = Size_4 + Teacher_2$$

Fixed Effects

- Ex: Data on math performance and class size

$$Y_1 = Size_1 + Teacher_1$$
$$-Y_2 = Size_2 + Teacher_1$$

$$Y_1 - Y_2 = (Size_1 - Size_2) + (Teacher_1 - Teacher_1)$$

$$\rightarrow Y_1 - Y_2 = (Size_1 - Size_2)$$
$$Y_3 - Y_4 = (Size_3 - Size_4)$$

What Are We Estimating?

- "Treatment" effect after conditioning out fixed, time-invariant characteristics

$$Y_1 - Y_2 = (Size_1 - Size_2) + (Teacher_1 - Teacher_1)$$

- Cannot estimate effects for ANY time-invariant chars

$$Y_1 = Size_1 + Teacher_1 + FemaleTeacher$$
$$Y_2 = Size_2 + Teacher_1 + FemaleTeacher$$

$$Y_1 - Y_2 = (Size_1 - Size_2) + (Teacher_1 - Teacher_2) + (Female - Female)$$

What Are We Estimating?

- "Treatment" effect after conditioning out fixed, time-invariant characteristics
  - Cannot estimate effects for ANY time-invariant chars

- Calculates effects using only variance from "within" the fixed effect
  - All between-unit variance eliminated
  - Precision-weighted treatment effect
    - Covariance of "variance of treatment within units" and "effect within units"
    - Average within-unit variance in treatment

$$Y_1 - \bar{Y} = (Size_1 - \overline{Size})$$

$$E[\hat{\delta}] = \bar{\delta} + \frac{Cov(\sigma_j^2, \bar{\delta}_j)}{\overline{\sigma_j^2}}$$

Fixed Effects

- Typically have more than two observations

$$Y_1 = Size_1 + Teacher_1$$
$$Y_2 = Size_2 + Teacher_1$$
$$Y_3 = Size_3 + Teacher_1$$

$$Y_1 - \bar{Y} = (Size_1 - \overline{Size}) + (Teacher_1 - \overline{Teacher})$$

$$Y_1 - \bar{Y} = (Size_1 - \overline{Size})$$
$$Y_2 - \bar{Y} = (Size_2 - \overline{Size})$$
$$Y_3 - \bar{Y} = (Size_3 - \overline{Size})$$

Fixed Effects

- Do we actually create this system of equations? Generally no.

$$Y_1 - \bar{Y} = (Size_1 - \overline{Size})$$
$$Y_2 - \bar{Y} = (Size_2 - \overline{Size})$$
$$Y_3 - \bar{Y} = (Size_3 - \overline{Size})$$

- Equivalent to:

$$Y_i = Size_i + Teacher_1 + \cdots + Teacher_n$$
$$Y_i = Size_i + Teacher\_FE$$

Types of Fixed Effects

- College, teacher, course,…
- Individual FE
  - Online course-taking
  - Returns to certificates

$$Y_1 = Online + Oded_1$$
$$Y_2 = NotOnline + Oded_1$$
$$Y_2 - Y_1 = (Online - NotOnline)$$

- Family FE
  - Twin studies, birth weight, Head Start, left-handed
- Interactions
  - Course and teacher vs. “course interacted with teacher”

Fake Class Size Effects

Table 1. Fake Class Size Effects									
	(1)		(2)		(3)		(4)		(5)
Class Size	-0.0069	**	-0.0028		0.0089	**	0.0009		-0.0007
	(0.0022)		(0.0029)		(0.0030)		(0.0033)		(0.0038)
Fixed Effects									
Course	N		Y		N		Y		N
Teacher	N		N		Y		Y		N
Course x Teacher	N		N		N		N		Y
Stata	reg		areg xtreg		areg xtreg		felsdvreg a2reg		areg xtreg

- areg: don't care about FE
- xtreg: Want each FE
- felsdvreg: Two FE
- a2reg: No standard errors
- encode: creates dummies

Estimation Strategy

- Fixed Effects model

$$Y_{ist} = Class\_size_s + \theta_t + \mu_i + \pi_s + X_{st} + \varepsilon_{ist}$$

θ_t: "teacher by course" fixed effect

μ_i: student fixed effect

π_s: section fixed effects (time and location)

X_{st}: section-specific covariates ("peer effects")

Data

- Data from 2005-06 to 2011-12
  - 817,000 student-course observation
  - 92,500 unique students
  - 33,500 course sections
  - 4,400 teacher-course fixed effects (no teacher chars.)
- Sample restrictions:
  - Weaker academic (e.g., PE), prior degree, FE requirements
  - Rule of Thumb: Restrictions have small effect; sample slightly younger and worse academically; more English and Sciences courses

Outcomes

- Course Performance
  - Passed Course
  - Course Grade

- Persistence
  - Within college
  - Within subject (10 categories: art, business, ESL, English, health, language, math, science, social science, tech)

Fixed Effects

- For causality, ideally "treatment" variable is conditionally random
  - After controlling for fixed effects, are there residual correlations between class size and other factors?
  - Regress potential confounders on treatment effect plus fixed effects

$$Y_{ist} = Class\_size_s + TeacherxCourse + Student + \cdots + \varepsilon_{ist}$$

- Plus SUTVA (treatment assignment of one student does not affect the outcome of another student) and correct functional form

$$X_{st} = Class\_size_s + \varepsilon_{ist}$$

$$X_{st} = Class\_size_s + Teacher\ x\ Course + \cdots + \varepsilon_{ist}$$

Table 2. Association Between Peer Characteristics and Class Size

	(1)		(4)	
Age	-0.17906	***	-0.01872	***
	(0.00241)		(0.00280)	
Latino	0.00032	***	-0.00004	
	(0.00005)		(0.00009)	
Black	0.00024	***	-0.00025	***
	(0.00004)		(0.00007)	
Asian/PI	0.00262	***	0.00088	***
	(0.00009)		(0.00013)	
Other	-0.00016	***	-0.00011	
	(0.00003)		(0.00005)	
Female	0.00005		0.00006	
	(0.00008)		(0.00012)	
Number of Terms Enrolled	-0.03261	***	-0.00488	**
	(0.00100)		(0.00183)	
Cumulative GPA	-0.00630	***	0.00042	
	(0.00014)		(0.00023)	
Units Attempted	-0.11402	***	-0.02980	
	(0.00850)		(0.01752)	
Units Earned	-0.07604	***	-0.00067	
	(0.00578)		(0.01028)	
Controls:	N		N	
Teacher x Course FE	N		Y	
Section-Level FE	N		Y	
N	33510		33510	

Main Specification

Table 3. Estimated Class Size Effects, Using Final Class Size

	(1) Passed Course		(2) Course Grade		(4) Persisted or Graduated		(6) Persisted In Subject or Graduated	
No Controls	-0.000199	**	-0.001131	***	-0.000128	*	-0.000199	*
	(0.000075)		(0.000232)		(0.000053)		(0.000082)	
Peer Controls	-0.000202	**	-0.001130	***	-0.000131	*	-0.000192	*
	(0.000075)		(0.000233)		(0.000052)		(0.000082)	
N	816,763		658,410		687,867		687,867	

*** p<0.001 ** p<0.01 * p<0.05

Fixed Effects

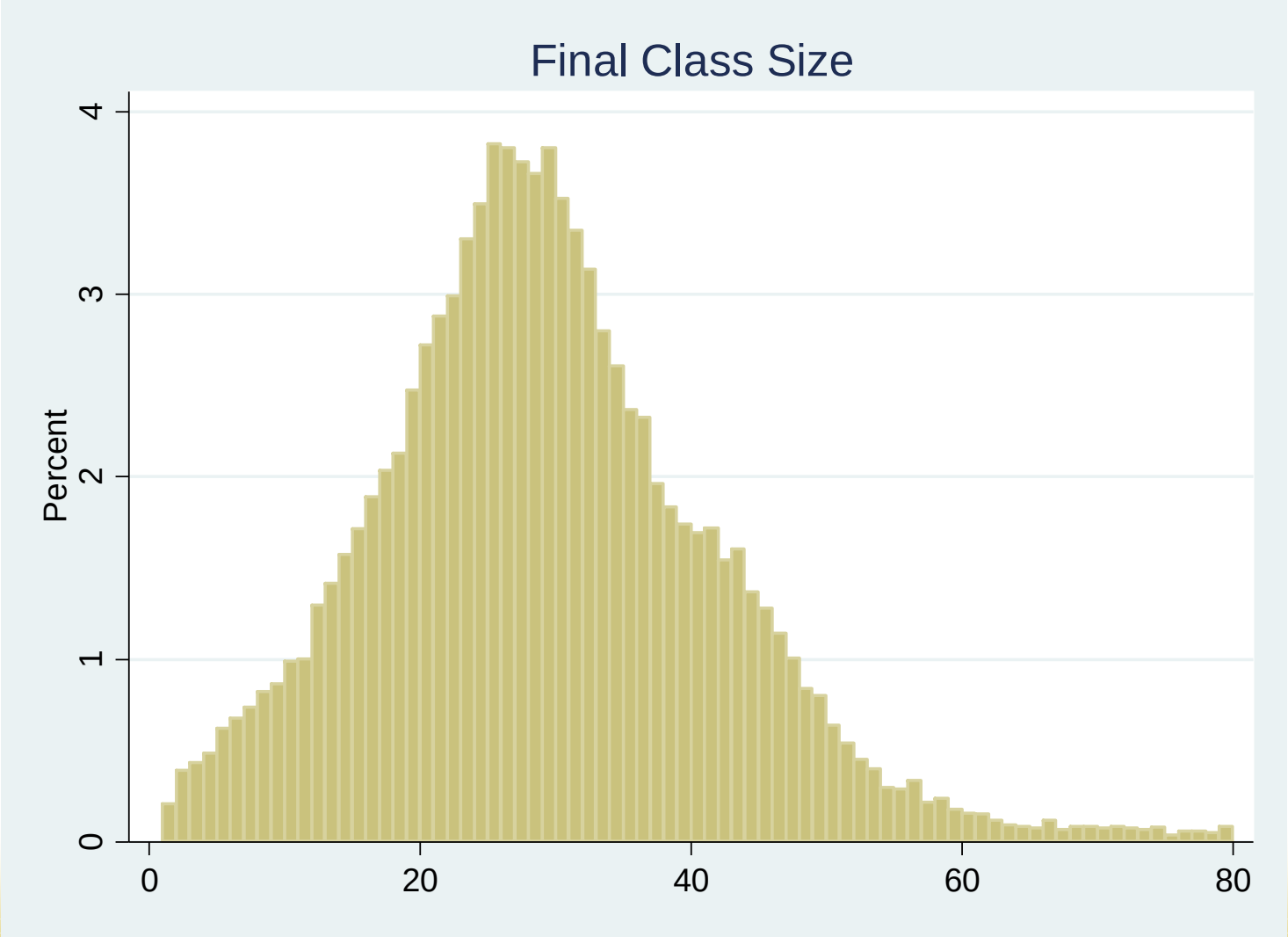
- Clearly, must have "within" variation
  - At least two observations for each FE
  - Sample that contributes to the estimate changes as a result of restrictions
    - Example: Class size effects
      - Students who take one class eliminated
      - Teachers who teach once eliminated
    - Example: Do students perform better in online classes?
    - Example: Left-handed individuals and family fixed effect

Common Issues

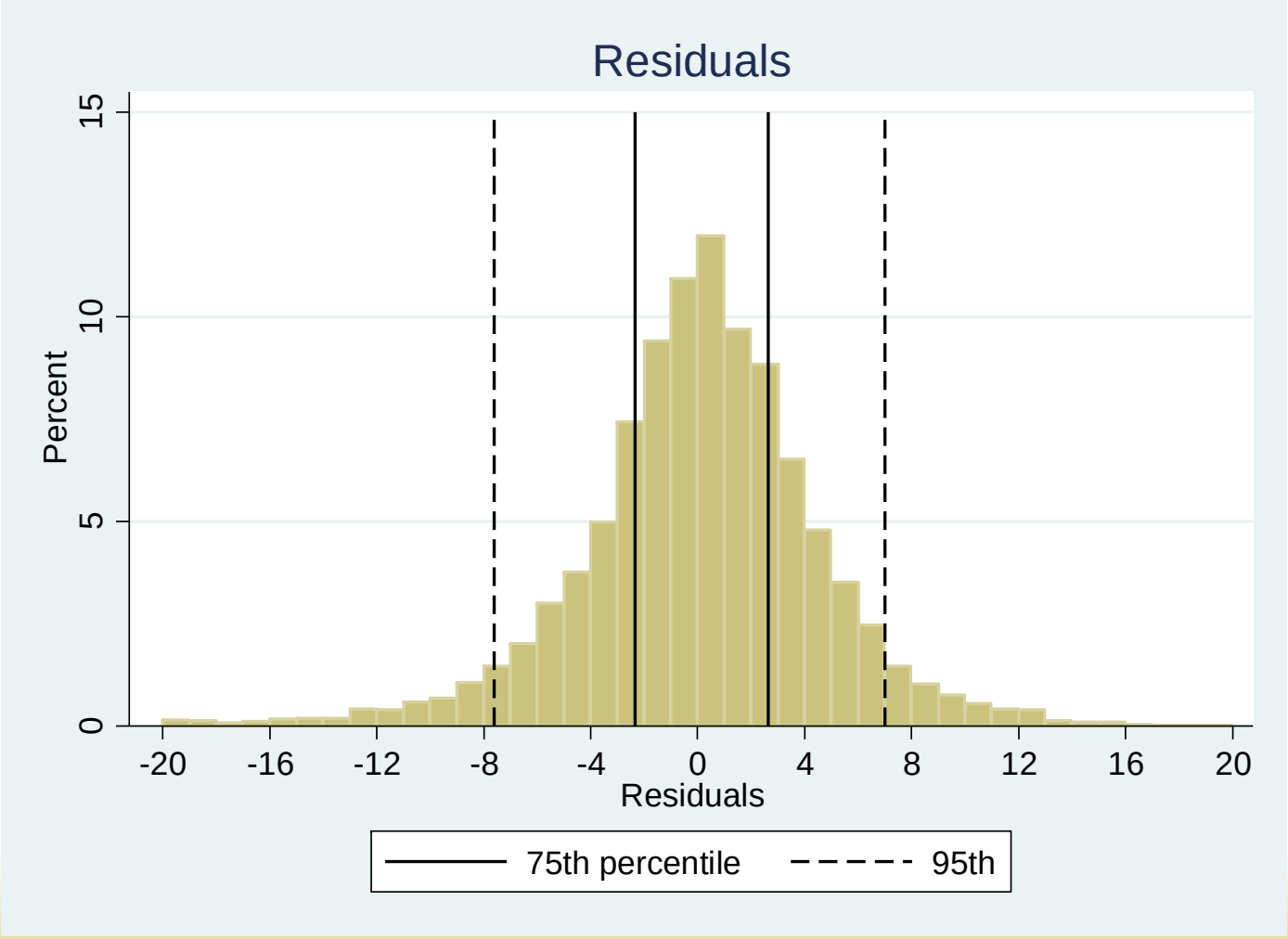
- External Generalizability
  - To whom can you extrapolate?
  - Example: put treatment condition on left-hand side and condition on fixed effects

$$Class\_size = Teacher\ x\ Course + Section + \varepsilon_{ist}$$

Final Class Size



$$Class\_size = Teacher\ x\ Course + Section + \varepsilon_{ist}$$



Common Issues

- Omitted Variables Bias can remain
  - Example: Within-institution tuition changes and enrollment
    - When tuition increases are there concurrent changes? Economic conditions, applicant pool
  - Example: Effect of childcare on student outcomes?
    - Conditionally on family fixed effect, why does one child end up in childcare and the other does not?
  - Example: Online education?
    - Maybe student took course online because they were less interested? Maybe they faced external issues that semester?

Threats to internal validity

- Important to test assumptions:
  - Extreme values (FE can be sensitive to measurement error)
  - Growth can be problematic in FE models

Table 4. Estimated Class Size Effects, Using Final Class Size

	(1) Passed Course		(2) Course Grade		(4) Persisted or Graduated		(6) Persisted In Subject or Graduated	
Eliminated Extreme 10 Percent	-0.000182	*	-0.001296	***	-0.000141	*	-0.000143	
	(0.000086)		(0.000258)		(0.000062)		(0.000097)	
Teacher x Course x Year FE	-0.000206	*	-0.001219	***	0.000190	*	-0.000008	
	(0.000083)		(0.000265)		(0.000079)		(0.000099)	
Subject-specific Preferences	-0.000172	*	-0.000876	***	-0.000153	**	-0.000462	***
	(0.000083)		(0.000251)		(0.000057)		(0.000092)	
N	728,285		586,045		615,150		615,150	
	646,642		519,620		545,864		545,864	
	816,763		658,410		687,867		687,867	

Threats to internal validity

- Important to test assumptions:
  - "Unobserved" preferences for smaller classes

Table 4. Estimated Class Size Effects, Using Final Class Size

	(1) Passed Course		(2) Course Grade		(4) Persisted or Graduated		(6) Persisted In Subject or Graduated	
Eliminated Extreme 10 Percent	-0.000182	*	-0.001296	***	-0.000141	*	-0.000143	
	(0.000086)		(0.000258)		(0.000062)		(0.000097)	
Teacher x Course x Year FE	-0.000206	*	-0.001219	***	0.000190	*	-0.000008	
	(0.000083)		(0.000265)		(0.000079)		(0.000099)	
Subject-specific Preferences	-0.000172	*	-0.000876	***	-0.000153	**	-0.000462	***
	(0.000083)		(0.000251)		(0.000057)		(0.000092)	
N	728,285		586,045		615,150		615,150	
	646,642		519,620		545,864		545,864	
	816,763		658,410		687,867		687,867	

Common Issues

- Is fixed effect a "parameter of interest" or a "nuisance parameter"?
  - Some procedures estimate each effect (xtreg)
  - Absorb if you do not care (areg)

- Do I care about each teachers intercept?
  - Class Size: Not necessarily
  - Teacher Value-Added: Yes

Do we need to use fixed effects?

- Why not difference by hand?
  - Software might not handle too many FE
- Easy with one fixed effect but must correct s.e.
  - Degrees of freedom doesn't account for loss of FE
- Multiple fixed effects: problems w/ unbalanced panels
  - "States and years" not a problem
  - "Teachers and students" is a problem

mark	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
classsize2	-.0024178	.0020708	-1.17	0.243	-.0064775	.0016419
age	.0028419	.0042757	0.66	0.506	-.0055404	.0112242
_cons	2.429507	.1328273	18.29	0.000	2.169104	2.68991
sct2	F(852, 4745) =		3.313	0.000	(853 categories)	

Source	SS	df	MS
Model	1.00590145	2	.502950725
Residual	2319.62136	5597	.414440122
Total	2320.62726	5599	.414471738

Number of obs =	5600
F(2, 5597) =	1.21
Prob > F =	0.2972
R-squared =	0.0004
Adj R-squared =	0.0001
Root MSE =	.64377

c_mark	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
c_classsize2	-.0024178	.0019067	-1.27	0.205	-.0061556	.00132
c_age	.0028419	.0039368	0.72	0.470	-.0048758	.0105596
_cons	-4.41e-10	.0086027	-0.00	1.000	-.0168647	.0168647

Econometrica, Vol. 76, No. 1 (January, 2008), 155–174

NOTES AND COMMENTS

HETEROSKEDASTICITY-ROBUST STANDARD ERRORS FOR FIXED EFFECTS PANEL DATA REGRESSION

BY JAMES H. STOCK AND MARK W. WATSON[1]

The conventional heteroskedasticity-robust (HR) variance matrix estimator for cross-sectional regression (with or without a degrees-of-freedom adjustment), applied to the fixed-effects estimator for panel data with serially uncorrelated errors, is inconsistent if the number of time periods T is fixed (and greater than 2) as the number of entities n increases. We provide a bias-adjusted HR estimator that is $\sqrt{nT}$-consistent under any sequences (n, T) in which n and/or T increase to ∞. This estimator can be extended to handle serial correlation of fixed order.

Do we need to use fixed effects?

- Standard error calculations can be extremely time-consuming for two-way FE models, so try `a2reg' first
  - Easily confused, must have no missing data

- "Trick" to cluster s.e. for two-way models

```
g x=1
foreach var in classsize control {
a2reg `var' x, individual(student) group(teacher)
predict `var'2
}
reg classsize2 control2, cluster(___)
```

Fixed effects vs. First differencing

$$Y_1 = Size_1 + Teacher_1$$
$$Y_2 = Size_2 + Teacher_1$$
$$Y_3 = Size_3 + Teacher_1$$

- Fixed Effect

$$Y_1 - \bar{Y} = (Size_1 - \overline{Size})$$
$$Y_2 - \bar{Y} = (Size_2 - \overline{Size})$$
$$Y_3 - \bar{Y} = (Size_3 - \overline{Size})$$

- First Difference:

$$Y_2 - Y_1 = (Size_2 - Size_1)$$
$$Y_3 - Y_2 = (Size_3 - Size_2)$$

- FD might be better if error term correlated
  - Hard to test
- FD incorrect when lagged terms in model
- FE better for unbalanced panels

Fixed Effects - Heterogeneity

- Removes ALL time-invariant characteristics within the fixed effect
  - Example: Cannot include race or ethnicity as variables
  - Can interact terms or run separate regressions
    - CAUTION! Different regressions can lead to different results
    - Example: Does class size have different impacts for males and females?
  - Not every FE model is well-suited to examining heterogeneity

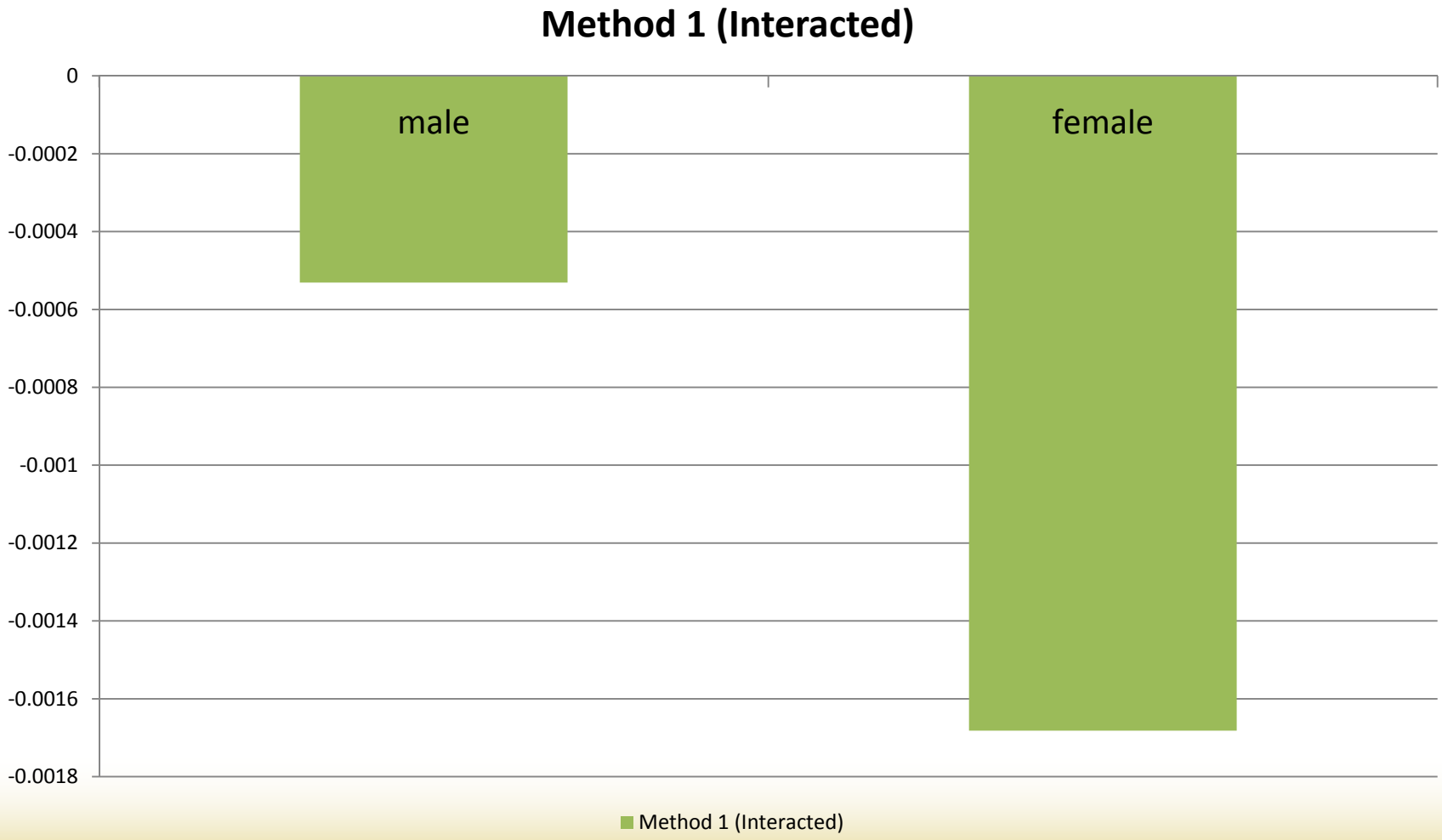
Heterogeneity

- Fixed Effects model

$$Y_{ist} = CS + CS * female + \mu_i + \pi_s + \theta_t + X_{st} + \varepsilon_{ist} \qquad (1)$$

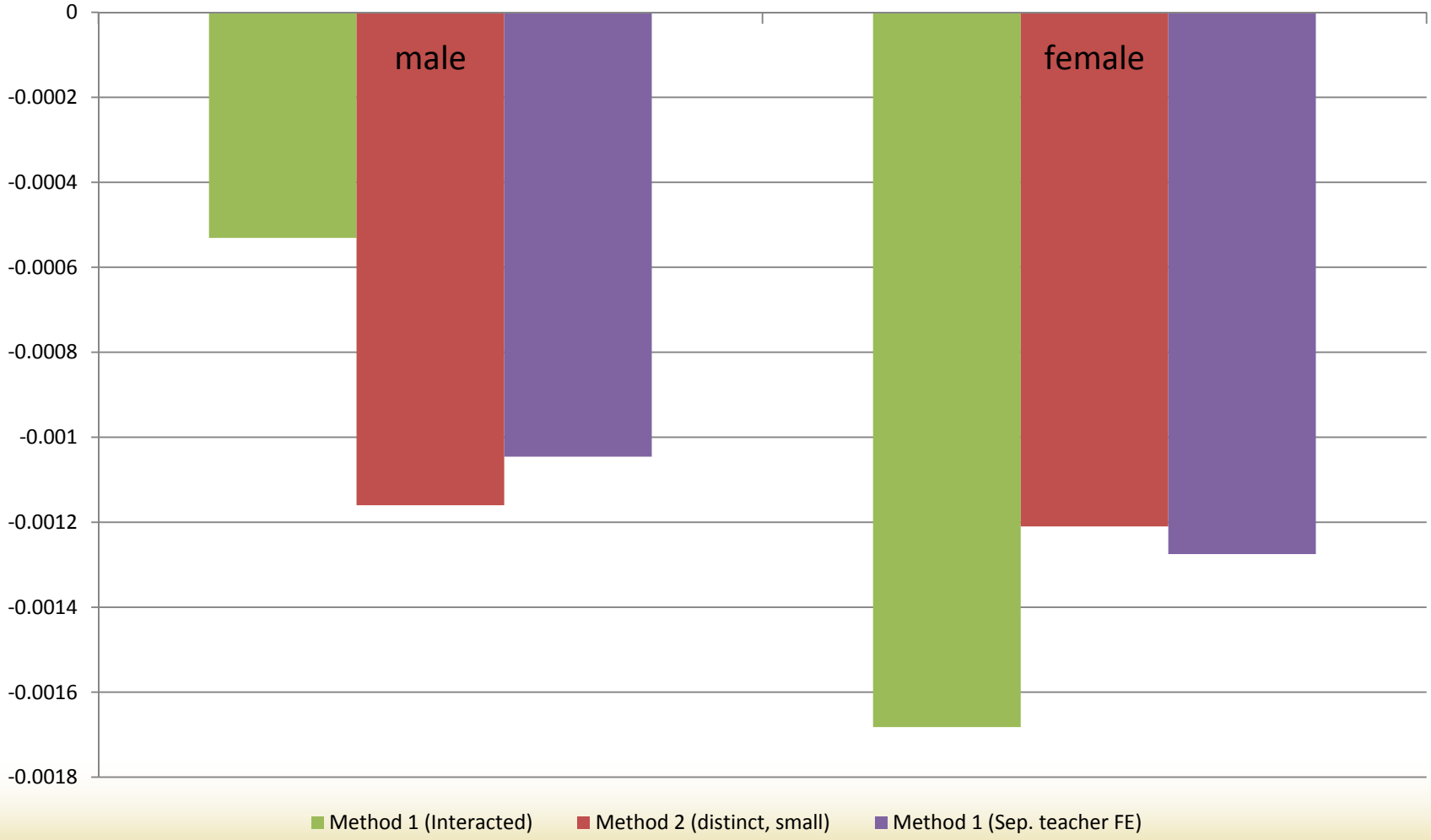
$$Y_{ist} = CS + \mu_i + \pi_s + \theta_t + X_{st} + \varepsilon_{ist} \text{ (females only)} \qquad (2)$$

Male vs. Female Heterogeneity



Male vs. Female Heterogeneity

Male vs. Female Heterogeneity



Effect Size

- Increase of five students decreases passage rates by ~0.1 percentage points (mean=68.6%)
- Standard Deviation: ~18 students over entire sample, ~8 within subject
  - "Standardized Effect": ~0.01 standard deviations over full sample
- Instruct 300 students in:
  - 9 classes of 33.3 students vs. 10 classes of 30 students
  - Pay ~$3000 or $10/student
  - $1000 reduces individual student failure by 6pp

Conclusion

- Class size inversely related to course performance
- Effects are much smaller in magnitude than those found in selective four-year universities
- Likely "pure" class size effect
  - Small changes in class size likely unrelated to corresponding changes in course content, instructional style, peer qualities, technology
- Class size increases may be appropriate policy response during recession compared to alternatives of lower enrollment

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