

# How Does Your Kindergarten Classroom Affect Your Earnings? Evidence from Project STAR

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## How Does Your Kindergarten Class Affect Your Earnings?

- What are the long-term impacts of early childhood education?
- Limited evidence to date because few datasets link information on early childhood test scores with data on adult outcomes
- We link data from the STAR experiment to US tax records to analyze how KG class assignment affects long-term outcomes

## Project STAR: Background

- Student/Teacher Achievement Ratio (STAR) experiment is one of the most widely studied education interventions
  - Conducted from 1985 to 1989 in Tennessee
  - One cohort of 11,571 children in grades K-3 at 79 schools
  - Most children in the experiment born in 1979-80 → graduate high school in 1998
- Students and teachers randomized into classrooms within schools
  - Class size differs: small (~15 students) or large (~22 students)
  - Classes also differ in teachers and peers
- Only one cohort treated → no repeat teacher observations

## Project STAR: Background

- Large literature on STAR shows that class size, teacher quality, and peer quality have causal impacts on scores
    - Students in small classes have 5 percentile point (0.2 sd) higher test scores in K-3 (Krueger 1999)
    - Students assigned to more experienced teachers have higher scores
  - Test score gains fade out to 1-2 percentiles by grade 8
    - Similar fade out effects observed in other early childhood interventions (e.g. Currie and Thomas 1995, Deming 2009)
- Do early test score gains translate into impacts on adult outcomes?

## United States Tax Data

- Access to selected variables in anonymous U.S. tax records to conduct research on behavioral responses to economic policies
- Dataset covers full U.S. population from 1996-2008
- Approximately 90% of working age adults file tax returns
- *Third-party* reports yield data on many outcomes even for non-filers
  - Employer and wage earnings from W-2 forms
  - College attendance from 1098-T forms
- 95% of STAR records were linked to tax data
  - Match rate orthogonal to treatments

**Table 1: Summary Statistics**

	Mean (1)	St. Dev. (2)
Average Wage Earnings (2005-07)	\$15,910	\$15,558
Fraction With Zero Earnings ('05-'07)	13.9%	34.5%
Attended College in 2000 (age 20)	26.4%	44.1%
Ever Attended College by age 28	45.5%	49.8%
Average Parental Income ('96-'98)	\$48,010	\$41,622
Fraction Black	35.9%	48.0%

## Outline

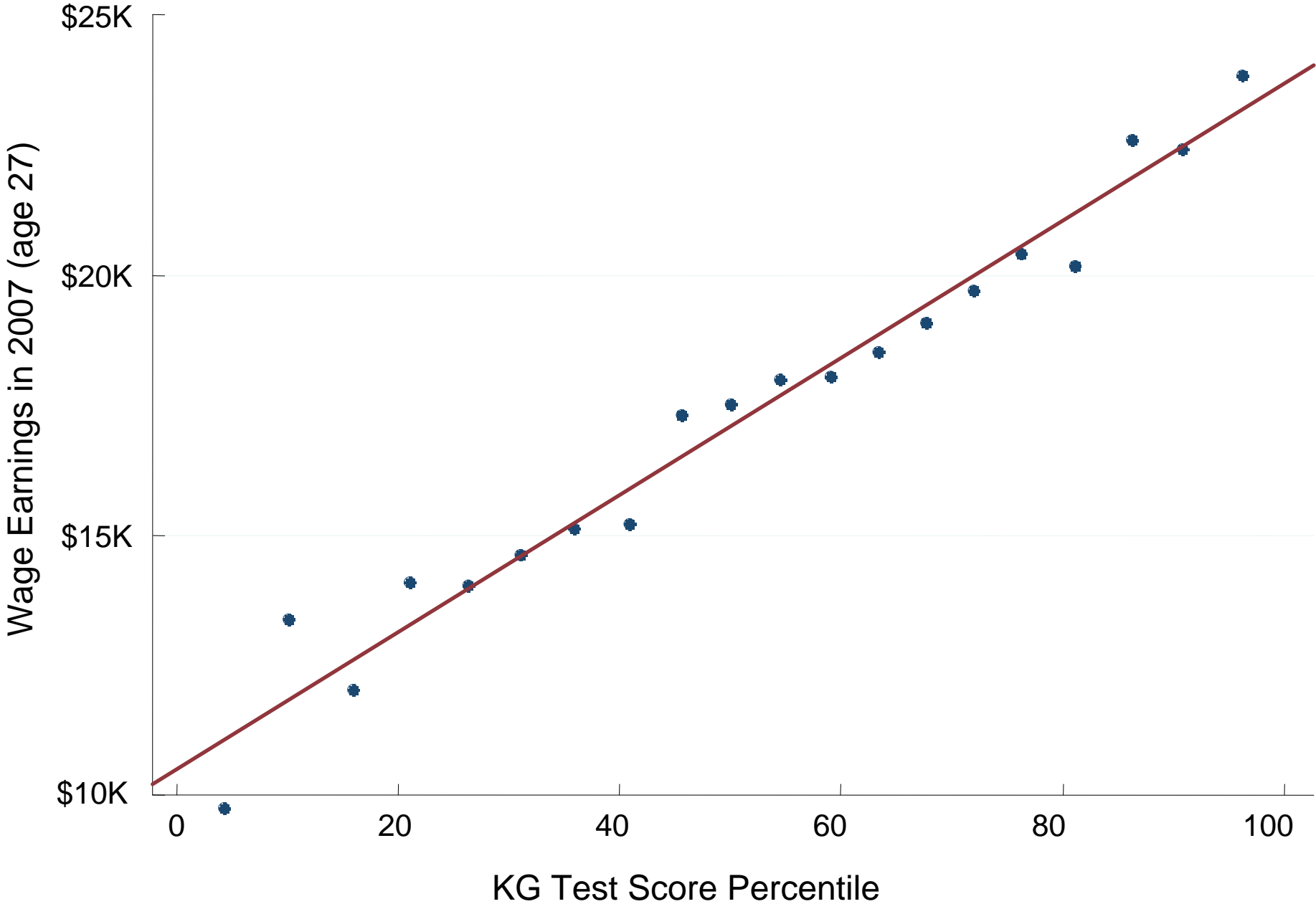
1. Test scores and adult outcomes in the cross-section
2. Re-evaluate validity of STAR experimental design
3. Class size impacts on adult outcomes
4. Teacher/peer impacts on adult outcomes
5. Fade-out, Re-Emergence, and Non-Cognitive Skills
6. Conclusion: Cost-Benefit Analysis

## Part 1: Cross-Sectional Correlations

- Begin with OLS estimates of return to higher early childhood test scores by correlating KG test scores with adult outcomes
- Useful to benchmark estimates obtained from randomized interventions
- Test score: percentile score on Stanford Achievement Test (math + reading), constructed as in Krueger (1999)
- Estimate both raw correlations and with controls:
  - quartic in parental household income interacted with marital status
  - mother age at child's birth
  - parent's 401K contributions, home ownership
  - child's gender, free lunch status, race, and age



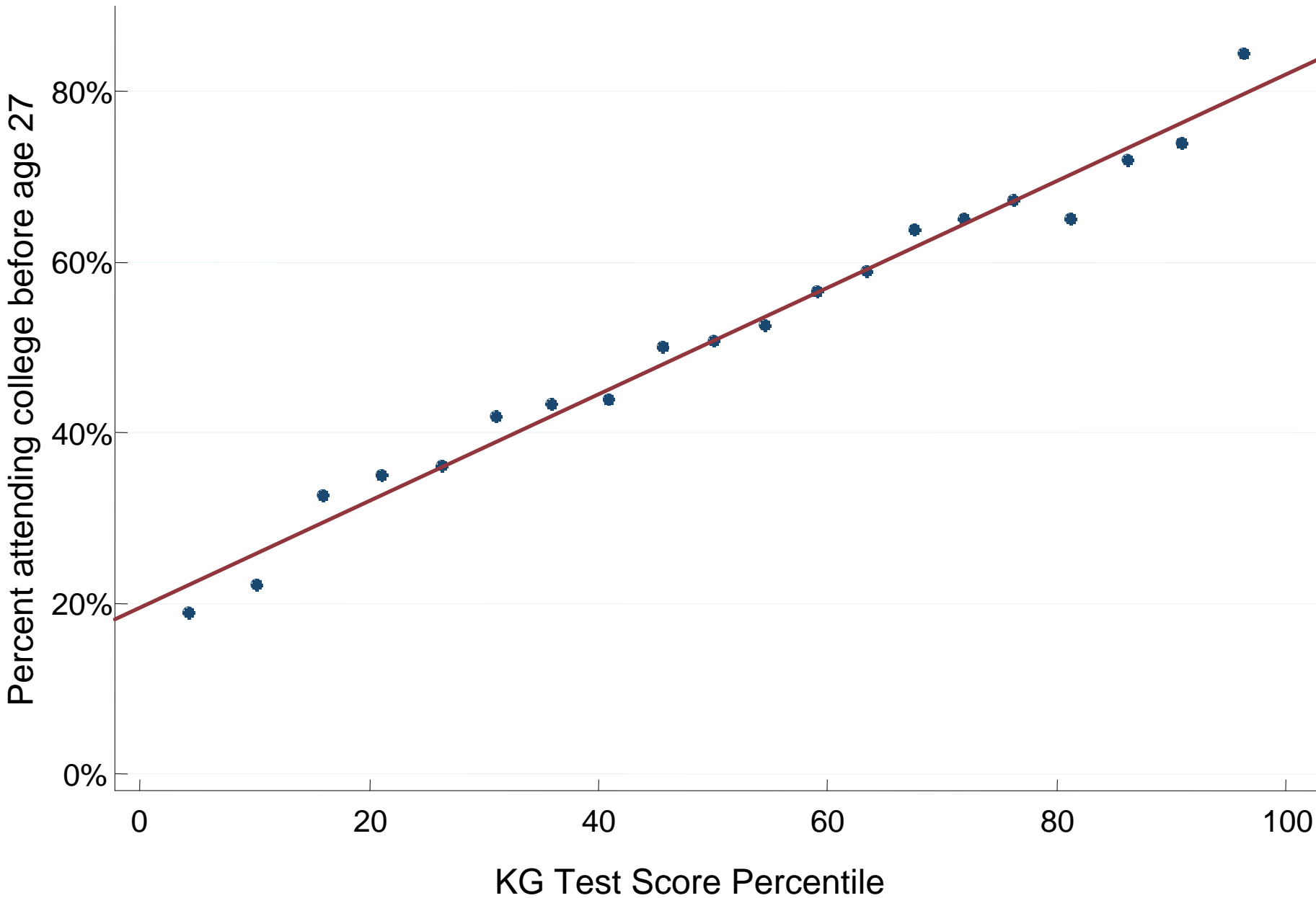
**Figure 1: Wage Earnings in 2007 vs. KG Test Score**



**Table 2: Test Scores and Earnings in the Cross-Section**

Dependent Var.:	Wage Earnings			Log Wage Earnings	Wage Earnings
	(1)	(2)	(3)	(4)	(5)
KG Test percentile	<b>\$131.74</b> (\$7.63)	<b>\$142.98</b> (\$9.32)	<b>\$93.79</b> (\$9.56)		<b>\$105.54</b> (\$9.46)
KG Test z score				<b>0.180</b> (0.026)	
Parental Income Percentile					<b>\$157.68</b> (\$8.54)
Black			-\$46.77 (\$878.70)	0.086 (0.085)	
Controls			x	x	
Class Fixed Effects		x	x	x	x
Adjusted R <sup>2</sup>	0.05	0.09	0.17	0.11	0.16
Observations	5,621	5,621	5,621	5,154	5,621

**Figure 2a: College Attendance Rates vs. KG Test Score**



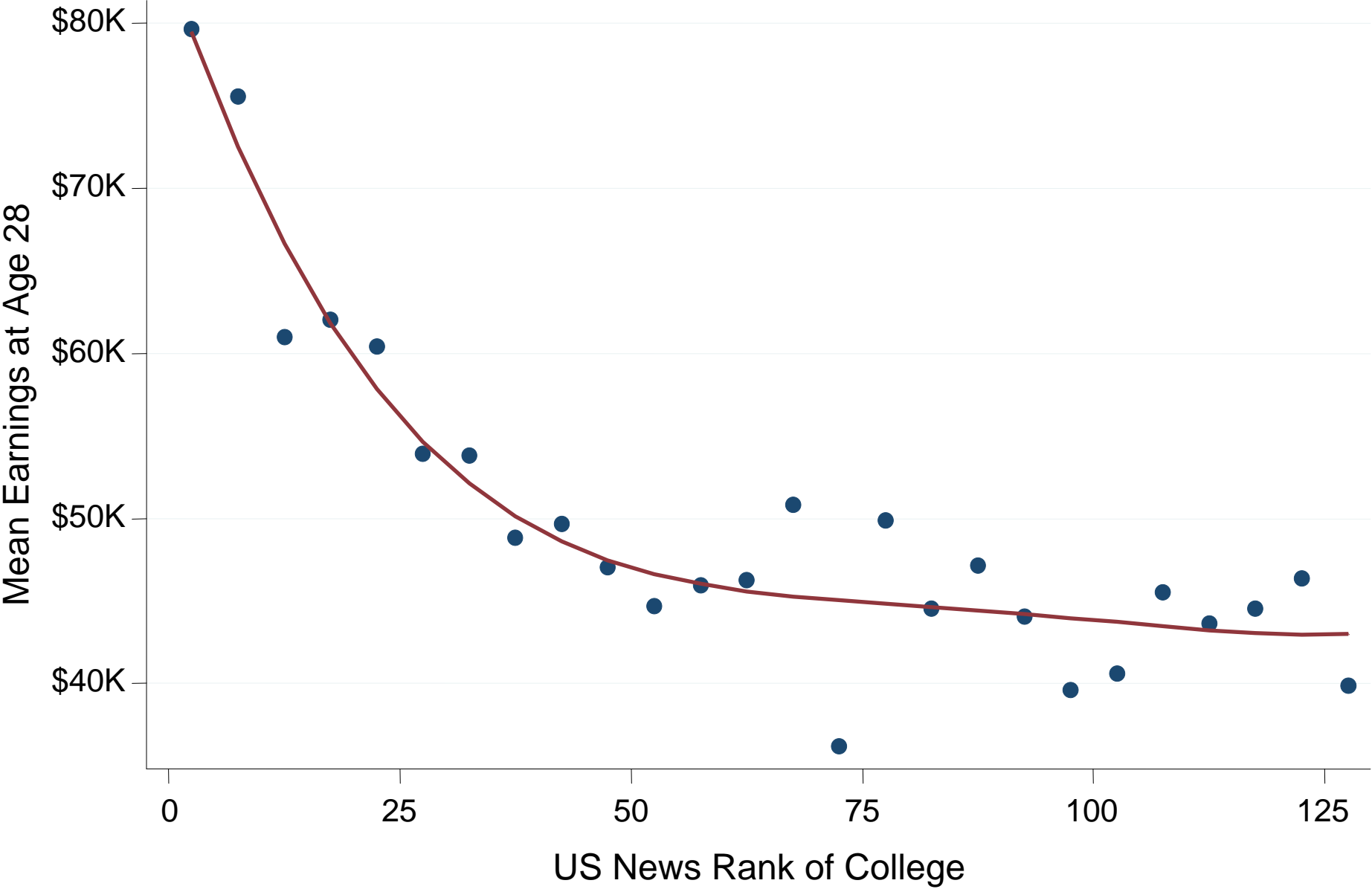
## An Earnings-Based Index of College Quality

- We construct an index of college quality using tax data
- Tuition paid to any higher ed. institution automatically generates a 1098-T form linking student and institution
  - Form filed even if student did not pay out-of-pocket and received a full scholarship
- Find everyone age 20 enrolled in college in 1999
- Calculate average wage earnings in 2007 (from W-2s) by college
- For those who do not attend college, define college quality index as mean earnings for those not in college in 1999

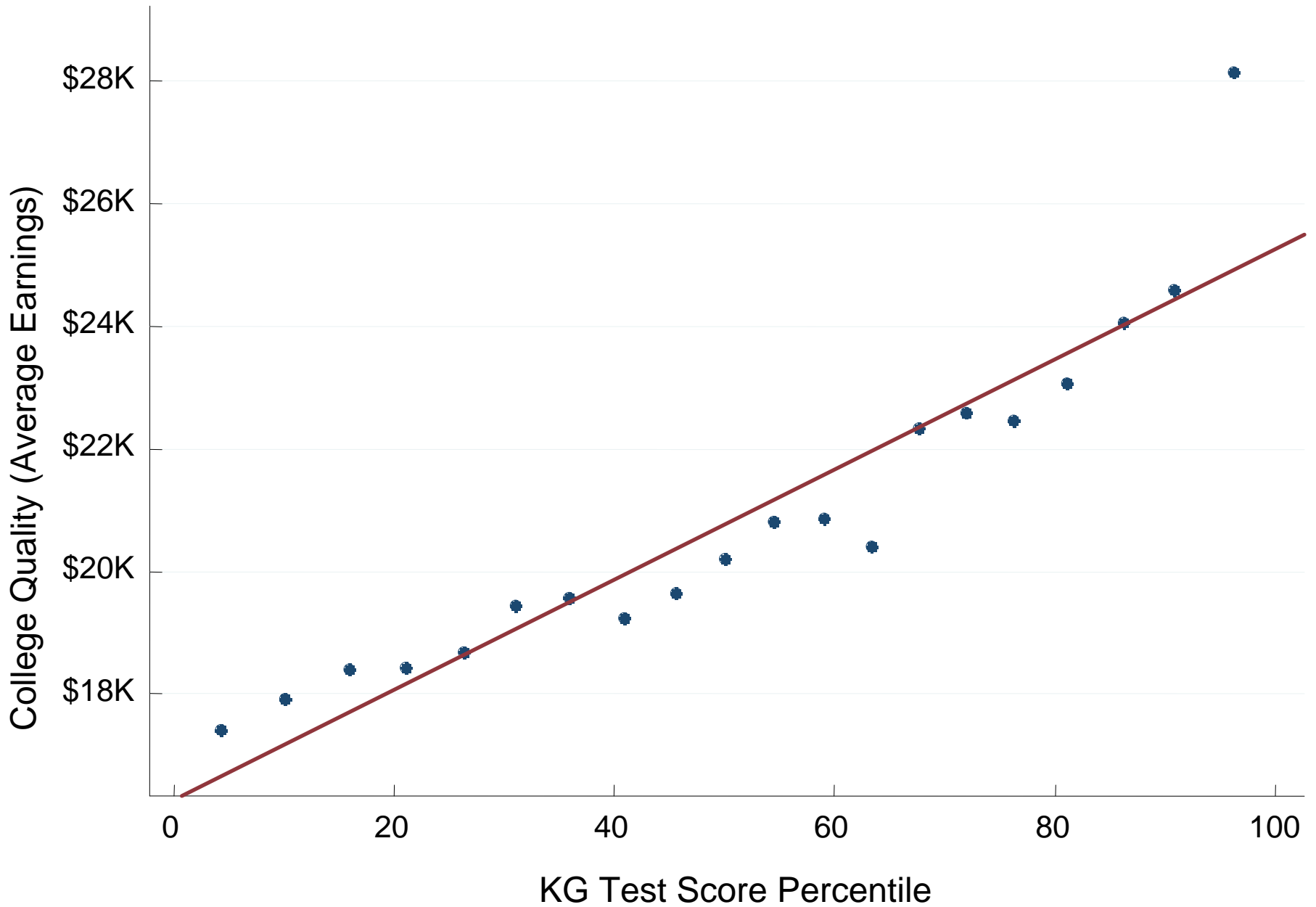
**Table 3: An Earnings-Based Index of College Quality**

US News Ranking	College	Mean Earnings at age 28
1	Harvard Princeton Yale Cal Tech MIT	\$79,643
2		
3		
4		
5		
6	Stanford U Penn Columbia U Chicago Duke	\$75,570
7		
8		
9		
10		
....		
121	Arizona St. Catholic U MI Tech U Buffalo U San Fran	\$46,390
122		
123		
124		
125		

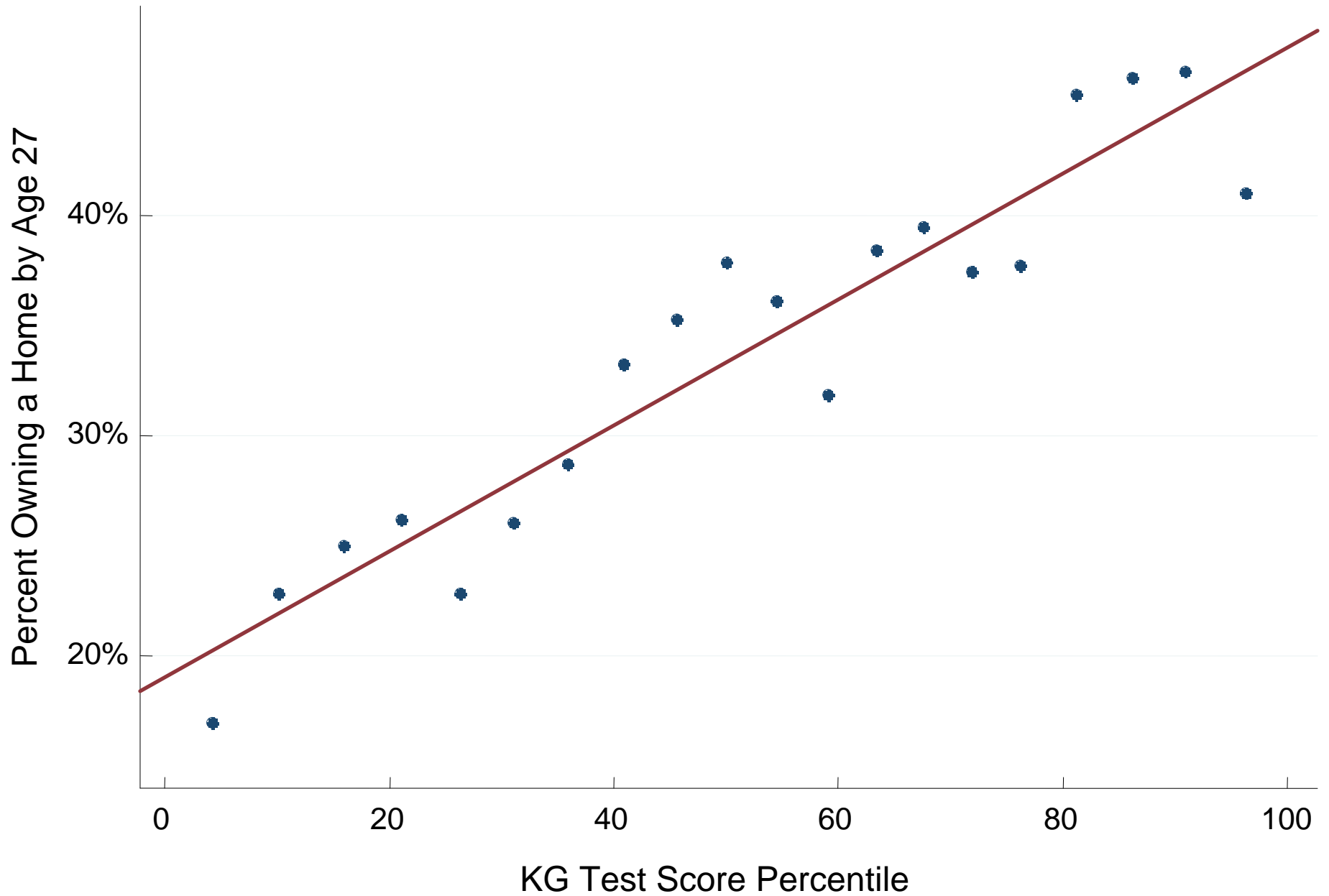
# College Mean Wage Earnings by US News Ranking



**Figure 2b: College Quality vs. KG Test Score**

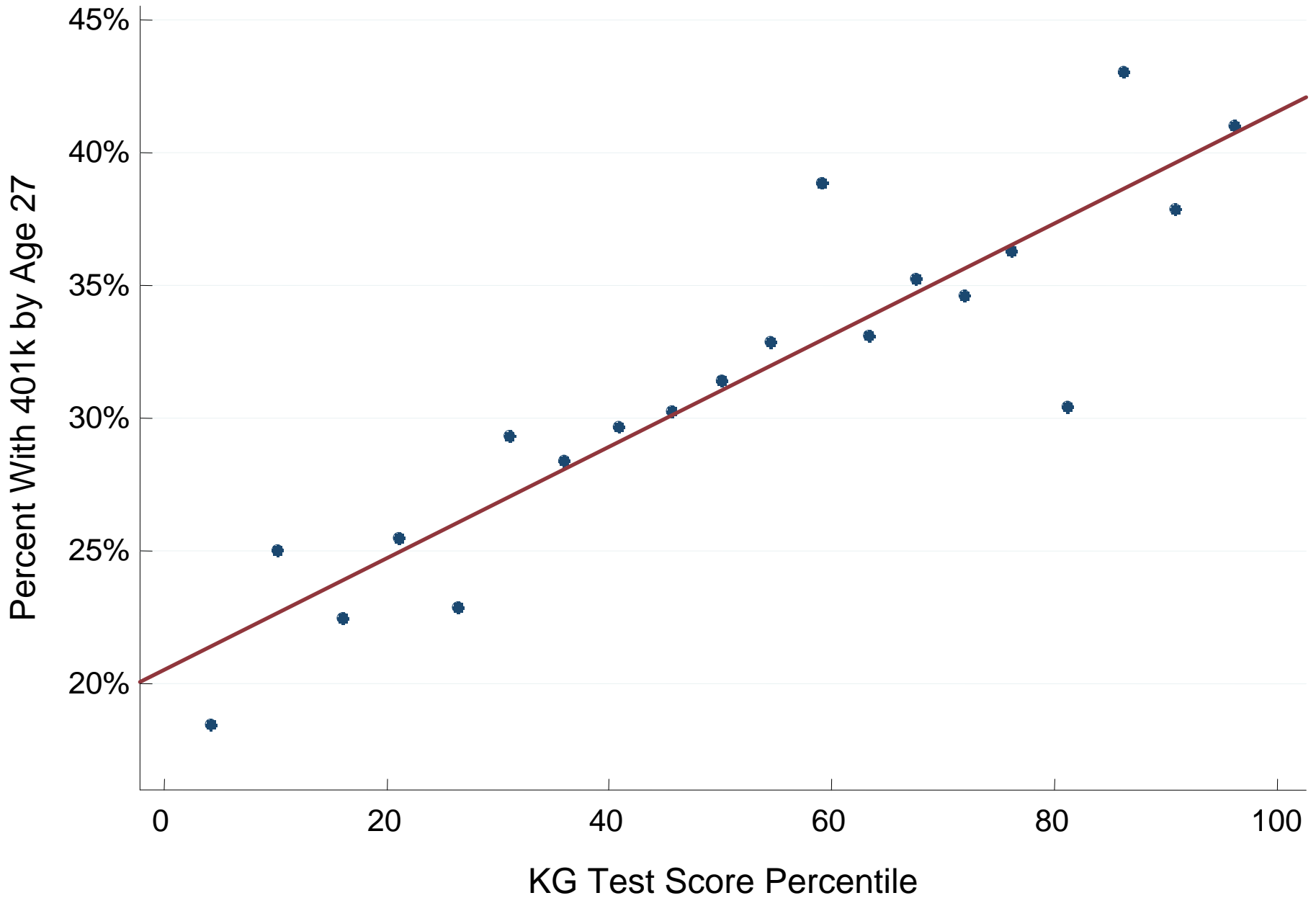


**Figure 3a: Home Ownership vs. KG Test Score**

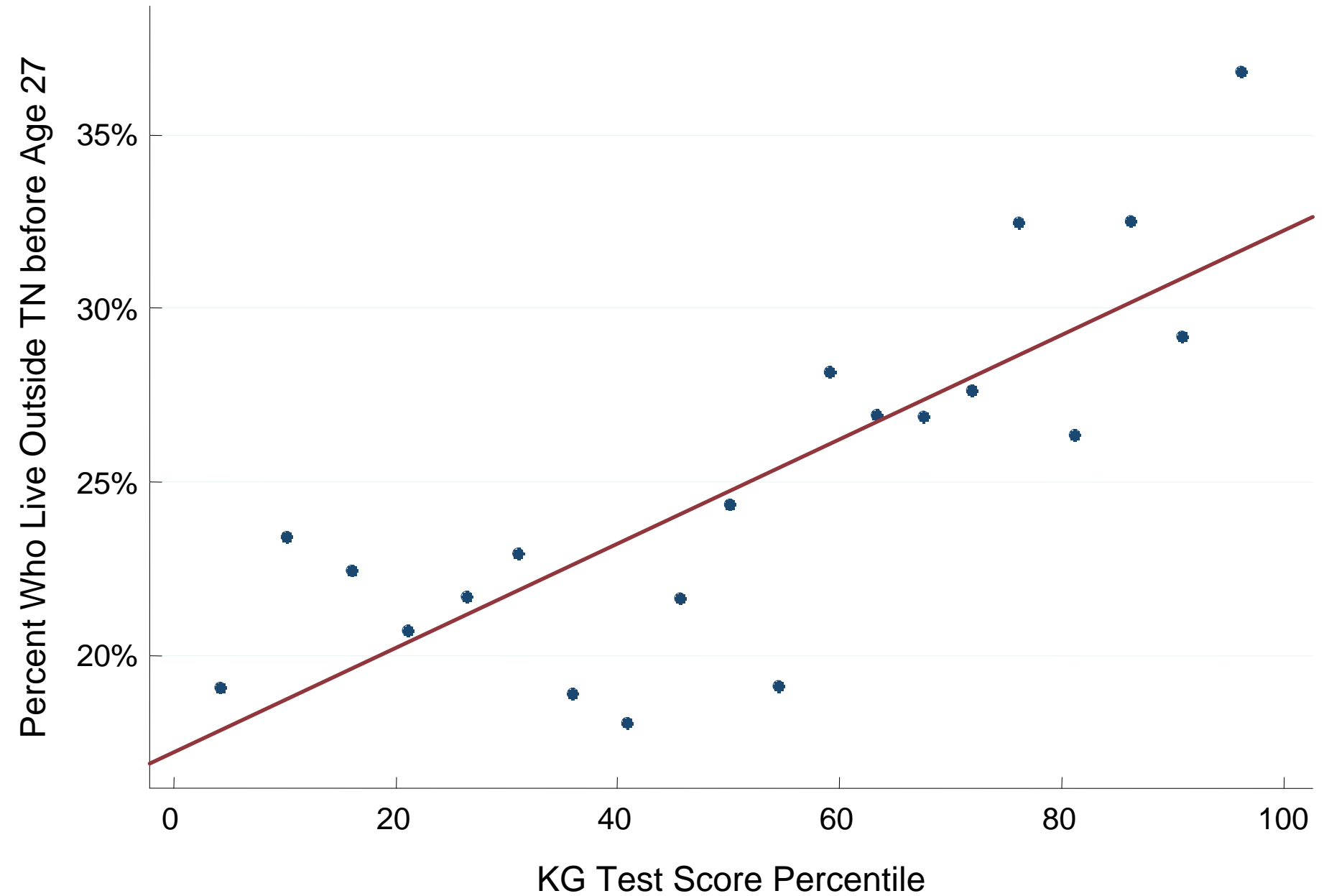




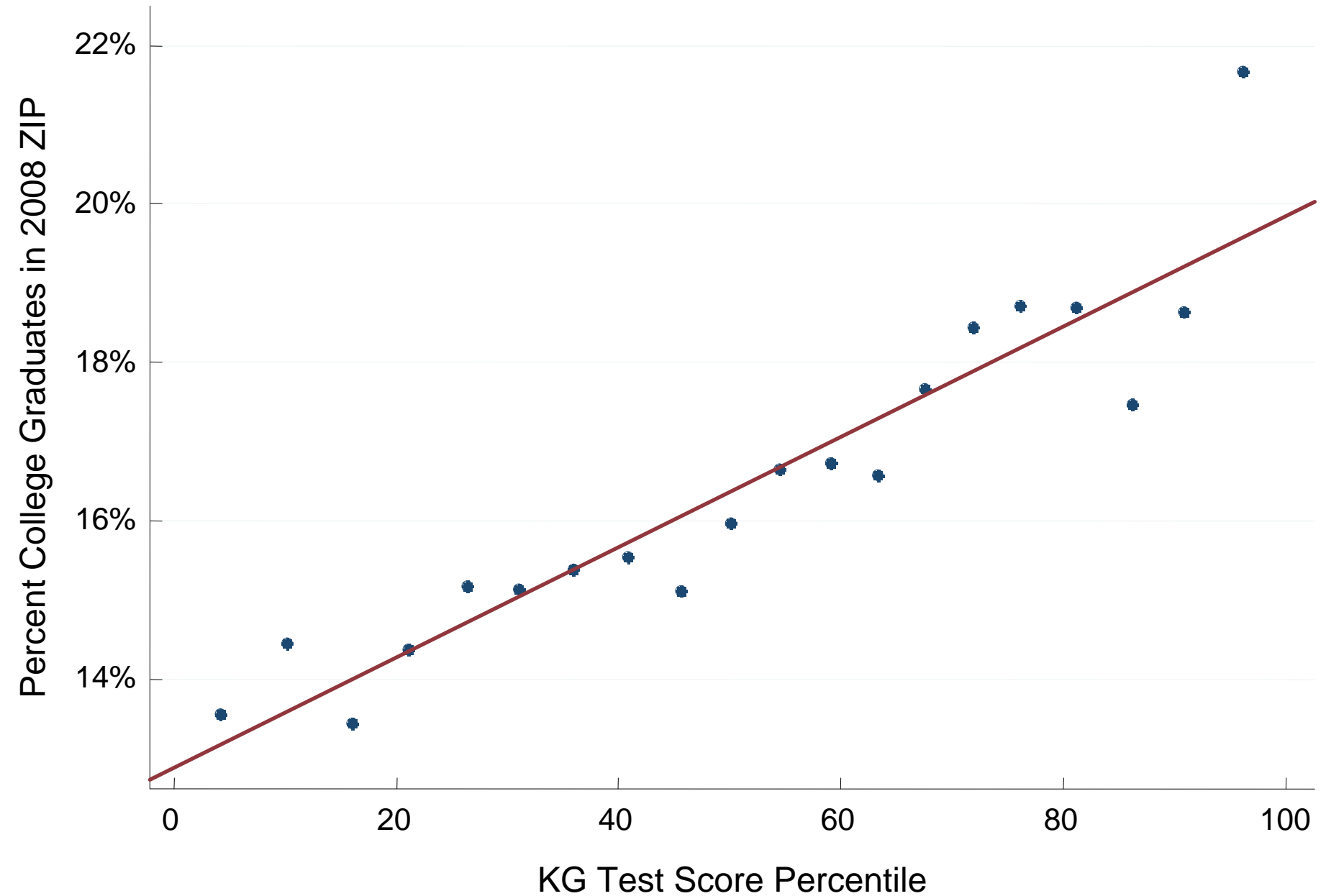
**Figure 3b: Retirement Savings vs. KG Test Score**



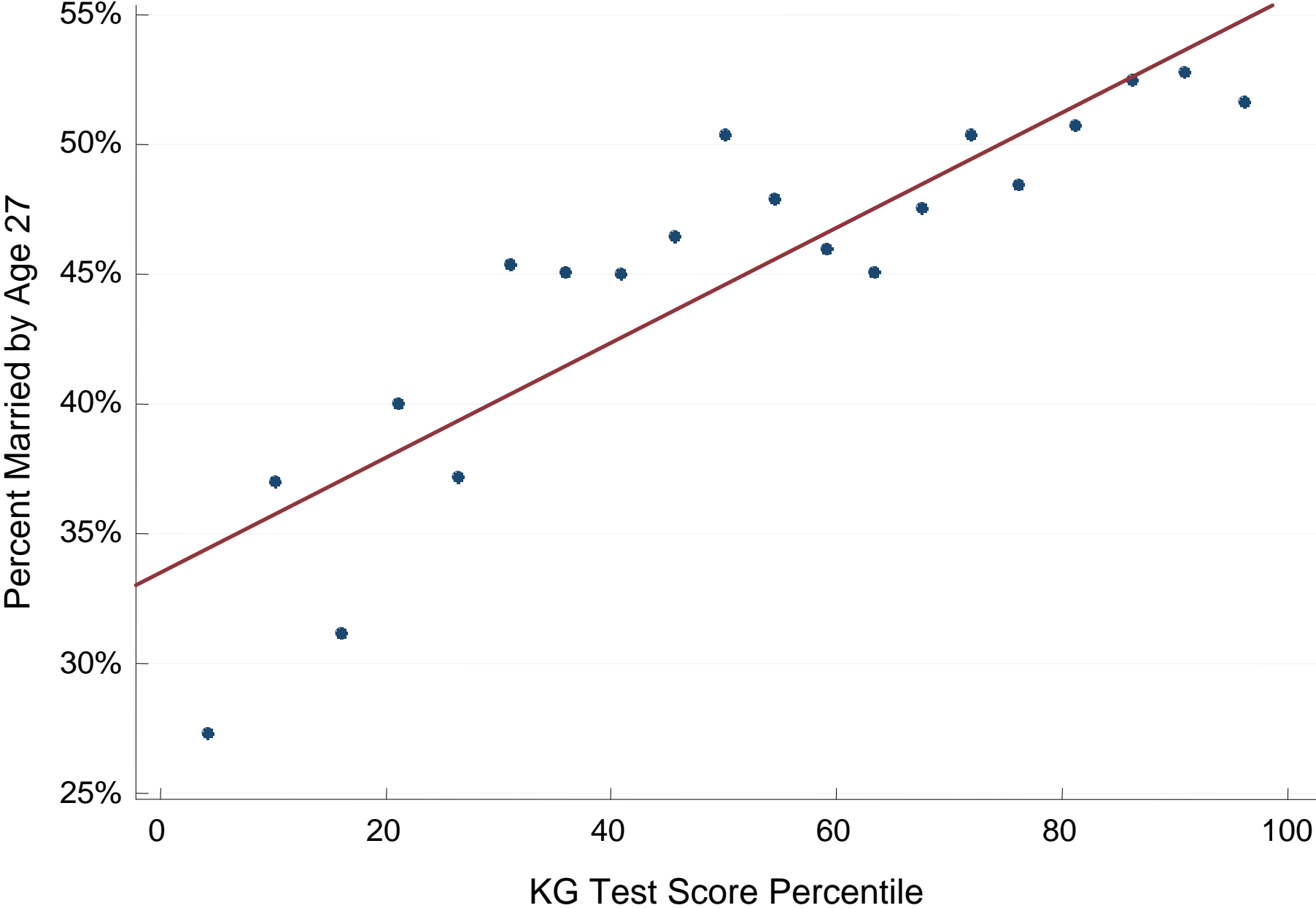
**Figure 3c: Cross-State Mobility vs. KG Test Score**



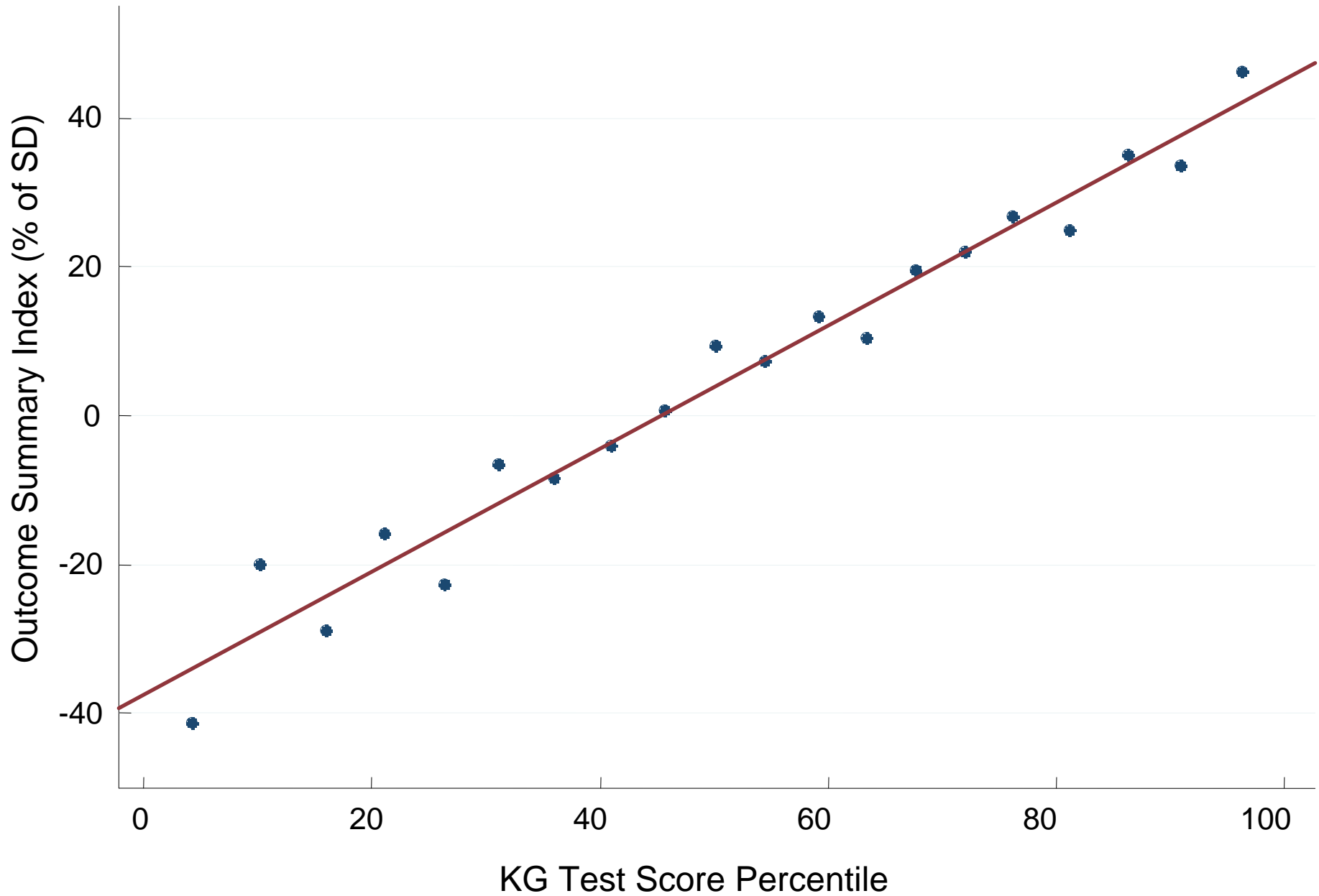
**Figure 3d: College Graduate in ZIP code vs. KG Test Score**



**Figure 3e: Marriage by Age 27 vs. KG Test Score**



**Figure 3f: Summary Outcome Index vs. KG Test Score**



## Part 2: Validity of the STAR Experimental Design

- Experimental analysis rests on two assumptions: randomization and no differential attrition across treatment groups
  - All pre-determined variables (e.g. parent characteristics) are balanced across classrooms
  - No evidence of differences in match rates across classrooms

## Part 2: Validity of the STAR Experimental Design

- Threat #1: *Failure of Randomization*
  - Prior studies had few baseline measures, limiting ability to evaluate randomization protocol (Schanzenbach 2006)
- We test for balance across class types with an expanded set of parent/sibling characteristics in two ways:
  1. Do characteristics vary across small vs. large class types?
  2. Do characteristics vary across classrooms within schools?

**Table 4: Randomization Tests**

Dependent Variable:	First Obs. Test Score	Small Class
	(1)	(2)
Household Income (\$1,000s)	0.085 (0.008) [11.20]	-0.003% (0.014%) [-0.248]
Parents Age at STAR Birth	0.178 (0.039) [4.520]	0.029% (0.072%) [0.411]
Parents Ever Have 401k	1.863 (0.518) [3.598]	1.455% (0.942%) [1.545]
Female	3.510 (0.460) [7.632]	-.224% (0.832%) [-0.270]
Black	-8.779 (0.920) [-9.546]	0.205% (1.656%) [0.124]
p-Value on F-Statistic	0.000	0.259
Observations	9,393	10,992

Note: Regressions include school-by-entry-wave fixed effects.



## Validity of the STAR Experimental Design

- Threat #2: *Selective Attrition*
- Much less attrition than in prior studies of STAR because we follow 95% of the sample
- Test for selective attrition through two channels:
  1. Does match rate vary across treatment groups?
  2. Does death rate vary across treatment groups (Muennig et al. 2010)?

**Table 5: Tests for Selective Attrition**

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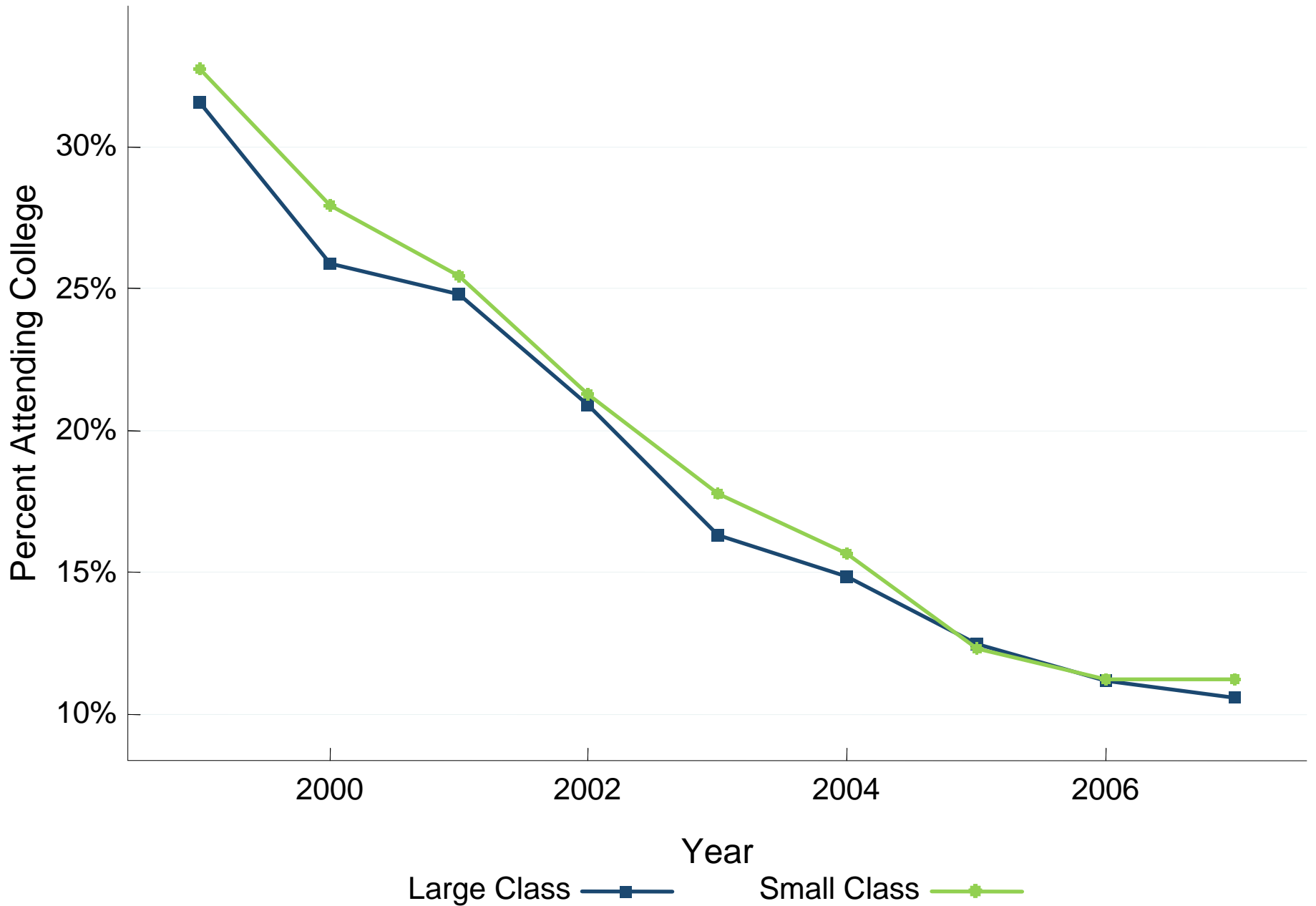
Specification:	Match Rates		Death Rates	
	(%)	(%)	(%)	(%)
	(1)	(2)	(3)	(4)
Difference	-0.019 (0.476)	0.079 (0.418)	-0.011 (0.293)	-0.006 (0.293)
F-Test P-Value on Class F.E.'s	0.951	0.888	0.388	0.382
Controls		x		x
Observations	11,571	11,571	10,988	10,988

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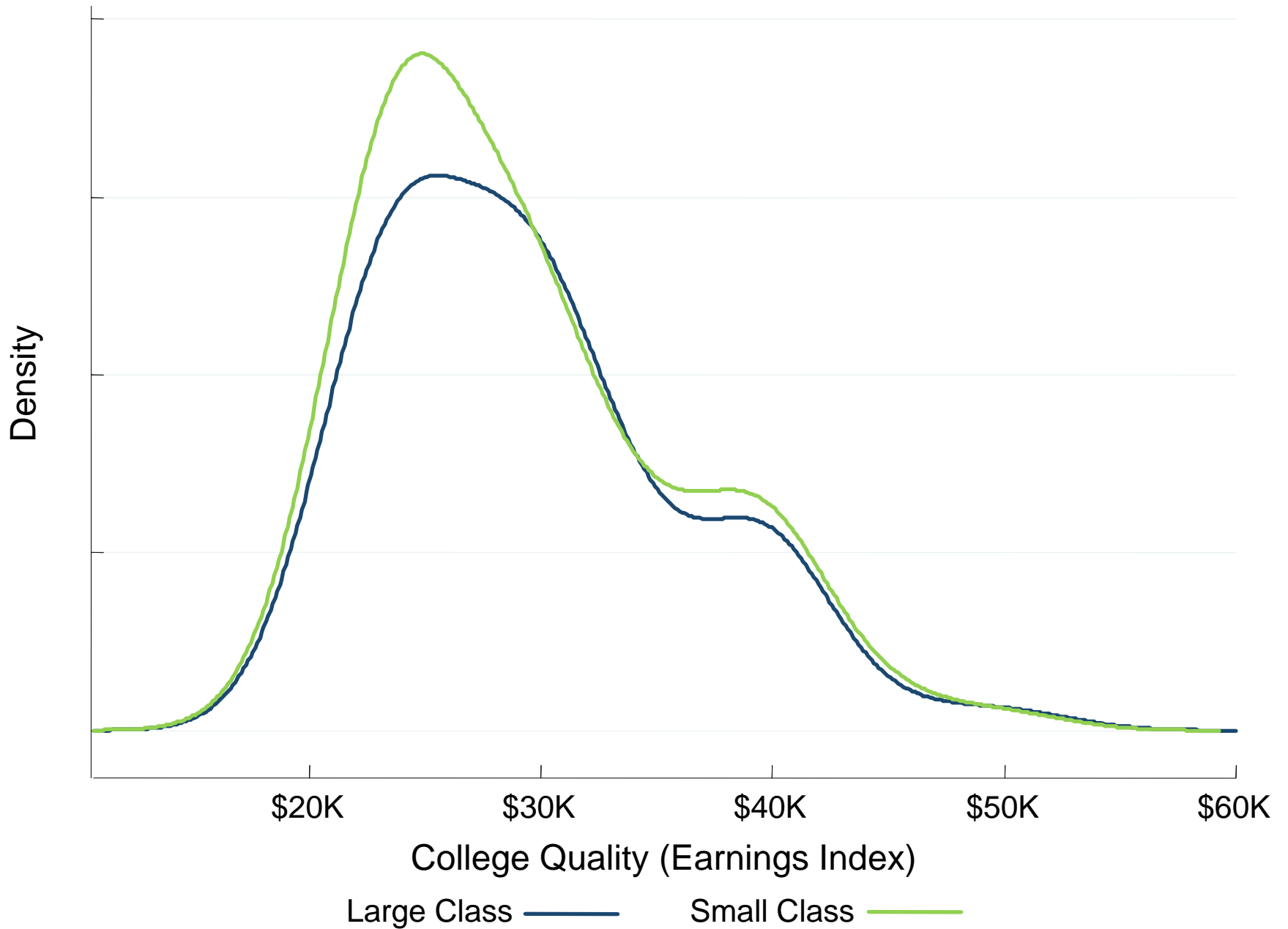
## Part 3: Class Size Impacts

- Replicate specifications in previous studies
- Independent variable: dummy for small class *assignment* (ITT)
- Focus on four outcomes:
  1. College attendance in 2000
  2. College quality index
  3. Mean earnings (ages 25-27)
  4. Standardized (SD = 1) summary index of other outcomes:  
$$\text{Index} = 401K + \text{Home Owner} + \text{Married} + \text{Moved (Leave TN)} + \text{Pct. College Grads. in Zip}$$

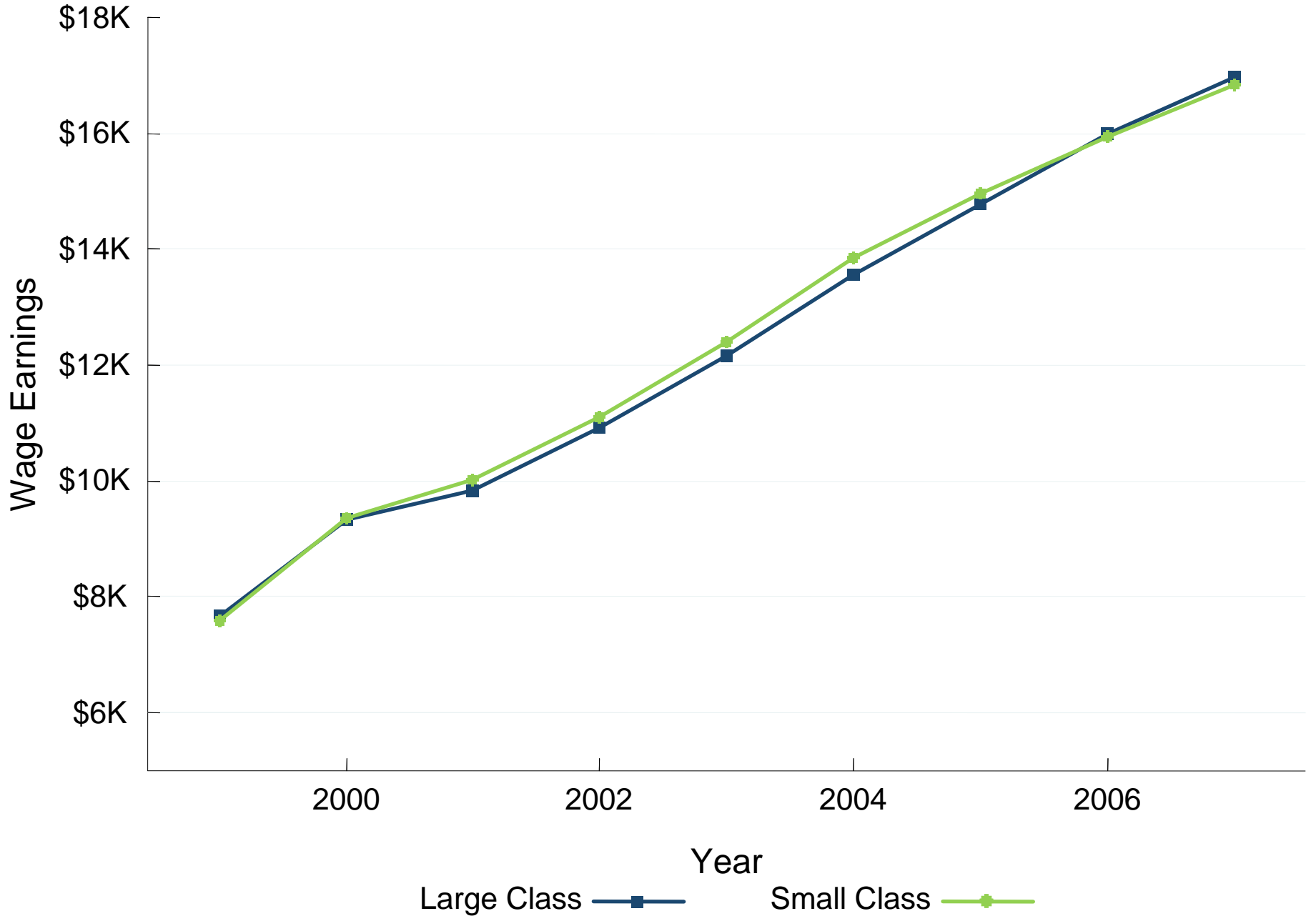
**Figure 4a: Effect of Class Size on College Attendance by Year**



**Figure 4b: College Earnings Quality by Class Size**



**Figure 4c: Effect of Class Size on Wage Earnings by Year**



**Table 6: Impacts of Class Size on Adult Outcomes**

Dependent Var.:	Attended College In 2000 (1)	College Quality (3)	Wage Earnings (4)	Index of Other Outcomes (6)
Small Class	1.78% (0.87%)	\$212.9 (\$145.6)	-\$124.3 (\$324.5)	4.74% (2.05%)
Observations	10,992	10,992	10,992	10,605
Mean of Dep. Var.	26.4%	\$20,147	\$15,912	0.00

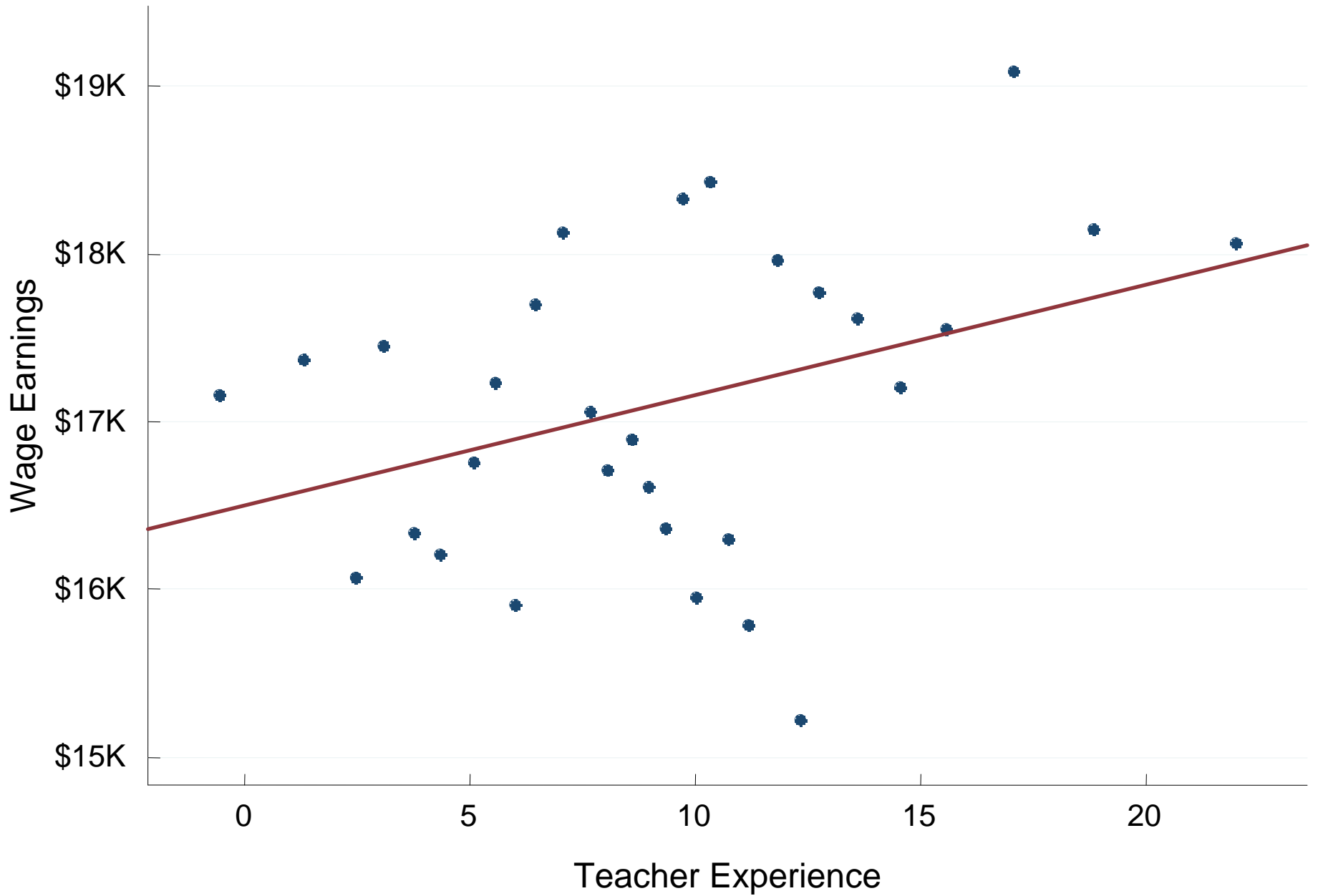
Note: All specifications control for school by entry wave effects and class size and the following other controls: a quartic in parental income interacted with marital status, mother's age at child's birth, student gender, free-lunch status, age, and race. Summary index includes a dummy for owning a home, having a 401(k), being married, having moved outside TN, and percent college graduates in 2008 zip.

## Part 4: Teacher/Peer Effects

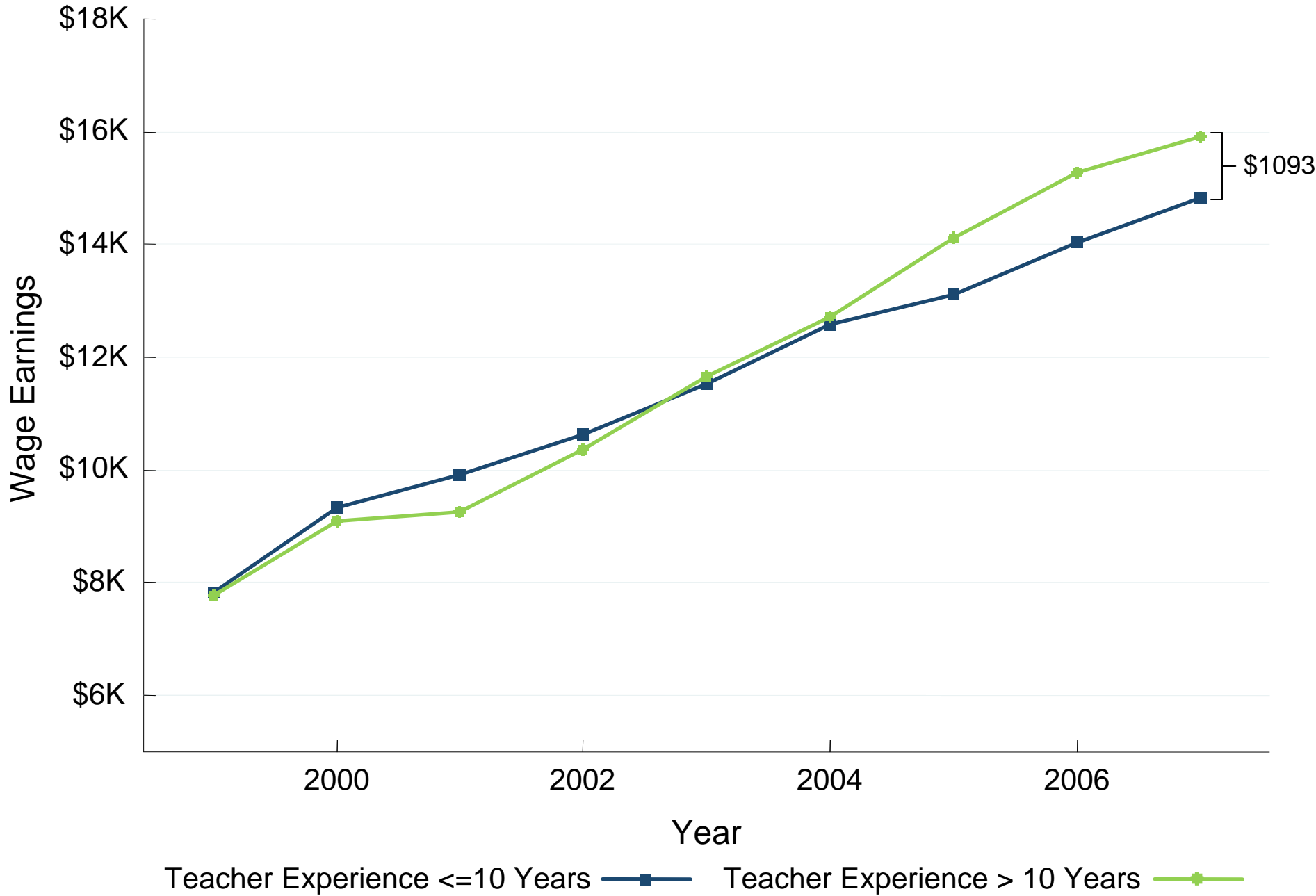
- Students randomly assigned to classes that differ in teacher and peer quality
- Do teachers/peers affect adult outcomes?
  - First examine impacts of observable characteristics of teachers and peers (e.g. teacher experience)
- Throughout remainder of talk, isolate variation across classes within schools *and* class type (small vs. large)
  - Control for school fixed effects and indicator for class size



**Figure 5a: Causal Effect of Teacher Experience on Earnings**



**Figure 5b: Effect of Teacher Experience on Earnings by Year**



**Table 7: Observable Teacher vs. Peer Effects**

Dependent Var.:	Wage Earnings			
	(1)	(2)	(3)	(4)
Teacher with >10 Years Experience	<b>\$1093</b> (\$453.7)			
Teacher Experience (years)		<b>\$57.13</b> (\$37.70)		
Teacher Degree Higher than a BA	-\$261.1 (\$489.7)	-\$204.7 (\$493.5)		
% Black Peers			-\$1,758 (\$3,063)	
% Female Peers			-\$67.56 (\$1,535)	
% Free-Lunch Peers			-\$284.1 (\$1,593)	
Average Age of Peers			-\$26.67 (\$1,440)	
Predicted Peer Scores				-\$15.91 (\$90.62)
Observations	6,005	6,005	10,992	10,992

Note: All specifications control for school fixed effects and class size, as well as family characteristics listed above.

## Class Effects

- Most of teacher and peer quality (e.g. clarity of instruction, enthusiasm) not captured by observable measures
- Well known problem in literature on teacher effects (see e.g. Rockoff and Staiger 2010)
- Modern literature captures unobserved teacher characteristics by estimating distribution of teacher effects on scores
- We use this approach and test for class-level effects on adult outcomes
- This “class effect” includes effect of teachers, peers, and any class-level shocks such as noise outside classroom

## Class Effects: ANOVA

- Test for class effects using analysis of variance
- Do earnings vary across classes by more than what would be predicted by random variation in student abilities?
  - F test for significance of class fixed effects
  - Random effects estimate of class-level SD for outcomes

**Table 8: F-Tests for Kindergarten Class Effects**

Dependent Var.:	Grade	Grade	Wage Earnings		
	K Scores	8 Scores	(3)	(4)	(5)
	(1)	(2)			
P-value of F-Test on KG Class Fixed Effects	0.000	0.411	0.043	0.023	0.020
SD of Class Effects (RE estimate)	8.367	0.001	\$1,514	\$1,536	\$1,703
Demographic Controls				x	x
School Fixed Effects	x	x	x	x	x
Indicator for Small Class	x	x	x	x	
Large Classes Only					x
Observations	5,621	4,448	6,025	6,025	4,208

Note: All specifications control for school fixed effects and class size as well as family background controls listed above.

## Class Effects on Scores and Earnings

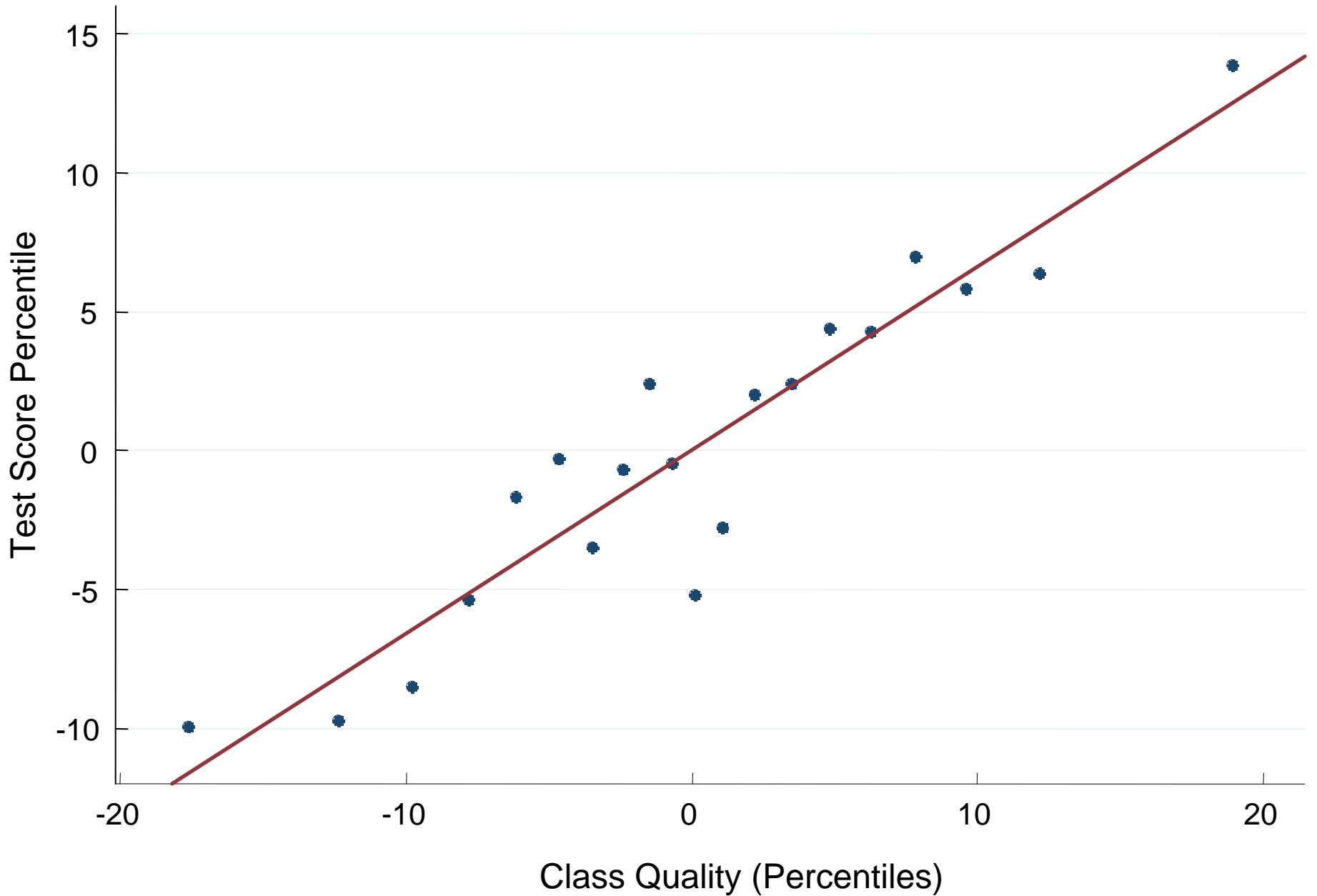
- Key question: Are class effects on KG scores correlated with class effects on earnings?
  - Do (unobserved) interventions that raise test scores also improve adult outcomes?
- Cannot simply regress score class f.e.'s on earnings class f.e.'s
  - Class fixed effect includes a student's own test score → bias toward OLS regression of earnings on scores
  - Equivalent to a weak-instruments problem because class size is finite
  - We address this using a leave-out mean (i.e. jackknife)

## Peer-Score Measure of Class Quality

- Measure unobserved “class quality” using leave-out mean:
  - Class Quality = Mean Peer Scores in Class – Mean Peer Scores in School
  - How good are your classmates’ scores, compared with the classmates you could have had?
- Because we use peers’ test scores at the *end* of KG, class quality reflects teacher + peer effects + random class-level shocks
  - Good teachers and class environments raise peer test scores
- Because students were randomly assigned to classes, class quality varies randomly within schools



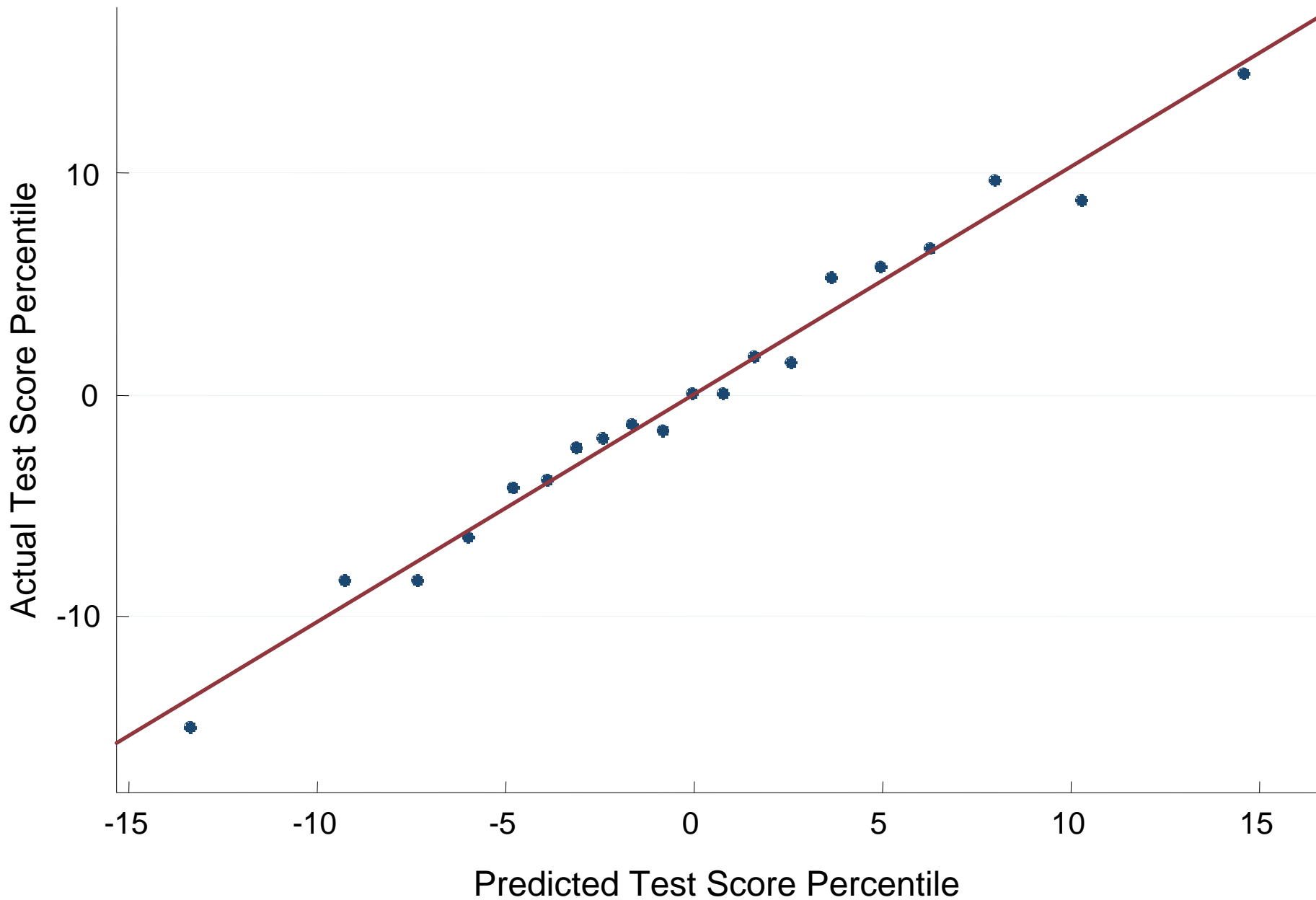
**Figure 6a: Causal Effect of Class Quality on Own Score**



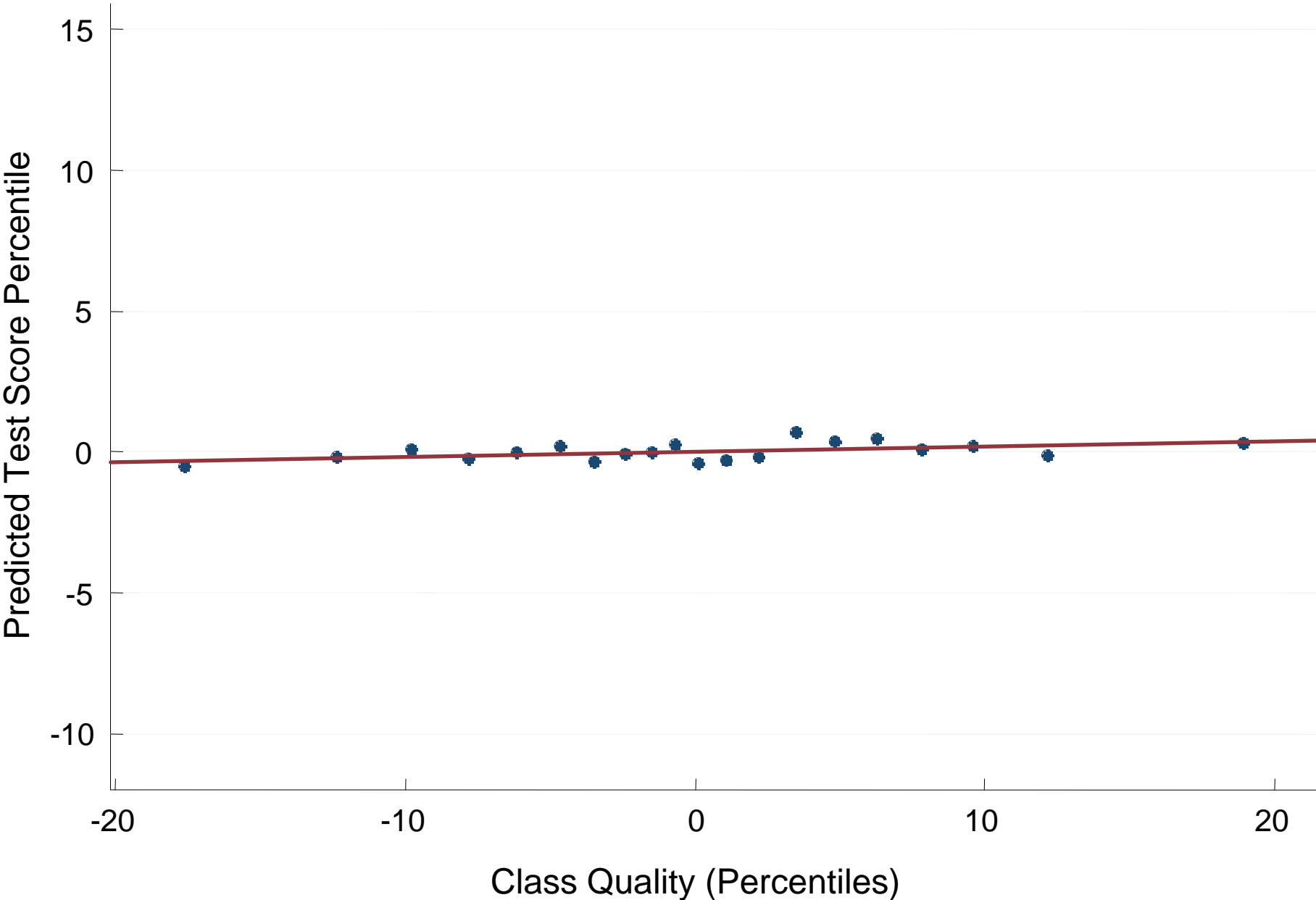
## Peer-Score Measure of Class Quality: Placebo Test

- To confirm that leave-out mean captures causal effect of class quality on own score, run a placebo test
  - Predict each student's score from regression of actual score on pre-determined demographics and parental background
  - Test whether class quality is correlated with predicted test score
  - Effectively a test for balance in student characteristics across classes of different quality

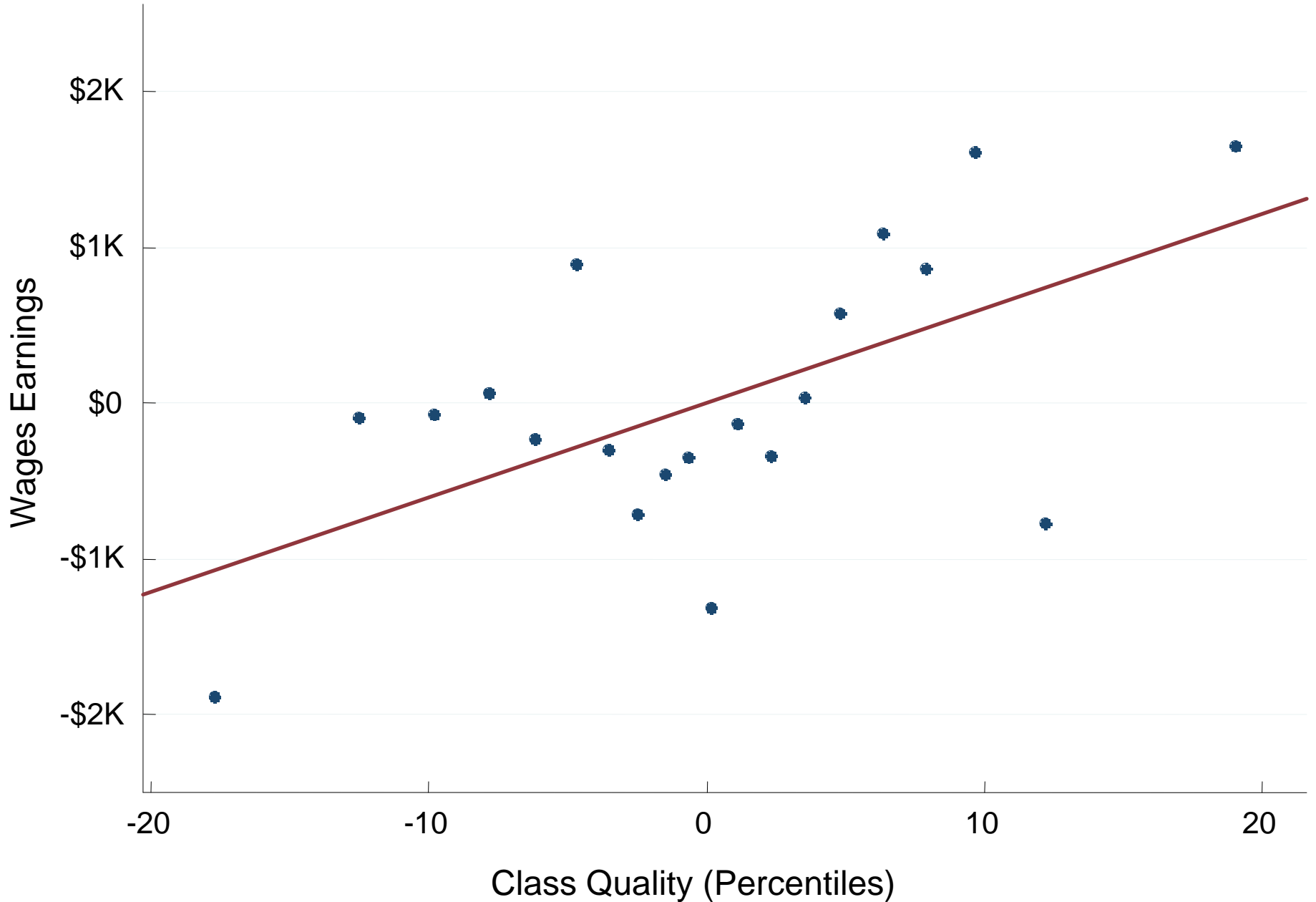
**Figure 6b: Actual Test Score vs. Predicted Test Score**



**Figure 6c: Placebo Test: Class Quality and Predicted Own Score**



**Figure 6d: The Causal Effect of Kindergarten Classrooms on Earnings**



**Figure 6e: Placebo Test: Class Quality and Predicted Earnings**

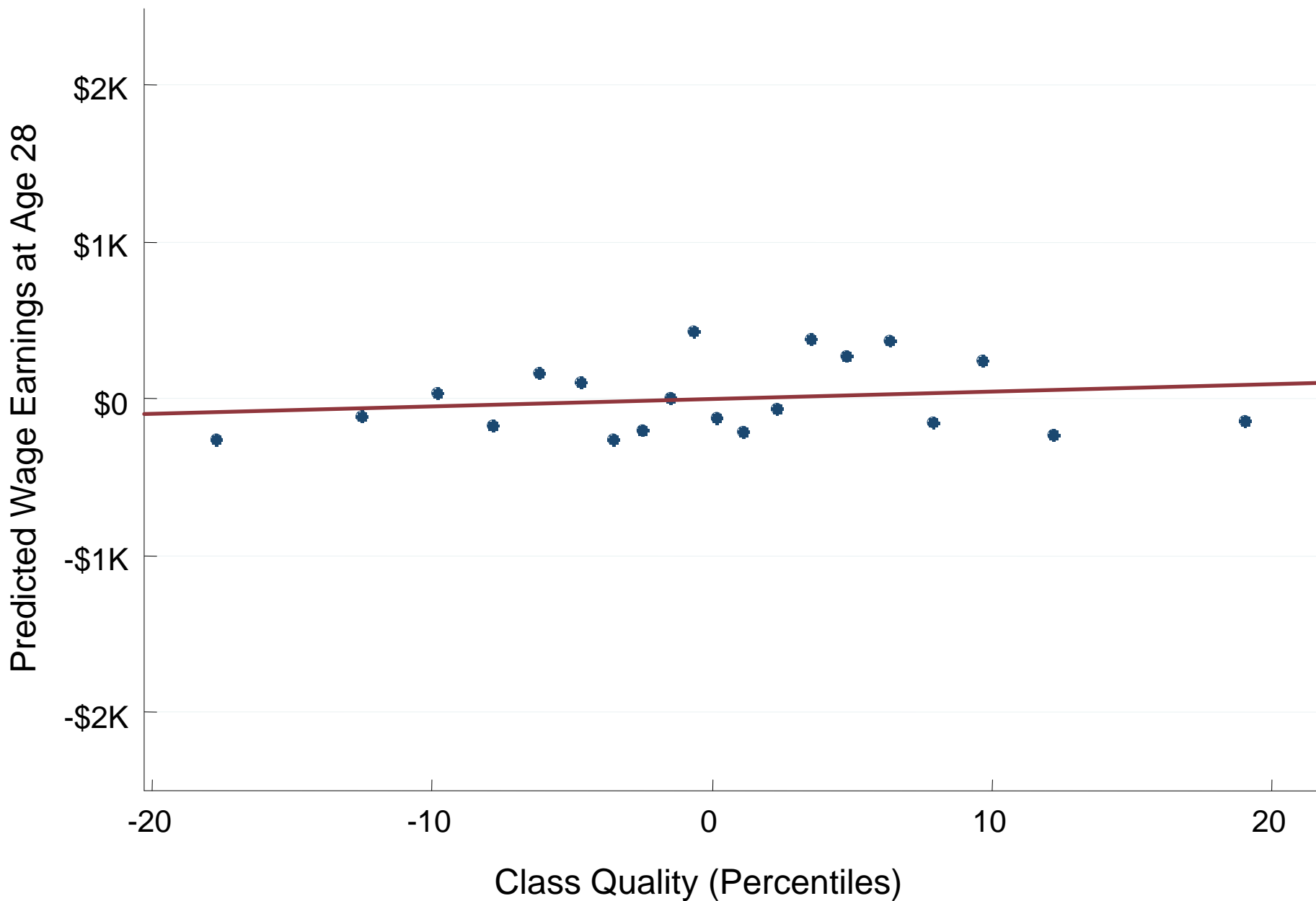
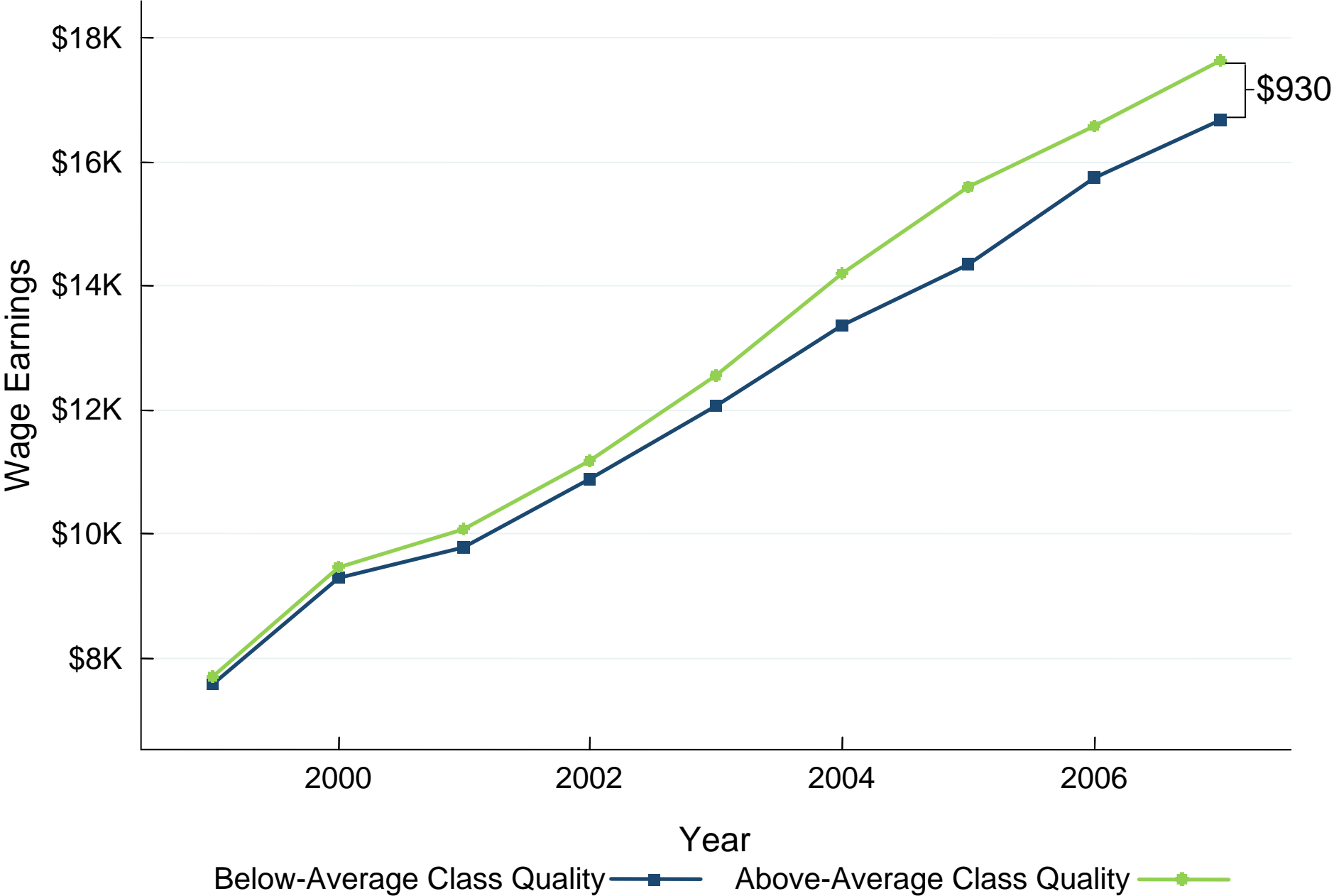


Figure 6f: Effect of Class Quality on Earnings by Year



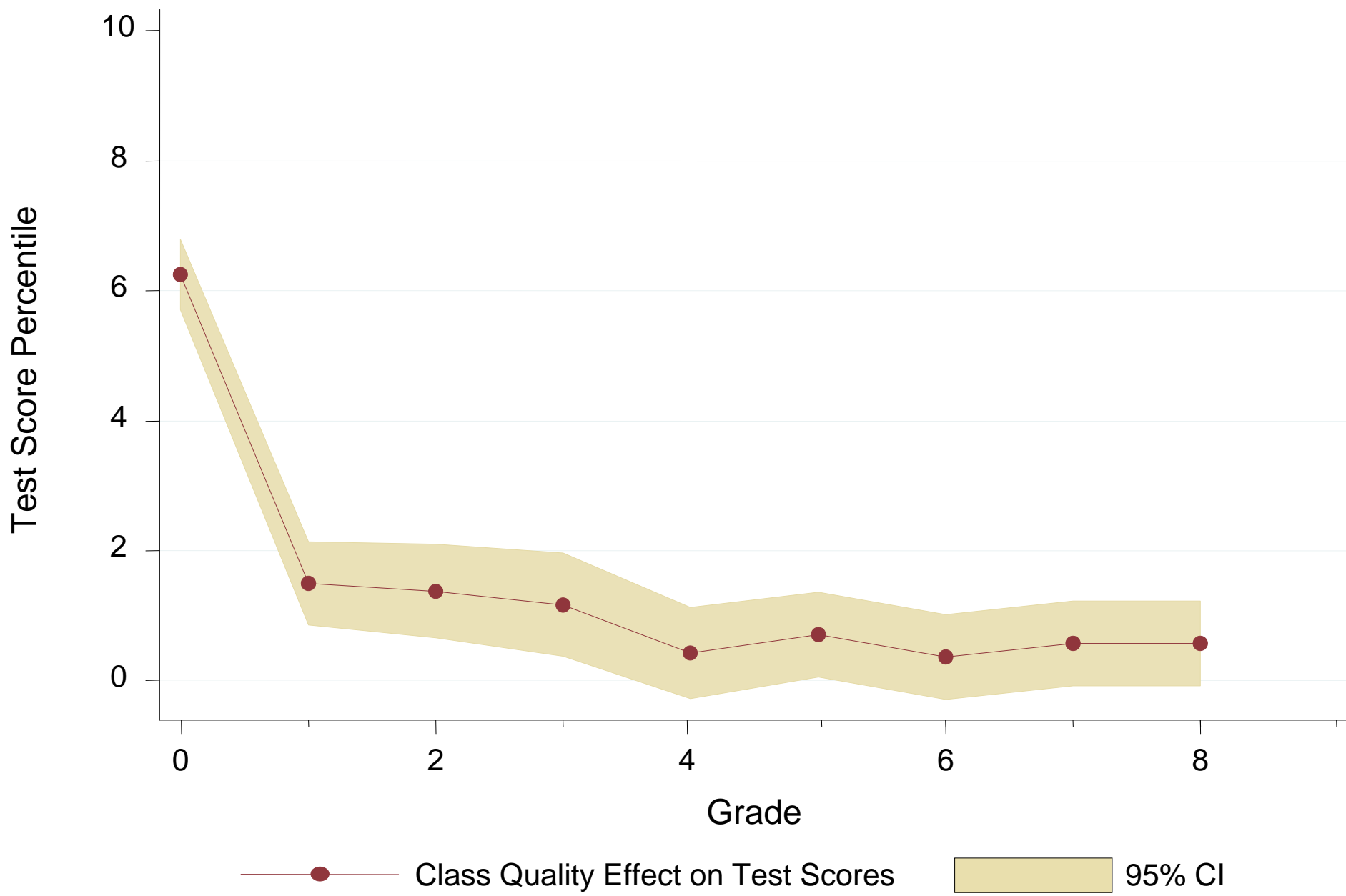
**Table 8: Impacts of Class Quality on Adult Outcomes**

Dependent Var.:	Test Percentile	Wage Earnings	College in 2000	Ever College	College Quality	Summary Index
	(%)	(\$)	(%)	(%)	(\$)	(%)
	(1)	(2)	(3)	(4)	(5)	(6)
Class Quality	0.66	50.60	0.10	0.11	17.20	0.21
	(0.02)	(15.35)	(0.04)	(0.05)	(6.90)	(0.10)

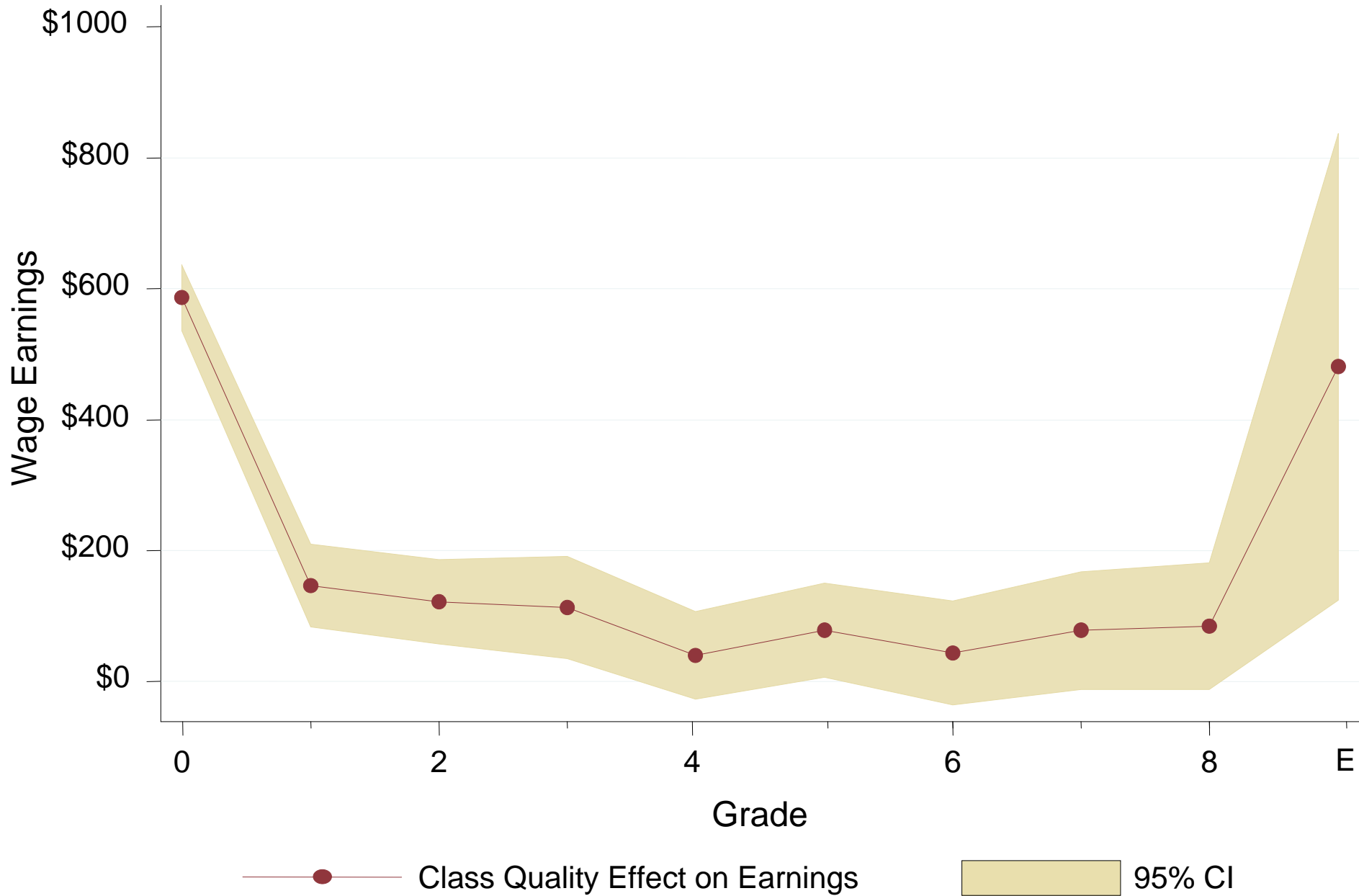
Note: All specifications control for school fixed effects and class size. Demographic controls include a quartic in parental income interacted with marital status, mother's age at child's birth, parent savings, student gender, free-lunch status, and race.



**Figure 7: Fadeout of Class Effects**  
**Effect of 1 SD of Class Quality on Test Scores by Grade**



**Figure 7: Fadeout of Class Effects**  
**Effect of 1 SD of Class Quality on Earnings**



## Fade-out and Re-emergence: The Role of Non-Cognitive Skills

- Why do effects of kindergarten class fade out on test scores and then reappear in adulthood?
- One explanation: non-cognitive skills (Heckman 2000)
- Data on non-cognitive measures was collected for random subset of STAR students in 8<sup>th</sup> grade
  - Effort, initiative disruptive behavior rated by English and Math teachers
  - Convert mean score to percentile scale
- Do effects of KG class quality persist on non-cognitive skills?

**Table 9: Impacts of Class Quality on Non-Cognitive Skills**

Dependent Variable:	Wage Earnings	Grade 4 Scores		Grade 8 Scores	
		Test	Non-Cognitive	Test	Non-Cognitive
	(1)	(2)	(3)	(4)	(5)
Grade 4 Non-Cognitive	\$87.68 (\$19.55)				
Grade 4 Test Score	\$36.42 (\$23.32)				
Class Quality		<b>0.047</b> (0.040)	<b>0.153</b> (0.070)	<b>0.064</b> (0.037)	<b>0.129</b> (0.061)
Observations	1,360	4,023	1,671	1,780	1,772

## Cost-Benefit Analysis: Class Quality

- Assume: 3% real discount rate, constant percent income gains, income follows average US income profile
- One SD increase in KG class quality leads to \$1,536 (9.7%) increase in wage earnings at age 27
  - Lifetime earnings gain of **\$39K** for average individual in US
  - Total present value earnings gain for class of 20 students of **\$784,000** from a 1 SD improvement in class in a *single year*
- This calculation highlights stakes at play in early childhood education
- But not directly useful for policy because we cannot manipulate class quality directly

## Cost-Benefit Analysis: Class Size Reduction of 33%

- Method 1: use estimated earnings impacts at age 27
  - NPV earnings gain per student of \$1K, 95% CI = **(-\$9K,17K)**
- Problem: estimates imprecise and earnings impacts may not appear by age 27
- Method 2: project earnings gains based on estimated impacts of class quality on scores and earnings
  - 1 pctile improvement in class quality → 0.52 percentile gain in scores and \$50 increase in earnings (\$95 per pctile gain)
  - Class size reduction → 5 pctile gain in scores = \$475
  - NPV earnings gain per student of **\$11,500** per student
- Benefits may be larger than per-student cost of \$9,355

## Cost-Benefit Analysis: Teacher Quality

- Method 1: use estimated impacts of teacher experience
  - 1 SD increase in teacher experience raises NPV earnings by **\$7,500** per student
- Method 2: project earnings gains based on estimated impacts of class quality on scores and earnings
  - Rockoff (2004) and Kane and Staiger (2008) estimate that a 1 SD improvement in teacher quality raises scores by 0.2 SD
  - We estimate \$95 per pctile score gain → 1 SD improvement in teacher quality raises earnings by \$515 (3%) at age 27
  - 1 SD increase in teacher quality yields NPV earnings gains of **\$13,000** per student
  - **\$260K** for a class of 20 students