Measuring the Effect of Class Size and Supplemental Instruction on Student Success in Introductory Macroeconomics

Preliminary Report on the Efficacy of Using Adjuncts
to Improve Student Learning in the Fall of 2008

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Abstract. This paper examines the effect of utilizing adjunct instructors in an introductory macroeconomics course at Sacramento State University. Students in a large lecture course who participate in the adjunct program are compared to several control groups, namely, peers enrolled in the large lecture section but not the adjunct program and peers enrolled in a small lecture section taught by the same instructor in which adjuncts were not made available. The preliminary results indicate that, after controlling for student age, race, high school GPA, class, and college major, participation in the adjunct section appears to reduce students' probability of earning a D, F, or W. More research on the determinants of a student's decision to participate in the adjunct program is warranted and forthcoming.

Introduction & Background

California State University (CSU) is struggling to improve student learning and retention while reducing instructional costs in a time of increased student enrollment in General Education (GE) courses. Like many other CSU campuses, Sacramento State has increased class size to meet increased student demand with little evidence on how student outcomes will be affected. This research examines the effects of class size and Supplemental Instruction (SI) on student success in *Economics 1A: Introduction to Macroeconomic Analysis*. Econ 1A is a GE course required by several majors that involves a high level of critical reading and mathematical reasoning. In addition, over the last five years, several Econ 1A classes with large enrollments of 75-150 students have had passing rates that dipped below 75 percent.

In the fall semester of 2008, Professor Kristin Van Gaasbeck taught one large section of Econ 1A (section 1 with 120 seats) and one small section of Econ 1A (section 3 with 50 seats). Four adjunct labs taught by student instructors were attached to the large section of Econ 1A and offered only to those students, creating a "treatment" group that we compare to several different "control" groups – other students in the large section who did not participate in the adjunct labs and students in the small section that were not offered the adjunct labs. Additionally, this design allows the small section students to be compared with students enrolled in the larger lecture who did not participate in an adjunct section to address the issue of class size alone, a somewhat controversial topic that is part of most conversations about reducing instructional costs. Our hypothesis is that the combination of instructional cost and student success may make the large class size with Supplemental Instruction more cost effective than either the large class size without adjuncts or the small class size. The analysis focuses on differences in student outcomes (i.e. performance in various facets of the class as well as overall course grade) between the

treatment and control group. We address the possibility of selection bias inherent in the voluntary nature of the intervention as well as differences in other student background characteristics. We intend the results of this research to offer evidence on whether Supplemental Instruction could be utilized in other selected GE courses across campus and at other California State University campuses.

Description of Data

The dataset utilized consists of individual-level data on students enrolled in both of Professor Van Gaasbeck's Economics 1A courses in the fall 2008 semester, a total of 139 students. Of these students, all students enrolled in the large section were offered the possibility to participate in an additional one-credit course taught by adjunct instructors employed by the Learning Skills Center. No inducements were offered for students' participation, nor was the professor aware until after final grades were submitted of which students opted to participate. Of the 94 students enrolled in the large section of Econ 1A, one-third chose to also enroll in one of the adjunct sections. Students enrolled in the small section of Econ 1A were not offered the adjunct courses. All other facets of the course – time/days offered, lectures, homework assignments, exams, and grading scale – were constant across all students enrolled in both sections.

Course performance data (homework and exam scores, overall course grade, and proportion of D, F, and W grades) are matched to important student background characteristics, like high school GPA, remedial course-taking, and college major, made available by the CSUS Office of Institutional Research.

Data Analysis

The research design permits several types of comparisons in the data, which are designed to address different research questions. We list these separately for clarity.

1. *Impact of Adjuncts Alone.* We identify the effect of participating in a one-credit adjunct course by focusing just on the students enrolled in the large section of Econ 1A and comparing students who elect to participate in the adjunct sections (treatment group) to those who do not (control group).
2. *Impact of Class Size.* We identify the effect of larger class sizes by comparing large section students who *did not* participate in the adjunct sections (treatment group) to those enrolled in the small section of Econ 1A (control group).
3. *Combined Impact of Adjunct and Class Size.* We identify the combined effect of participating in a one-credit adjunct course while enrolled in a large section of Econ 1A (treatment group) relative to enrolling in a small section of Econ 1A with no adjunct available (control group) by comparing student outcomes in those two groups.

In many cases, selection into these groups may be a function of underlying student characteristics. Perhaps college freshmen are more likely to enroll in larger sections of classes due to space availability at their later registration time. Perhaps students who are weaker in mathematics are more likely to participate in an adjunct section. After initial analyses to simply compare treatment and control groups, we return to these selection issues to insure that our results do not suffer from selection bias.

Table 1 presents student demographic characteristics for the various treatment and control groups identified above. Within the large section of Econ 1A, students who participated in adjunct sections (column (1)) are slightly older, less likely to be white or Asian, more likely to

major in one of the social sciences, and more likely to have taken remedial courses than those who did not enroll in an adjunct section (column (2)). Comparing all those who *did not* participate in an adjunct section but were in different class sizes (column (2) versus column (4)), we see that the non-adjunct students in the large section of Econ 1A are more likely to be white, upper-classmen, and business majors than students in the small section. Finally, a comparison of adjunct participants in the large section with students in the small section (column (1) versus column (4)) indicates that the former group is older, more likely to major in business and the social sciences, and has earned more total units as of the fall of 2008. Many of these underlying differences across students are controlled for in our regression analysis in the next section.

Table 2 presents various course outcome measures for each of the five student groups discussed in Table 1. We examine homework performance, scores on each individual exam and the overall exam average, and final course grades as measured by the average out of 100 percent, the distribution of assigned letter grades, and the proportion of D, F, and W grades. Across the five columns in Table 2, there are only very small differences in most of these student course performance measures. The biggest differences are with respect to the proportion of D, F, and W grades assigned, which reflects underlying differences in the distribution of letter grades assigned even though the overall course averages are essentially identical across the groups. The large lecture students who participated in one of the adjunct sections had a significantly lower proportion of D, F, and W grades (28 percent) than either of their comparison groups (35 percent among the other students in the large lecture who were not in an adjunct section and 38 percent among students enrolled in the small section).

The unconditional means from Table 2 are also summarized graphically in Figures 1, 2, and 3 to visually address each of the three comparisons listed on the previous page. Figure 1

indicates that large lecture adjunct participants perform slightly worse on homework, exams, and overall relative to their non-participating peers enrolled in the large lecture, but that the former is substantially less likely to earn an F than the latter. Similarly, Figure 2 reveals almost no difference in average course performance between students in the large section (without adjuncts) relative to those in the small section (also without adjuncts), but the large lecture students are much more likely to receive an A in the course than their small section peers. Finally, Figure 3 again shows almost no difference in course performance measures between large lecture adjunct participants and students enrolled in the small section without adjuncts. However, there are substantial differences in the distribution of grades that imply a lower rate of D, F, and W grades among the large lecture students who utilize an adjunct instructor.

Regression Analysis

Although the comparisons of averages across the different treatment and control groups yield some insight as to how the subsamples of students differ from one another, in terms of both background characteristics and course outcomes, such comparisons may be misleading. For example, if the large section of Econ 1A contains less academically prepared students than the small section, failure to take this into account when examining differences in student performance between the large and small sections would incorrectly lead one to conclude that larger class sizes are bad for student performance. If students in the large section perform worse on measured outcomes than their peers in the small section even after controlling for differences in academic preparation (as well as differences in other student characteristics), then such a conclusion about large sections would be supported by the empirical evidence. Regression analysis is the tool that allows us to control for these underlying differences in the subsamples of

students. That is, holding all observable student characteristics constant, do the differences in student performance that we see in Figures 1, 2, and 3 still persist? There are three tables of regression results to again separately address the three treatment/control comparison groups outlined above.

Table 3 contains the parameter estimates from regressions examining various student outcomes in Econ 1A (see column headings for outcomes) as a function of available demographic characteristics and whether or not students participated in an adjunct section. The regression in Table 3 is run on the subsample of students enrolled in the large lecture section and, as a result, the coefficient estimate on the binary variable "Adjunct participant" identifies the effect of participation in an adjunct section holding all other variables constant, including class size. The parameter estimates reveal a positive association between participation in an adjunct section and students' homework, exam, and overall course averages, although none of these positive effects is statistically significant at conventional. After controlling for observable student attributes, participating in an adjunct section does reduce the probability of receiving a D, F, or W grade by 28.5 percentage points (from a predicted probability of 38.5 percent among non-participants to 9.9 percent among participants) and this effect is highly statistically significant. As we would expect, students with higher high school GPAs are predicted to have better course performance and lower probabilities of getting a D, F, or W grade. Even after controlling for this measure of academic preparation, the regression results indicate a fairly consistent negative effect on course performance for black students.

Table 4 contains the parameter estimate from regressions examining the effect of class size alone on student performance in Econ 1A. To clarify, none of the observations included in these regressions participated in an adjunct section. The coefficient estimate on the binary

variable “Large lecture enrollee” identifies the effect of being in the large section relative to the small section, without adjunct support in both cases, while controlling for observed differences in student characteristics. The results indicate that students enrolled in the large section of Econ 1A have a lower homework average (by 6.5 percentage points on a 100-point scale) relative to their small section peers. None of the other differences in course performance are statistically significantly different from zero. Again, better academic performance as proxied by higher high school GPA is positively associated with performance in all facets of the course. Additionally, older students appear to have higher measured performance on homework and the overall course grade, including lower rates of D, F, and W grades. The race/ethnicity variables are statistically related to a variety of course performance measures, with predominantly negative effects associated with categories of minority students other than Hispanics relative to their white peers.

Table 5 presents the regression results that examine the combined effect of Supplemental Instruction and class size. The coefficient estimate on the binary variable “Adjunct participant in large lecture” identifies the effect of being in the larger section with an adjunct relative to being in the smaller section with no adjunct. Although the estimated effects of being in the large section with an adjunct are positive for homework, exam, and course averages, none of these estimates is different from zero at conventional levels of statistical significance. Based on the differences in the distribution of letter grades visible in Figure 3, it is not surprising that Table 5 indicates that adjunct participants in the large lecture have a 30.6 percentage point lower probability of earning a D, F, or W grade than their peers in the small section of Econ 1A. As in Tables 3 and 4, high school GPA is the most consistent predictor of student outcomes in this course.

Discussion

The preliminary results presented above provide some evidence that supplemental instruction in this Econ 1A course effectively reduced the proportion of D, F, and W grades for those students who elected to participate in one of the adjunct sections. There is little evidence that student participation in adjunct sections improved homework or exam performance across the board for students after we control for other student background characteristics, including academic preparation measures. While overall course performance was virtually the same for adjunct participants as for non-participants in the large lecture (see Figure 1) and as for non-participants in the small lecture who were not offered adjunct sections (see Figure 3), the distribution of letter grades earned by these groups of students were statistically different from one another. Additionally, these differences in student letter grades and D, F, and W grades remained even after controlling for observable student attributes including academic ability measures like high school GPA. With small sample sizes working against our ability to find statistically significant results, this finding on fewer D, F, and W grades among adjunct participants encourages us to expand our analysis of this dataset.

While these preliminary results might be interpreted as a supportive of the Supplemental Instruction model, particularly for students in larger enrollment courses, several caveats are necessary to keep in mind and these issues will be addressed in future versions of this research.

First, participation in the adjunct sections is voluntary and, as a result, the subsample of participating students may be different from non-participants in important ways that are related to student success in the course. For example, if more motivated students are likely to both participate in an adjunct section and be more diligent about completing course work and studying, then we would expect a positive bias on the effect of adjuncts on student outcomes.

While we are unable to control for differences in student motivation because it is unobserved, there are several ways that we can control for these sorts of unobservable student attributes and selection into participation in the adjunct program. In future versions of this research, we will examine a student's decision to participate in an adjunct section and then control for those determinants in our regression analyses.[1] Additionally, we will look at the number of homework assignments attempted as a proxy for student effort and motivation in the class.[2]

A second caveat concerns the fact that the results reported here are from a case study, albeit a quantitative one, based on the way in which one professor teaches this course. Note, for example, that Table 2 reports that the average course GPAs in all categories of students enrolled in Econ 1A are below a 2.0, less than a C average. It is worth noting that the ten-term average for lower-division Economics courses at Sacramento State is a 2.3.[3] While this difference in Professor Van Gaasbeck's Econ 1A course relative to the department average isn't important for interpreting the marginal effects of utilizing adjuncts (because all of her students enrolled are getting the same course), the difference does raise the possibility that adjunct sections could have very different effects for different courses and/or instructors. For example, Professor Van Gaasbeck is known for having extremely well-organized course materials and lecture, but also for being very challenging in terms of course demands on her students. Adjuncts might have very different effects on student outcomes with an instructor that is less organized but not as demanding in terms of course material. Because there is a large amount of autonomy, and

[1] Initial analysis of this decision reveals very few predictors of adjunct participation in our data, indicating only a small selection bias in the results reported here. Students who have taken remedial courses in mathematics are more likely to sign up for an adjunct section than their peers, but no other variables are statistically significant. We will investigate ways of controlling for this selection mechanism for future analyses.

[2] The online homework software utilized in this course, Aplia, involves an un-graded "practice" assignment for each graded assignment that directly affects students' grade. We are able to track individual students' attempts on the "practice" assignments as well as the number of graded assignments they completed over the semester and utilize this information as a measure of student commitment and motivation to succeed in the course.

[3] See http://www.oir.csus.edu/aadc/Departmental%20Factbooks/Economics08.pdf.

therefore variation, in the way in which individual faculty members teach the same class, further study using a broader set of instructors that could control for these differences in instructor methods is certainly warranted. Because that sort of analysis is not possible with the dataset described here, all of our results (and the results of any study of a single course or single instructor, for that matter) must be interpreted with this important caveat in mind.

Table 1
Student Demographic Characteristics

	Large Section			Small Section	All Students
	w/ Adjunct	w/o Adjunct	Total		
	(1)	(2)	(3)	(4)	(5)
Student Age	22.22	20.24	20.94	19.44	20.45
Race/Ethnicity					
Asian	0.22	0.38	0.32	0.33	0.32
Black	0.22	0.06	0.12	0.09	0.11
Hispanic	0.16	0.13	0.14	0.18	0.15
White	0.28	0.35	0.33	0.29	0.32
Other race/ethnicity	0.13	0.08	0.10	0.11	0.10
Class Rank & Majors					
CSUS native (non-transfer)	0.59	0.75	0.69	0.76	0.71
Freshman	0.66	0.65	0.65	0.67	0.65
Sophomore	0.00	0.11	0.07	0.11	0.09
Junior	0.25	0.13	0.17	0.22	0.19
Senior	0.09	0.10	0.10	0.00	0.06
Post-baccalaureate	0.00	0.02	0.01	0.00	0.01
Undeclared major	0.00	0.16	0.11	0.13	0.12
Business major	0.50	0.46	0.48	0.38	0.45
Social Sciences major	0.25	0.06	0.13	0.04	0.10
STEM major	0.16	0.19	0.18	0.22	0.19
Other major	0.09	0.13	0.11	0.22	0.14
Academic Measures					
High school GPA	2.95	3.07	3.02	3.05	3.03
College GPA (spring 2009)	2.55	2.65	2.64	2.68	2.65
Units attempted (fall 2008)	13.78	14.11	14.00	13.67	13.89
Total units earned	30.95	26.96	28.60	23.13	26.83
Taken remedial English at CSUS	0.34	0.21	0.24	0.38	0.29
Taken remedial math at CSUS	0.31	0.13	0.18	0.33	0.23
Sample Size (N)	32	63	94	45	139

Notes. Numbers between 0 and 1 are proportions of the total number of observations (N). A small number of students are missing high school GPA information. Additionally, because two-thirds of the sample are freshmen and have no college GPA, the college GPA variable reported is measured in the following semester (spring 2009).

Table 2
Student Outcomes in Economics 1A, Fall 2008

	Large Section			Small Section	All Students
	w/ Adjunct	w/o Adjunct	Total		
	(1)	(2)	(3)	(4)	(5)
Homework average	0.65	0.67	0.66	0.68	0.67
Exam 1 average	0.68	0.69	0.69	0.67	0.68
Exam 2 average	0.61	0.63	0.62	0.62	0.62
Exam 3 average	0.53	0.62	0.59	0.58	0.58
Final exam average	0.69	0.67	0.68	0.67	0.68
Overall exam average	0.68	0.71	0.70	0.68	0.69
Overall course average	0.67	0.68	0.68	0.66	0.67
Letter grade distribution					
Proportion As	0.00	0.14	0.10	0.02	0.07
Proportion Bs	0.34	0.21	0.26	0.24	0.25
Proportion Cs	0.38	0.30	0.32	0.36	0.33
Proportion Ds	0.16	0.13	0.13	0.18	0.14
Proportion Fs	0.06	0.22	0.17	0.20	0.18
Proportion Ws	0.06	0.00	0.02	0.00	0.01
Overall proportion of D,F,W grades	0.28	0.35	0.32	0.38	0.34
Average course GPA (4-point scale)	1.96	1.92	1.94	1.72	1.87
Sample Size (N)	32	63	94	45	139

Notes. Numbers between 0 and 1 are proportions of a possible 100 percent (1.00) in the case of course performance variables and proportions of the total number of observations (N) in the case of the grade distribution variables.

Table 3

Regression Results to Examine Impact of Adjuncts: Parameter Estimates Based on the Large Lecture Sample

	Various Course Outcomes			
	Homework Average	**Exam Average**	**Course Average**	**D, F, W Grade***
Variable				
Adjunct participant	0.055	0.044	0.070	**-0.285**
Student Age	0.004	-0.001	0.001	**-0.128**
Black	**-0.162**	-0.105	**-0.178**	**0.414**
Hispanic	0.057	0.076	0.033	-0.065
Asian	0.027	-0.070	-0.011	-0.087
Other race/ethnicity	-0.081	0.053	-0.059	0.064
Freshman	-0.114	-0.079	-0.110	**-0.573**
Social Sciences major	-0.046	-0.053	-0.052	0.019
High school GPA	**0.118**	**0.106**	**0.124**	**-0.417**
Taken remedial math at CSUS	-0.019	-0.102	-0.032	0.027
Adjusted R-squared	0.255	0.063	0.112	0.267

Notes. The sample size for all regressions is N=79, which is less than the full sample of 94 students enrolled in the large lecture due to missing high school GPA information. The results on 'Adjunct participant' are robust to the exclusion of GPA and use of the full sample. Bolded parameter estimates are statistically significant at at least the 90 level.

* Whether a student received a grade of D, F, or W is a binary variable, thus, logistic regression is utilized and the estimates presented in the last column are marginal effects.

Table 4
Regression Results to Examine the Impact of Class Size: Parameter Estimates Based on Non-Adjunct Sample

	Various Course Outcomes			
	Homework Average	**Exam Average**	**Course Average**	**D, F, W Grade***
Variable				
Large lecture enrollee	**-0.065**	-0.011	-0.018	0.104
Student Age	**0.041**	0.018	**0.036**	**-0.171**
Black	**-0.283**	**-0.231**	**-0.310**	**---**
Hispanic	-0.022	-0.058	-0.056	-0.057
Asian	-0.053	**-0.104**	**-0.083**	0.000
Other race/ethnicity	**-0.174**	-0.101	**-0.121**	0.234
Freshman	0.048	-0.038	0.006	-0.081
Social Sciences major	-0.103	-0.099	-0.129	0.320
Business major	**-0.075**	-0.043	-0.053	0.058
High school GPA	**0.193**	**0.150**	**0.190**	**-0.662**
Taken remedial math at CSUS	-0.016	-0.056	-0.021	0.246
Adjusted R-squared	0.331	0.203	0.335	0.309

Notes. The sample size for all regressions is N=89, which is less than the full sample of 109 students who did not participate in adjunct sections due to missing high school GPA information. The results on 'Large lecture enrollee' are robust to the exclusion of GPA and use of the full sample. Bolded parameter estimates are statistically significant at at least the 90 level.

* Whether a student received a grade of D, F, or W is a binary variable, thus, logistic regression is utilized and the estimates presented in the last column are marginal effects. "Black" perfectly predicted receipt of a D, F, or W in this subsample of students and had to be dropped due to perfect collinearity.

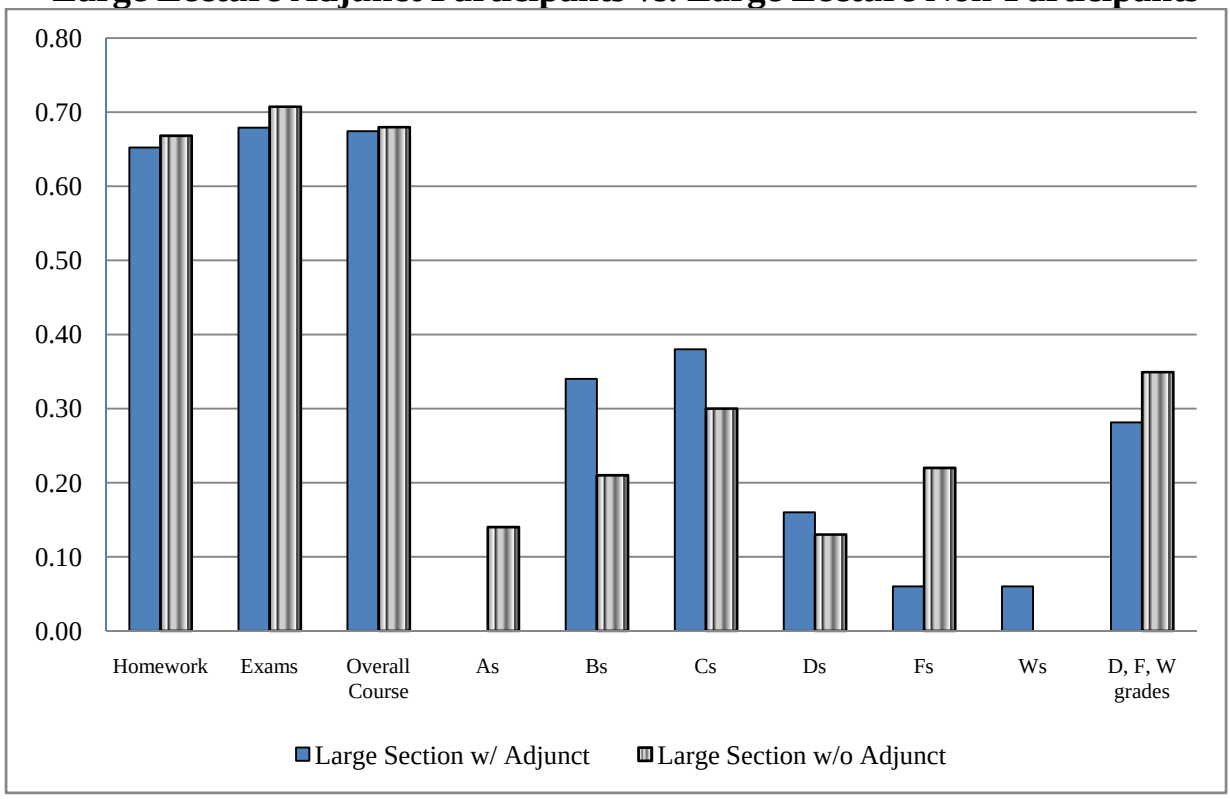
Table 5
Regression Results to Examine the Combined Impact of Adjuncts Sections and Class Size

	Various Course Outcomes			
	Homework Average	**Exam Average**	**Course Average**	**D, F, W Grade***
Variable				
Adjunct participant in large lecture	0.022	0.056	0.078	**-0.306**
Student Age	0.001	-0.003	-0.002	0.008
Black	-0.062	-0.077	-0.073	0.507
Hispanic	-0.063	-0.071	-0.078	0.181
Asian	0.001	-0.005	-0.004	-0.004
Other race/ethnicity	0.008	-0.011	0.009	0.079
Freshman	**-0.109**	-0.079	-0.094	**0.275**
Social Sciences major	**-0.126**	-0.103	-0.131	0.234
Business major	-0.068	-0.052	-0.062	0.104
High school GPA	**0.187**	**0.145**	**0.169**	**-0.370**
Taken remedial math at CSUS	-0.095	-0.104	-0.097	0.040
Adjusted R-squared	0.248	0.092	0.156	0.200

Notes. The sample size for all regressions is N=67, which is less than the full sample of 77 students who either participated in adjunct sections or were in the small section due to missing high school GPA information. The results on 'Adjunct participant in large lecture' are robust to the exclusion of GPA and use of the full sample. Bolded parameter estimates are statistically significant at at least the 90 level.

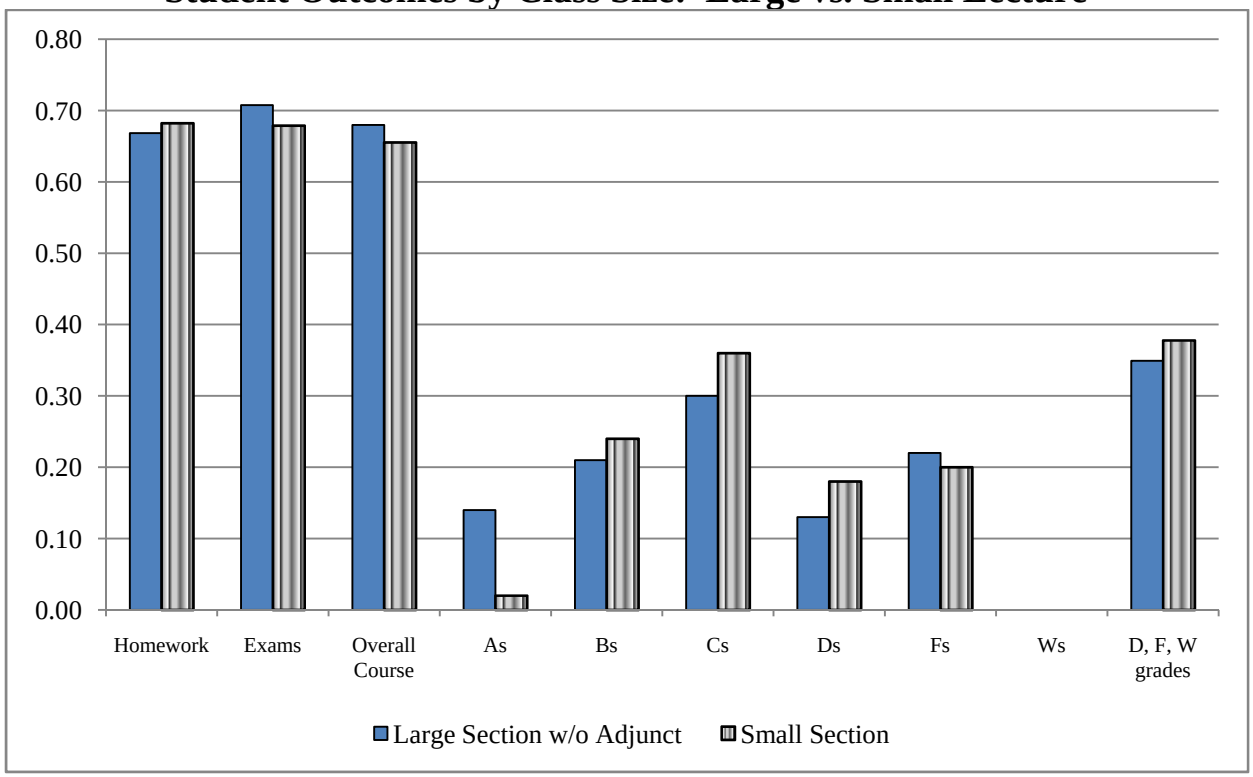
* Whether a student received a grade of D, F, or W is a binary variable, thus, logistic regression is utilized and the estimates presented in the last column are marginal effects.

Figure 1
Student Outcomes by Adjunct Participation:
Large Lecture Adjunct Participants vs. Large Lecture Non-Participants



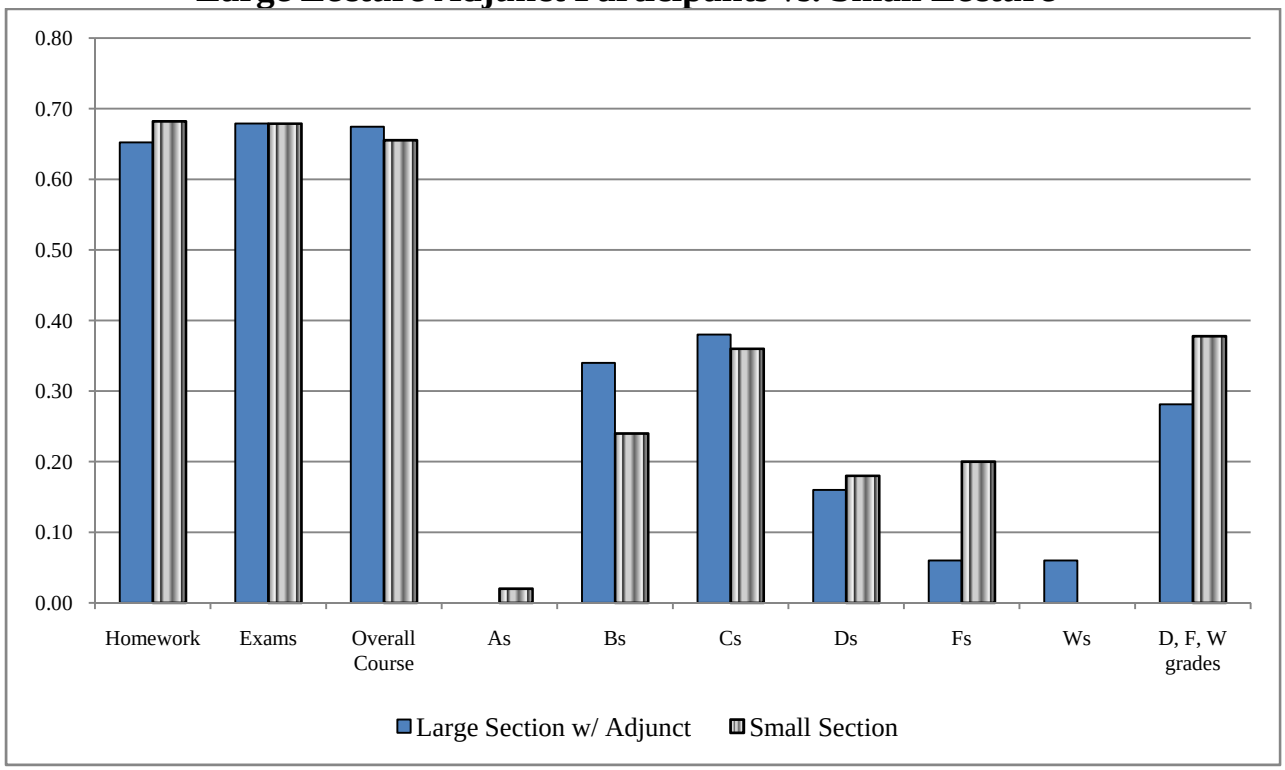
Notes. Data correspond to columns (1) and (2) in Table 2.

Figure 2
Student Outcomes by Class Size: Large vs. Small Lecture



Notes. Data correspond to columns (2) and (4) in Table 2.

Figure 3
Student Outcomes by Adjunct Participation and Class Size:
Large Lecture Adjunct Participants vs. Small Lecture



Notes. Data correspond to columns (1) and (4) in Table 2.