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Who Merits Financial Aid? Massachusetts' Adams Scholarship

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Abstract

The majority of states in the U.S. now fund merit-based financial aid programs, the effects of which depend on how strongly students react to changes in college costs. I estimate such reactions using quasi-experimental aspects of a recent Massachusetts merit scholarship program intended to attract talented students to the state's public colleges. This paper is the first to document heterogeneity in price sensitivity among students of varying academic abilities. My primary result is that, in spite of its small monetary value, the scholarship induced 6% of winners to choose four-year public colleges over four-year private colleges, the average of a large effect on the lowest ability winners and no effect on the highest ability winners. The bulk of funds nonetheless flowed to students who would have attended public colleges anyway, and the scholarship had no effect on the overall college attendance rate, which for winners was already above 90%. These findings have implications for the design of future government-sponsored financial aid programs.

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College costs in most industrialized countries have increased rapidly in recent years, presenting a serious public policy dilemma given most governments' stated goals of maintaining or improving access to higher education.[1] Different countries have adopted different approaches to address this dilemma, in a continual search for the optimal form and extent of state support for students. Germany has, for example, experimented with transforming a large fraction of student loans into outright grants. Great Britain, Australia and New Zealand have increased students' use of income contingent loans, in which each student's repayment amount depends upon her current ability to repay the loan. Merit-based financial aid, in which student support is contingent on demonstrated academic ability, has become increasingly common in both Canada and the United States. This last form of student support is the focus of this paper.

In the U.S., the increased popularity of merit-based aid can be partly explained by rapidly rising college costs. From 2000 to 2005, the price (tuition and fees) of public and private colleges rose annually by an average of 9.1% and 5.6% respectively, far exceeding the inflation rate of 2.5%. Public concern over these increases has made political programs to reduce such costs quite popular. State governments have reacted particularly strongly to these political pressures; since 1980 the amount of financial aid offered by the states has more than doubled relative to that offered by the federal government. By 2005, state and local governments were spending $59 billion (7.4% of revenue) on students enrolled in public postsecondary institutions, in the form of both financial aid for students and direct support for those institutions.[2]

As the states have increased their funding for financial aid programs, they have also shifted the mix of funding away from purely need-based programs and toward programs based partially or solely on academic merit. By 2005, 31 states were providing under-

[1] For more on the challenges facing U.S. and European higher education, see Heller and Rogers (2006).

[2] Postsecondary education facts in this paragraph come from Heller (2002) and from Tables 280 and 282 of U.S. Census Bureau (2005).

graduate financial aid at least partly on the basis of merit. This merit-based aid totalled $2.1 billion (29% of all state-based financial aid), of which $1.2 billion was based solely on merit and $0.9 billion was based on a combination of merit and need.[3] Advocates argue that these programs raise college attendance rates, incentivize student achievement, prevent state-level brain drain, and reduce the financial burden of college. Opponents of these programs argue that targeting aid based on merit rather than need diverts funds toward high-income students and away from those low-income students whom the funds would most benefit.

Evaluating merit-based programs depends in large part upon understanding how students, particularly at the upper end of the ability distribution, respond to changes in the costs of various college options. My analysis below answers this question in the context of Massachusetts' Adams Scholarship, a merit scholarship that is assigned on the basis of a state-administered standardized test score and that reduces the price of in-state public colleges by about 17%, or $1,700 a year. The program was intended by legislators primarily to attract more talented students to the state's public colleges. Using data provided by the state's Board of Education, I exploit two quasi-experimental aspects of the scholarship in order to identify its effects. First, the scholarship was introduced relatively unexpectedly, allowing me to construct a difference-in-difference estimator, comparing the college attendance patterns of winners and losers in the years before and after the scholarship began.[4] Second, the scholarship was awarded on the basis of standardized test scores, allowing me to use a regression discontinuity design that compares college attendance patterns of students just above and below the threshold eligibility score.

[3] U.S. merit aid data come from Table 8 of National Association of State Student Grant and Aid Programs (2006). Gucciardi (2004) finds that Canada now spends $200 million annually on merit scholarships, of which $80 million or so comes from the national or provincial governments.

[4] As I explain in Section 4, the status of "winner" or "loser" in years prior to the scholarship's existence is imputed by determining whether, based on her test scores, a given student would have won the scholarship had it then existed.

This paper makes at least four contributions to the literature on financial aid generally and merit-based scholarships specifically. First, my analysis is based on a very clean quasi-experiment and student-level data for every Massachusetts high school graduate from 2003-2005, making the estimated effects more convincing than much of the previous literature on merit scholarships. Second, because my data contains detailed test score information, I can explore heterogeneity in price sensitivity among students of varying academic abilities, which no previous paper has done. Third, the Adams Scholarship grants students much less money than do the most widely studied merit scholarships, allowing measurement of students' reactions to financial incentives that are arguably quite small. Finally, receipt of the scholarship is automatic, so that my results do not suffer from the selection bias potentially confounding evaluation of those aid programs requiring applications.

My primary result is that, in spite of its small monetary value, the Adams Scholarship induced roughly 6% of winners to choose four-year public colleges instead of four-year private colleges, showing that students are quite sensitive to small differences in costs. The scholarship had little or no effect on the overall college attendance rate, which among winners was already above 90%. Even with this fairly large reaction, the bulk of funds flowed to those students who would have attended public colleges absent the scholarship. Winners with relatively low academic ability had particularly strong reactions to the price change, while the highest ability winners had little or no reaction. This is presumably due to the fact that the highest ability winners secure admission to the highest quality private institutions and that the Adams Scholarship is worth too little to those students to induce a large sacrifice in college quality. I also find that low-income winners react strongly to the scholarship, but that this effect diminishes when I control for academic ability. Previous research may have mistaken heterogeneity by academic ability for heterogeneity by income, given the commonly observed correlation between income and test scores.

My results have implications both for the general design of financial aid programs and for evaluating the Adams Scholarship program in particular. In general, governments designing financial aid programs should understand the characteristics of the targeted student populations, paying particular attention to existing relations between academic ability, income and students' college attendance decisions. Programs based purely on need may subsidize the college educations of those whose academic ability is too low for the benefits of college to outweigh the costs, while programs based purely on merit run the risk of channeling aid to those students most likely to attend college anyway. Optimally designed aid programs would target those students whose academic ability suggests they would benefit from college but whose incomes imply a relatively high probability that they do not enroll.

The Adams Scholarship is particularly poorly designed in this regard. Its goal of moving students from private to public colleges has questionable economic value at best, particularly given potential alternative uses of the $30 million annually devoted to the scholarship. Even taking that goal as worthwhile, the program would have induced greater movement to public colleges per dollar spent had its eligibility rules included a low-income criterion. I present evidence for Massachusetts that high-ability, low-income students are less likely to attend four-year college than their higher income peers of similar ability. This suggests some scope for a potentially efficient state intervention that tightly targets aid to high-ability, low-income students.

The paper proceeds as follows. Section 1 reviews previous literature on the effects of financial aid and merit scholarships. Section 2 explains the details of the Adams Scholarship. Section 3 reviews the data and describes the population of students in question. In Sections 4 and 5, I use the difference-in-difference and regression discontinuity methodologies to estimate the impact of the Adams Scholarship on students' college attendance decisions, while in Section 6 I explore heterogeneity in these reactions by academic abil-

ity. Section 7 discusses the implications of my findings for the design of financial aid programs.

1 Previous Literature

This paper is related to two strands in the economics and education literatures. The first strand is research on student reactions to financial aid. Although an extensive empirical literature has studied the relation between college costs and college attendance decisions, until the last decade or so the literature has suffered from omitted variable bias because variation in costs is not exogenous to unobserved determinants of schooling. In the U.S., exploration of various quasi-experiments has helped alleviate this problem. Such quasi-experiments include changes in Pell grant rules, as in Seftor and Turner (2002); the effect of GI bills, as in Bound and Turner (2002); within-state tuition changes, as in Kane (1995); elimination of Social Security student benefits, as in Dynarski (2003); and discontinuities in a school's financial aid formula, as in van der Klaauw (2001).[5] Reviewing this recent literature, Dynarski (2002) concludes that the evidence consistently suggests that eligibility for $1,000 in annual aid raises college attendance rates by about 4 percentage points, but notes that the studies are evenly split on the question of whether college subsidies have a greater impact on low- or high-income students. The central result of this literature is that financial aid has a substantial impact on the college decisions of American high school graduates.

The second strand focuses specifically on the design and effects of American merit

[5]I know of only one quasi-experimental estimate of the affect of financial aid on European students' college enrollment decisions. Baumgartner and Steiner (2005) find no evidence that an exogenous transformation of student loans to non-repayable grants had an effect on college enrollment rates of German students. There is, however, a larger European quasi-experimental literature on the effect of college costs on time to degree completion, a particular challenge for European universities whose students often take full advantage of the low costs of attendance. Garibaldi et al. (2007) reviews this literature and finds that in Italy, raising college costs does motivate students to complete their studies significantly faster.

scholarship programs. Opponents of merit-based financial aid focus on the strong association between measures of merit and high socioeconomic status. Heller and Rasmussen (2002) show that this association causes Florida and Michigan, two of the largest funders of merit-based aid, to have disproportionately low representation of low-income students in their pool of merit scholarship winners. The authors argue that this diminishes the ability of the scholarships to raise college attendance rates, which are lowest among low-income students. Heller (2004) predicted that the design of the Adams Scholarship would similarly leave few disadvantaged students in the pool of winners. As I show in Section 4, his predictions were largely correct.

Previous evaluations of the effects of small state-run merit scholarship programs tend to suffer from data limitations and selection bias. Binder and Ganderton (2004) try to evaluate the effect of a New Mexico merit scholarship but have individual level data only for students enrolled in the University of New Mexico, as well as institution level data for colleges, which prevents analysis of non-attenders. St. John (2004) looks at programs in Washington and Indiana that award scholarships to high school students pledging to adhere to a set of behavioral and academic standards, but the study suffers from the fact that students choosing to make this pledge are likely different in important ways from their non-pledging counterparts.

The best evaluations of scholarship programs based on merit have focused on two states with the largest such programs, Georgia and California.[6] Dynarski (2000) uses data from the Current Population Survey to estimate the effects of Georgia's HOPE Scholarship Program, whose goal was to raise in-state college attendance rates from their base level of 30%. The scholarships granted free attendance at Georgia's public colleges to state residents with at least a B average in high school, regardless of income level. The maxi-

[6]Though these two states are the largest spenders on merit-based financial aid, Florida is not far behind, spending $270 million annually on its Bright Futures Scholarship. To my knowledge, no convincing evaluation of this program has yet been published and thus might provide material for future research.

mum annual value of the scholarship during the time period studied was roughly $3,500 (in 2005$). Using a difference-in-difference approach, Dynarski explores the change in college attendance rates around the time of the introduction of the scholarship program, using other southeastern states as a control group. She finds that the program increased Georgia's college attendance rate by over 7 percentage points but argues that the effect was concentrated among white students, likely due to the correlation between race, income and high school grades.

Cornwell et al. (2006) update this analysis in more detail using IPEDS data on Georgia's postsecondary institutions. They roughly agree with Dynarski's estimate of the increased attendance rate, but conclude that both black and white students exhibited such an increase. They also estimate that much of the apparent increase stems from students choosing Georgia institutions over out-of-state ones, and that ultimately only 15% of scholarship winners changed their college decision based on the increased aid. This last result is remarkably similar to mine. Nonetheless, unlike this paper, neither Dynarski nor Cornwell et al. has data that permits closer examination of high school students making their college decision.

More satisfying in this regard is Kane's (2003) evaluation of California's CalGrant program, which gave college grants worth up to $11,000 annually (in 2005$) to federal financial aid applicants who had achieved a minimum high school GPA and fell below certain income and asset limits. The largest grants were given to students attending private colleges because the state wanted to ease capacity constraints in its public postsecondary system. Kane evaluates the effect of CalGrant using detailed student information from federal financial aid applications and exploiting the multiple discontinuities inherent in the program design (minimum GPA, maximum income and maximum assets). That the GPA threshold was determined late in the process by state funding availability eliminates the possibility that students more desirous of aid tried "to claw their way above the

threshold," which would invalidate the smoothness assumption underlying regression discontinuity techniques.

Kane concludes that the grants caused a 3-4 percentage point rise in college enrollment among financial aid applicants and caused low-income applicants to more than double their rate of private college attendance (from 15% to over 30%). Though the paper's identification strategy is quite convincing, it suffers from two limitations. First, selection effects may bias the results, given that only students filing the Free Application for Federal Student Aid (FAFSA) were considered for grants and are thus in his data. Second, and more important, the regression discontinuity design allows Kane to estimate the effects of the grants only for students near the GPA threshold. As I will show below, my data and the design of the Adams Scholarship rule out any selection bias, while my empirical approach allows investigation of the heterogeneity in students' reactions by varying academic ability.

The above papers make clear that a merit-based financial aid program can have a significant impact on a student's decision whether to attend college at all and, if so, whether to attend in the public or private sector. Also clear is that states' merit-based scholarships vary widely both in their goals and in their designs, which differ as to award values and eligibility criteria. Evaluation of these programs requires consideration of whether the goals are sensible and whether the design efficiently achieves those goals. I argue below that the Adams Scholarship fails both of these tests and that understanding why this is so will aid in the design of future merit-based scholarship programs.

2 The Adams Scholarship Program

In 10th grade, all public high school students in Massachusetts take the Massachusetts Comprehensive Assessment System (MCAS), which includes an English Language Arts

portion and a Mathematics portion.[7] On each portion of the MCAS, students' scores, which range in multiples of two from 200 to 280, are categorized in descending order as "advanced" (260-280), "proficient" (240-258), "needs improvement" (220-238), or "warning/failing" (200-218). In January 2004, Massachusetts Governor Mitt Romney proposed the John and Abigail Adams Scholarship Program[8], which would waive tuition at any Massachusetts community college, state college or University of Massachusetts (U. Mass.) campus for those students whose combined English and mathematics scores on the MCAS placed them in the top 25% statewide. This announcement met with huge political opposition from state legislators concerned that the waivers would go largely to students in wealthy, high-performing school districts.

In October 2004, the state Board of Higher Education voted to accept a modified version of the proposal in which a student must satisfy two criteria in order to receive a tuition waiver. First, her combined English and mathematics score must place her in the top 25% of students in her own school district rather than the whole state, a condition designed to alleviate the aforementioned political opposition. Each district is thus associated with a cutoff score representing the 75th percentile of its students' total scores. Second, she must score in the "advanced" ($\geq$260) category on one portion of the exam and in the "proficient" ($\geq$240) or "advanced" category on the other portion, thus requiring a total MCAS score of at least 500. This objective threshold helped satisfy those who

[7]Information on Massachusetts' educational system and the Adams Scholarship Program comes from http://www.doe.mass.edu. The history of and reactions to the Adams Scholarship come from Russell and Vaishnav (2004), Russell (2004a), Russell (2004b), Russell (2005), and Jan (2005), as well as my discussions with Robert Lee and others at the Massachusetts Department of Education.

[8]The eponymous couple placed great value on education. John Adams wrote, in 1780, that "I must study politics and war that my sons may have liberty to study mathematics and philosophy. My sons ought to study mathematics and philosophy, geography, natural history, naval architecture, navigation, commerce, and agriculture, in order to give their children a right to study painting, poetry, music, architecture, statuary, tapestry, and porcelain." His wife, Abigail Adams, may have agreed with her husband's sentiment but not with his single-sex phrasing of the issue. She once wrote, "It is really mortifying, sir, when a woman possessed of a common share of understanding considers the difference of education between the male and female sex, even in those families where education is attended to." Mrs. Adams would likely have been pleased that women constituted the majority of the first class of scholarship winners.

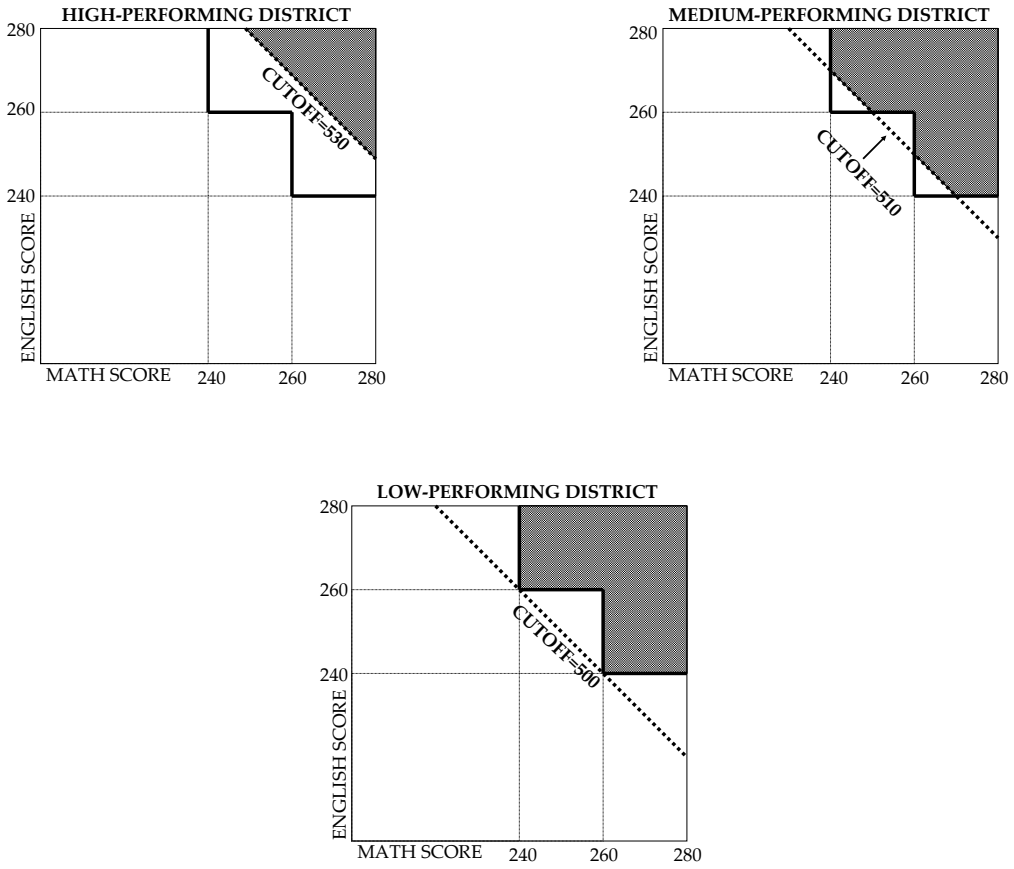

Figure 1: Graphical Representation of Scholarship Eligibility

objected that scholarships might be granted to low-performing students in even lower-performing school districts.

Figure 1 provides a graphical interpretation of scholarship eligibility in different types of school districts. In all three panels, students must pass the same proficient/advanced threshold represented by the thick solid line. Students must also achieve their own district's cutoff score, represented by the thick dashed line. Scholarship winners are those students whose test scores fall in the shaded region. In a high-performing district, as in the top left panel, the district's cutoff score is so high that the proficient/advanced con-

straint does not bind. In a medium-performing district, as in the top right panel, the district's cutoff score interacts with the proficient/advanced threshold in a complex way. In the lowest-performing districts, as in the bottom panel, the district's cutoff score is so low that passing the proficient/advanced threshold is sufficient to win a scholarship. In the class of 2005, roughly 18% of students came from low-performing districts with cutoff scores less than or equal to 500, 32% came from high-performing districts with cutoff scores greater than or equal to 520, and the remaining 50% came from medium-performing districts with cutoff scores from 502 to 518.

Students who qualify for an Adams Scholarship are automatically notified by letter in the fall of their senior year that they have been granted free tuition at any of fifteen (two-year) community colleges, seven (four-year) state colleges, or four U. Mass. campuses.[9] As Table 1 shows, receipt of the scholarship far from eliminates the cost of college attendance. In fact, for the high school class of 2005 (the first to be eligible for the Adams Scholarship), tuition at individual public colleges in Massachusetts ranged from only 16-24% of direct cost of attendance, with fees making up the remaining portion. Community college students paid an annual average of $740 in tuition and $2,782 in fees, state college students paid $961 in tuition and $4,389 in fees, and U. Mass. students paid $1,575 in tuition and $7,612 in fees. These figures imply that the average annual (total) value of the Adams Scholarship was $740 ($1480) for community college students, $961 ($3,846) for state college students, and $1,575 ($6,299) for U. Mass. students.

The Adams Scholarship thus differs from other studied merit-based aid programs both in award value and in its definition of merit. The maximum Adams Scholarship award is roughly half the value of a HOPE award and one-sixth the value of a CalGrant award.[10] Dynarski (2004) lists over a dozen states' merit-based aid programs in which the

[9] After receiving that letter, a student must then file a FAFSA and must enroll in college the semester immediately following his high school graduation. He must also maintain a 3.0 grade point average in college in order to continue receiving the tuition waiver.

[10] One official at the Massachusetts Department of Education told me that there was already political

Table 1: Average Costs of Massachusetts' Public Colleges, 2005/06

		1 Year		Total (2 or 4 years)		Tuition as
	N	Tuition	Fees	Tuition	Fees	% of Cost
University of Mass.	4	$1,575	$7,612	$6,299	$30,448	17.1%
State colleges	7	961	4,389	3,846	17,557	18.0%
Community colleges	15	740	2,782	1,480	5,563	21.1%

Source: Massachusetts Board of Higher Education: Fiscal Policy (Tuition and Fee Survey)

definition of merit is loose as to include over 30% of the student population, including some where the proportion is much greater. Under Arkansas' definition, 60% of its students qualify for merit-based aid. The Adams Scholarship, in contrast, is awarded to less than 25% of graduating Massachusetts seniors.

The primary goals of the program seem to be keeping talented students from leaving the state and improving the quality of Massachusetts' public colleges. At a June 15, 2004 meeting of the state Board of Higher Education, Governor Romney "explained that the Abigail and John Adams Scholarship will attract Massachusetts students to stay in Massachusetts by providing a special incentive to our brightest students.... It is a priority to attract the very best students to our public colleges."[11] The Board of Higher Education's website now lists as one of the scholarship's purposes, to "help attract more high-performing students to Massachusetts public higher education." It is not clear why this particular priority is an economically sensible use of the state's education budget. Keeping talented students in state might be worth the expenditure if in the long run students tend to settle where they attend college, but recent work by Groen (2004) shows that, at most, 10% of students induced to stay in-state will remain in that state's labor market 10-15 years later. Also, there is no reason to assume, given Massachusetts' impressive set of

pressure on the state government to extend the scholarship to cover fees as well as tuition, after parents of scholarship winners realized that free tuition was worth much less than they had initially believed.

[11]Minutes of the meeting can be found at http://www.mass.edu/p_p/home.asp?id=5.

Table 2: Mean Characteristics of Massachusetts' Four-Year Colleges

		SAT Score Percentiles				
		Verbal		Math		2005/2006
	N	25th	75th	25th	75th	Tuition and Fees
Private colleges	56	529	615	533	618	$27,821
University of Mass.	4	504	604	512	616	8,806
State colleges	7	454	551	454	551	5,474

Source: NCES' Integrated Postsecondary Education Data System (IPEDS)

private colleges, either that the state suffers from net brain drain or that it would benefit by diverting students from private to public colleges.

To understand why legislators might be concerned about the difference between public and private colleges in Massachusetts, consider Table 2, which compares the enrollment-weighted mean characteristics of three categories of BA-granting four-year colleges.[12] SAT scores (which range from 200 to 800) show that private colleges attract a much more talented set of students than do state colleges, with a more than 60-point difference in both verbal and math scores at the 25th and 75th percentiles.[13] The U. Mass. campuses look more similar to private colleges than do other state colleges, at least at the 75th percentile of SAT scores. Talented students are thus found at both sets of institutions.

I show in Section 6 that the Adams Scholarship's primary effect was to attract to the U. Mass. campuses students in the 60-79th percentiles of academic ability. The scholarship thus failed to attract any new students to state colleges and failed to attract many students above the 80th percentile of academic ability to the U. Mass. campuses. In fact, had the scholarship taken the original form proposed, with a state-wide rather than a district-

[12] I limit the comparison to four-year colleges because the scholarship's effect is limited to those student attending four-year colleges, as will be seen in Sections 4 and 5.

[13] This comparison is certainly skewed by the fact that Massachusetts' private colleges attract a large number of talented students from out of state. Ideally I could compare these institutions on the basis of enrollment by only Massachusetts students. Unfortunately, IPEDS does not permit this comparison.

wide cutoff score, almost no scholarships would have been awarded to students in the 60-79th percentiles, so that the program's effect would have been much smaller than it ultimately was.

3 The Data

The data was compiled by the Massachusetts Department of Education, combining its Student Information Managements System, which records every student's demographic variables and post-graduate intentions, with information on each student's MCAS scores and Adams Scholarship eligibility. The original data set contains 171,786 students: the complete classes of 2003 and 2004, who graduated prior to the existence of the Adams Scholarship, and the class of 2005, the first class of students eligible for the Adams Scholarship. For every student, the data contains: gender; race; a poverty indicator (based on whether the student qualifies for free or reduced price lunch); a vocational education indicator (based on the student's enrollment in a career/vocational educational program); a special education indicator (based on whether the student is officially registered with his school district as having special needs); an English-as-second-language indicator; English and math MCAS scores; the MCAS cutoff score for scholarship eligibility in that student's school district (for the class of 2005); and the student's post-graduation plans, as reported by his high school's guidance department at the end of his senior year. Each student is also assigned a randomized school district number, which allows me to identify which students came from the same school district while not identifying the district itself.

Post-graduation plans, the outcome variable of interest in this paper, fall into one of 9 categories: four-year public college; two-year public college; four-year private college; two-year private college; other postsecondary (trade school); work; military; other (e.g., travel, family); or plans unknown. I assign students to a graduating class based on when

their guidance departments reported their post-graduation plans. In cleaning the data, I removed 8,529 students whose MCAS scores were missing, as well as another 2,293 whose school district or post-graduation plan could not be determined. This leaves 93.7% of the original data, consisting of 160,964 graduating seniors from Massachusetts, over 50,000 each from the classes of 2003, 2004 and 2005. I label students as being from "medium poverty" districts if their graduating class had a poverty rate between 20% and 40% and "high poverty" districts if their graduating class had a poverty rate higher than 40%.

Table 3 shows summary statistics for the entire classes of 2003, 2004 and 2005, as well as for subpopulations of the class of 2004, which will serve as a base year from which to judge the effects of the Adams Scholarship. All variables listed are dummy variables, except for MCAS scores. The first three columns of Table 3 suggest that, of graduating seniors in Massachusetts, roughly 7% are black, 6% are Hispanic, and over 20% come from medium- or high-poverty school districts. Over 75% attend college, with somewhat more than half of those attending public colleges. About three-fifths of those who attend public college attend four-year public colleges, with the remainder attending two-year public colleges. In contrast, those who attend private colleges almost all attend four-year private colleges. Finally, MCAS scores appear to increase with time.

In the last six columns of Table 3, I analyze various subpopulations of the class of 2004. These figures reveal that women attend college more frequently than men, that most black and Hispanic seniors graduate from high-poverty school districts, and that such students have noticeably lower MCAS scores and college attendance rates. This suggests that heterogeneity in response to the Adams Scholarship will be an important phenomenon to consider.

To check that students' reported postsecondary intentions reflect actual college attendance, I used the National Center for Education Statistics' Integrated Postsecondary Education Data System (IPEDS), which breaks down freshman classes at all U.S. post-

Table 3: Mean Characteristics of Massachusetts' Graduating Seniors

	All Students			Class of 2004					
	Class of 2003	Class of 2004	Class of 2005	Female	Black	Hispanic	Poverty	Med. Pov. District	High Pov. District
Demographics									
Female	0.518	0.508	0.514	1.000	0.544	0.527	0.529	0.486	0.529
Black	0.065	0.067	0.068	0.072	1.000	0.000	0.228	0.102	0.294
Hispanic	0.059	0.060	0.067	0.062	0.000	1.000	0.251	0.093	0.257
Poverty	0.132	0.143	0.162	0.149	0.485	0.597	1.000	0.265	0.536
Medium Poverty District	0.086	0.107	0.110	0.103	0.164	0.166	0.199	1.000	0.000
High Poverty District	0.114	0.124	0.149	0.129	0.544	0.528	0.465	0.000	1.000
English as Second Language	0.098	0.100	0.110	0.103	0.187	0.591	0.361	0.169	0.362
Special Education	0.100	0.120	0.115	0.087	0.148	0.129	0.155	0.135	0.103
Vocational Education	0.190	0.184	0.167	0.156	0.236	0.364	0.326	0.516	0.250
Limited English Proficiency	0.023	0.019	0.037	0.019	0.063	0.145	0.095	0.018	0.104
College Choice									
Any College	0.771	0.780	0.802	0.843	0.717	0.631	0.639	0.654	0.677
Public College	0.429	0.425	0.454	0.447	0.348	0.399	0.393	0.449	0.360
Private College	0.342	0.355	0.348	0.396	0.369	0.232	0.246	0.205	0.317
Four Year Public College	0.257	0.257	0.278	0.272	0.178	0.138	0.160	0.201	0.175
Two Year Public College	0.172	0.168	0.176	0.175	0.170	0.261	0.233	0.248	0.184
Four Year Private College	0.319	0.330	0.327	0.370	0.318	0.181	0.206	0.175	0.268
Two Year Private College	0.023	0.025	0.021	0.026	0.050	0.051	0.041	0.030	0.050
MCAS Scores									
MCAS Score - English	241.7	244.7	246.6	246.8	234.2	232.2	233.6	236.8	236.2
	(16.9)	(16.4)	(15.7)	(16.3)	(15.6)	(15.1)	(15.3)	(15.1)	(16.8)
MCAS Score - Math	240.5	240.6	244.0	239.7	227.6	227.3	229.8	231.9	231.2
	(17.7)	(18.3)	(17.9)	(17.9)	(15.2)	(15.4)	(16.5)	(16.2)	(17.8)
MCAS Score - Total	482.2	485.3	490.6	486.5	461.8	459.4	463.4	468.7	467.4
	(32.2)	(32.2)	(31.0)	(31.9)	(28.2)	(27.8)	(29.1)	(28.6)	(32.2)
Adams Scholarship Variables									
Proficient/Advanced	0.262	0.300	0.340	0.302	0.087	0.080	0.109	0.127	0.155
Adams Scholarship Winner	0.196	0.211	0.239	0.218	0.068	0.064	0.094	0.123	0.154
Sample Size	52,750	53,715	54,499	27,274	3,595	3,230	7,669	5,758	6,651

All variables are dummy variables, except for MCAS scores, which have standard deviations listed in parentheses.

secondary institutions by state of residence. According to IPEDS, 46,846 Massachusetts students started college in 2004, a slightly higher number than the 41,912 reported in my SIMS data, due largely to students I discarded and the fact that IPEDS includes students attending private high schools and those who have taken some time off between high school and college. The proportions of students attending various categories of college are, however, nearly identical in the IPEDS and SIMS data. According to IPEDS (SIMS), the proportion of Massachusetts seniors attending four-year public college is 32.0% (32.9%), two-year public college is 22.6% (21.5%), four-year private college is 43.2% (42.3%), and two-year private college is 2.2% (3.2%). This confirms that reported intentions reflect actual enrollment decisions.

The outcome variable does, however, suffer from two limitations. First, the categories are broad, so that more detailed questions concerning the chosen colleges' characteristics, like selectivity and price, can not be explored further. The second is that, according to IPEDS, though 97% of students attending "two-year public college" are doing so in-state, only 72% of those attending "four-year public college" are doing so in-state. Over a quarter of that latter category thus comprises students attending public colleges outside of Massachusetts, preventing perfect identification of students attending in-state public college.

4 Difference-in-Difference Methodology and Results

Estimation of the Adams Scholarship's effects through comparison of the post-secondary plans of scholarship winners and losers would be heavily biased by the omission of academic ability as an explanatory variable. I eliminate this bias by constructing a difference-in-difference estimator comparing scholarship winners to losers in the year before and after the scholarship's introduction. To do this, I create a dummy variable WIN_{ij}, equal to

1 for any 2005 graduate i in district j who won the Adams Scholarship as well as for 2003 and 2004 graduates who would have won, according to their test scores, had the scholarship been in place in those years. To impute this value to the 2003 and 2004 graduates, I determine whether each student passed the proficient/advanced threshold and scored in the top 25% of his school district in his graduation year. The identifying assumption of the difference-in-difference approach is that, according to the construction of WIN_{ij}, between 2004 and 2005 nothing other than the Adams Scholarship affected the difference in college enrollment patterns between winners and losers.

Two facts might interfere with identification. First, because MCAS scores were lower in 2003 and 2004 so that fewer students passed the proficient/advanced threshold, a smaller fraction of those students would have been scholarship winners based on my construction of WIN_{ij}. This is confirmed in the bottom row of Table 3, where the proportion of students labeled winners rises from 19.6% to 23.9% over the three years. This could bias the difference-in-difference estimator if WIN_{ij} identifies slightly different parts of the ability distribution in different years. I will address this potential bias further below both with a regression discontinuity approach, using only a single year of data, and with regressions including a students' rank in the ability distribution. A second source of bias would arise if scholarship winners systematically included more students who had tried, as Kane (2003) puts it, to "claw" their way above the thresholds. This is ruled out here both because the program was announced over a year after the class of 2005 had taken their MCAS exams and because each district's cutoff score was a random variable that no student could predict ahead of time.[14]

Based on the construction of WIN_{ij}, Table 4 contains summary statistics for the three graduating classes, separated by winners and losers. Scholarship winners are much less

[14]There is some evidence that manipulation of the system began for later scholarship classes. One education official told me of an assistant principal who had transferred her 10th grade daughter to a lower-performing school district in order to guarantee that she win an Adams Scholarship.

likely than losers to be black or Hispanic, to be poor, and to be enrolled in special or vocational education programs. These demographics differences seem relatively stable over time. More interesting is the change over time in students' post-graduation plans. About 95% of winners plan to attend college, compared to 74% of losers, proportions that are relatively stable over time. Only 4% of scholarship winners attend public and private two-year colleges, a proportion that is also stable. What does change, however, is the proportion of winners attending four-year public and private colleges. These proportions, roughly 30% and 60% respectively, barely shift from 2003 to 2004, but change dramatically to 37% and 54% in 2005. No such change is observed among the losers, suggesting that scholarship winners in 2005 were affected by something other than a time trend differentially affecting winners and losers. The only plausible cause is the Adams Scholarship.

I confirm these differences in means in Table 5, comparing winners to losers by class in the first three columns, then computing differences between classes in those winner/loser differences in the final three columns. Column (4) suggests that between 2003 and 2004, there may have been some trend among winners (compared to losers) to move to public colleges and away from private ones. Column (5) suggests, however, that this trend increased markedly from 2004 to 2005. Column (6) shows the difference-in-difference-in-difference between winners and losers, between the classes of 2004 and 2005, and between the classes of 2003 and 2004. This estimate suggests that the Adams Scholarship raised attendance rates at public colleges by 3.1 percentage points while lowering private college attendance by 5.0 percentage points. This effect is certainly in the expected direction, though it does lead to the odd conclusion that the Adams Scholarship reduced the overall college attendance rate by 1.9 percentage points.

One problem with the raw differences presented in Table 5 is that, as shown in Table 4, the characteristics of winners and losers did change somewhat between graduating

Table 4: Mean Characteristics of Adams Scholarship Winners and Losers

	Winners			Losers		
	Class of 2003	Class of 2004	Class of 2005	Class of 2003	Class of 2004	Class of 2005
Demographics						
Female	0.566	0.525	0.535	0.507	0.503	0.508
	(0.005)	(0.005)	(0.004)	(0.002)	(0.002)	(0.002)
Black	0.018	0.022	0.029	0.077	0.079	0.08
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Hispanic	0.016	0.018	0.024	0.07	0.071	0.08
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Poverty	0.049	0.064	0.078	0.152	0.164	0.189
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Medium Poverty District	0.039	0.063	0.079	0.097	0.119	0.12
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
High Poverty District	0.080	0.090	0.121	0.123	0.133	0.157
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
English as Second Language	0.057	0.065	0.076	0.108	0.109	0.121
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Special Education	0.013	0.015	0.011	0.121	0.149	0.148
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Vocational Education	0.057	0.059	0.064	0.222	0.217	0.200
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Limited English Proficiency	0.012	0.002	0.019	0.025	0.024	0.043
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
College Choice						
Any College	0.940	0.951	0.956	0.729	0.735	0.754
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Public College	0.324	0.338	0.408	0.454	0.449	0.469
	(0.005)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)
Private College	0.616	0.613	0.548	0.275	0.286	0.285
	(0.005)	(0.005)	(0.004)	(0.002)	(0.002)	(0.002)
Four-Year Public College	0.301	0.307	0.371	0.246	0.243	0.249
	(0.005)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)
Two-Year Public College	0.023	0.031	0.037	0.208	0.205	0.220
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Four-Year Private College	0.610	0.604	0.544	0.248	0.256	0.259
	(0.005)	(0.005)	(0.004)	(0.002)	(0.002)	(0.002)
Two-Year Private College	0.006	0.009	0.004	0.027	0.030	0.026
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
MCAS Scores						
MCAS Score - English	262.715	263.822	263.301	236.633	239.626	241.286
	(0.082)	(0.080)	(0.070)	(0.069)	(0.068)	(0.067)
MCAS Score - Math	262.353	262.999	264.014	235.115	234.614	237.718
	(0.061)	(0.063)	(0.056)	(0.074)	(0.076)	(0.077)
MCAS Score - Total	525.068	526.821	527.314	471.748	474.24	479.003
	(0.105)	(0.106)	(0.094)	(0.129)	(0.128)	(0.127)
Adams Scholarship Variables						
Proficient/Advanced	1	1	1	0.082	0.113	0.132
	()	()	()	(0.001)	(0.002)	(0.002)
Adams Scholarship Winner	1	1	1	0	0	0
	()	()	()	()	()	()
Sample Size	10,348	11,338	13,041	42,402	42,377	41,458

Standard errors are listed below the estimates of population means.

Table 5: Mean Differences between Winners and Losers and between Classes

	(1)	(2)	(3)	(4)	(5)	(6)
	D			DD		DDD
	Winners - Losers, Class of					
	2003	2004	2005	(2) - (1)	(3) - (2)	(5) - (4)
Any College	0.211**	0.216**	0.202**	0.006	-0.014*	-0.019*
	(0.005)	(0.004)	(0.004)	(0.006)	(0.006)	(0.009)
Public College	-0.130**	-0.111**	-0.061**	0.019**	0.050**	0.031**
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.010)
Private College	0.341**	0.327**	0.263**	-0.014*	-0.064**	-0.050**
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.010)
Sample Size	52,750	53,715	54,499	106,465	108,214	160,964

Standard errors are reported below mean differences (* p<0.05 ** p<0.01).

classes. To control better for student characteristics, I construct a difference-in-difference estimator by running the regression

$$Y_{ij} = \alpha + \beta(2005_{ij} * WIN_{ij}) + \gamma 2005_{ij} + \delta WIN_{ij} + \psi X_{ij} + \epsilon_{ij} \quad (1)$$

where Y_{ij} is a dummy variable equal to one if student i in district j attends a particular category of college, 2005_{ij} is a dummy variable equal to one for 2005 graduates and 0 for 2004 graduates (I ignore 2003 graduates here), WIN_{ij} is the variable mentioned earlier, and X_{ij} are demographic controls. In the regressions that follow, I allow for heteroscedasticity by reporting robust standard errors and I cluster by school district to allow for intra-district correlation in the error terms ϵ_{ij}.

The top half of Table 6 shows the results of the regressions from (1). The coefficient of interest is β, the interaction between WIN_{ij} and 2005_{ij}, which under the identifying assumptions represents the effect of receiving the Adams Scholarship. Including a full set of demographic controls does not change these estimates much, except for rendering insignificant the result that the scholarship reduced the overall college attendance rate.

Table 6: DD Regressions of College Plans on Class and Scholarship Status

	Class of 2005 vs. Class of 2004 (N=108,214)						
	Any College	Public College	Private College	Four-Year Public College	Two-Year Public College	Four-Year Private College	Two-Year Private College
	Without Demographic Controls						
Winner * 2005	-0.014*	0.050**	-0.064**	0.058**	-0.009	-0.062**	-0.001
	(0.006)	(0.011)	(0.009)	(0.009)	(0.007)	(0.009)	(0.002)
Class of 2005	0.019**	0.020*	-0.001	0.005	0.015*	0.003	-0.004
	(0.006)	(0.010)	(0.012)	(0.007)	(0.007)	(0.011)	(0.004)
Winner	0.216**	-0.111**	0.327**	0.064**	-0.175**	0.348**	-0.021**
	(0.011)	(0.011)	(0.009)	(0.011)	(0.010)	(0.008)	(0.003)
R^2	0.047	0.006	0.067	0.009	0.039	0.079	0.004
	With Demographic Controls						
Winner * 2005	-0.010	0.051**	-0.061**	0.060**	-0.010	-0.059**	-0.001
	(0.006)	(0.010)	(0.009)	(0.009)	(0.007)	(0.009)	(0.002)
Class of 2005	0.020**	0.020	0.000	0.006	0.014	0.005	-0.004
	(0.006)	(0.011)	(0.013)	(0.006)	(0.008)	(0.012)	(0.004)
Winner	0.144**	-0.135**	0.280**	0.016	-0.152**	0.297**	-0.017**
	(0.006)	(0.008)	(0.007)	(0.009)	(0.008)	(0.007)	(0.002)
R^2	0.149	0.015	0.106	0.038	0.054	0.122	0.010
	Class of 2004 vs. Class of 2003 (N=106,465)						
	Any College	Public College	Private College	Four-Year Public College	Two-Year Public College	Four-Year Private College	Two-Year Private College
	Without Demographic Controls						
Winner * 2004	0.006	0.019	-0.014	0.008	0.011	-0.014	0.000
	(0.009)	(0.010)	(0.009)	(0.008)	(0.006)	(0.009)	(0.002)
Class of 2004	0.005	-0.006	0.011	-0.003	-0.003	0.009	0.002
	(0.008)	(0.007)	(0.010)	(0.006)	(0.005)	(0.009)	(0.004)
Winner	0.211**	-0.130**	0.341**	0.055**	-0.186**	0.362**	-0.021**
	(0.009)	(0.009)	(0.009)	(0.011)	(0.008)	(0.008)	(0.002)
R^2	0.043	0.010	0.080	0.003	0.037	0.093	0.003
	With Demographic Controls						
Winner * 2004	0.006	0.019	-0.013	0.007	0.012*	-0.013	0.000
	(0.008)	(0.010)	(0.009)	(0.008)	(0.005)	(0.009)	(0.002)
Class of 2004	0.012	-0.004	0.016	0.002	-0.006	0.014	0.002
	(0.009)	(0.007)	(0.010)	(0.006)	(0.005)	(0.009)	(0.004)
Winner	0.138**	-0.161**	0.299**	0.007	-0.168**	0.316**	-0.017**
	(0.006)	(0.008)	(0.007)	(0.010)	(0.007)	(0.007)	(0.002)
R^2	0.145	0.023	0.113	0.035	0.048	0.131	0.007

Robust standard errors clustered by school district are reported below coefficients (* $p<0.05$ ** $p<0.01$). Demographic controls are those referred to in Table 3.

Table 6 suggests that the primary effect of the Adams Scholarship was to raise the proportion of winners attending four-year public colleges by 6.0 percentage points while lowering the proportion attending four-year private colleges by a nearly identical amount. The overall college attendance rate was thus unchanged by the scholarship, an unsurprising result given that over 95% of winners already planned to attend college. There is also little evidence that the scholarship induced students to increase the number of years of college they intended to pursue, given the insignificant coefficients on the two-year college categories.

Note that, by this estimate, about 780 students (6.0% of the 13,041 2005 winners) were induced to switch from private to public colleges. According to the data, 5,318 (40.8%) of the 2005 scholarship winners attended public college and thus used their scholarship. This suggests that only 15% (=780/5,318) of scholarship users changed their behavior due to the scholarship, while the remaining 85% had their previous behavior subsidized by the state. The marginal effect of this scholarship is thus small in comparison to the inframarginal effect, similar to the findings in Georgia of Cornwell et al. (2006).

Interpretation of these effects as causal, rather than due to some trend in the differences between winners and losers, is bolstered by the bottom half of Table 6, where the same regressions are run for comparison between the classes of 2004 and 2003, neither of which was eligible for the Adams Scholarship. In this case, only one of the interaction coefficients is significant, suggesting that the coefficients in the top half of Table 6 are not attributable to any confounding trends.

To investigate whether reactions to the Adams Scholarship are heterogeneous, Table 7 shows the same regressions as Table 6 run separately for various subgroups of the student population. Table 7 shows that blacks, poor students, and students from high-poverty districts react more strongly to the scholarship than does the general population, whereas women, Hispanics, and students from medium-poverty districts react only slightly, if at

all, more strongly. Specifically, the scholarship raises the public college attendance rate by 18 percentage points among black students (from a base rate of 20%), 13 percentage points among poor students (from a base rate of 28%), and 9 percentage points among students in high-poverty districts (from a base rate of 28%).

5 Regression Discontinuity Methodology and Results

As mentioned above, the primary disadvantage of the difference-in-difference approach in (1) is that WIN_{ij} may identify slightly different parts of the ability distribution in different years. A regression discontinuity design eliminates this concern by focusing only on the class of 2005. I exploit the fact that scholarship receipt is a discontinuous function of a student's test scores due to the proficient/advanced and district cutoff thresholds. Students whose scores place them just inside the dark regions in Figure 1 are likely quite similar in terms of academic ability to students whose scores place them just outside those regions, yet the former receive the scholarship and the latter do not. Given that academic ability is one of the most powerful determinants of a student's college attendance decision, a regression discontinuity design allows me to eliminate an important source of bias when comparing scholarship winners and losers.

The major hurdle here is the complexity of the various thresholds that students must achieve in order to win the Adams Scholarship. To simplify the analysis, I will first ignore the proficient/advanced threshold and consider only whether students have met their districts' cutoff scores. Previous papers, such as Kane (2003) and van der Klaauw (2001), consider financial aid that is granted once students pass a single threshold that is applied uniformly. Here, the location of the discontinuity varies by district. To account for this variation, I define

$$GAP_{ij} = TOTAL_{ij} - CUTOFF_j \tag{2}$$

Table 7: DD Regressions of College Plans on Class and Scholarship Status, by Subgroup

Subgroup	Any College	Public College	Private College	Four-Year Public College	Two-Year Public College	Four-Year Private College	Two-Year Private College
All students (2005 vs. 2004)	-0.010	0.051**	-0.061**	0.060**	-0.010	-0.059**	-0.001
	(0.006)	(0.010)	(0.009)	(0.009)	(0.007)	(0.009)	(0.002)
All students (2004 vs. 2003)	0.006	0.019	-0.013	0.007	0.012*	-0.013	0.000
	(0.008)	(0.010)	(0.009)	(0.008)	(0.005)	(0.009)	(0.002)
Mean for 2004 winners (N=11,338)	0.951	0.338	0.613	0.307	0.031	0.604	0.009
Women (2005 vs. 2004)	-0.013*	0.061**	-0.073**	0.072**	-0.012	-0.069**	-0.004
	(0.006)	(0.014)	(0.012)	(0.011)	(0.008)	(0.012)	(0.003)
Women (2004 vs. 2003)	0.008	-0.001	0.010	-0.009	0.007	0.008	0.002
	(0.009)	(0.011)	(0.011)	(0.010)	(0.007)	(0.011)	(0.003)
Mean for 2004 winners (N=5,954)	0.969	0.307	0.662	0.282	0.025	0.652	0.010
Blacks (2005 vs. 2004)	-0.024	0.147**	-0.170**	0.179**	-0.033	-0.180**	0.010
	(0.020)	(0.039)	(0.042)	(0.038)	(0.023)	(0.039)	(0.007)
Blacks (2004 vs. 2003)	0.073	0.001	0.072*	-0.025	0.026	0.081*	-0.009
	(0.044)	(0.049)	(0.034)	(0.039)	(0.019)	(0.038)	(0.012)
Mean for 2004 winners (N=246)	0.927	0.224	0.703	0.199	0.024	0.695	0.008
Hispanics (2005 vs. 2004)	-0.034	0.071	-0.105*	0.081	-0.010	-0.093*	-0.012
	(0.029)	(0.043)	(0.041)	(0.042)	(0.024)	(0.040)	(0.017)
Hispanics (2004 vs. 2003)	0.075*	0.077	-0.002	0.046	0.031	-0.006	0.004
	(0.038)	(0.046)	(0.045)	(0.040)	(0.033)	(0.046)	(0.010)
Mean for 2004 winners (N=206)	0.927	0.340	0.587	0.262	0.078	0.573	0.015
Poor Students (2005 vs. 2004)	0.009	0.110**	-0.101**	0.131**	-0.022	-0.098**	-0.003
	(0.021)	(0.020)	(0.025)	(0.025)	(0.020)	(0.022)	(0.011)
Poor Students (2004 vs. 2003)	0.056*	0.041	0.015	0.011	0.030	0.013	0.002
	(0.025)	(0.025)	(0.027)	(0.026)	(0.017)	(0.029)	(0.007)
Mean for 2004 winners (N=722)	0.889	0.346	0.543	0.278	0.068	0.528	0.015
Med. Pov. Districts (2005 vs. 2004)	0.024	0.114**	-0.089**	0.077**	0.036	-0.088**	-0.001
	(0.024)	(0.029)	(0.020)	(0.023)	(0.022)	(0.020)	(0.010)
Med. Pov. Districts (2004 vs. 2003)	-0.078*	-0.054	-0.024	-0.026	-0.028	-0.023	-0.001
	(0.031)	(0.043)	(0.045)	(0.044)	(0.026)	(0.045)	(0.006)
Mean for 2004 winners (N=711)	0.900	0.391	0.509	0.350	0.041	0.501	0.008
High Pov. Districts (2005 vs. 2004)	-0.031	0.041	-0.073**	0.092**	-0.051	-0.082**	0.010
	(0.022)	(0.028)	(0.024)	(0.020)	(0.027)	(0.020)	(0.009)
High Pov. Districts (2004 vs. 2003)	0.096**	0.054	0.042	0.045	0.008	0.048	-0.005
	(0.031)	(0.034)	(0.026)	(0.024)	(0.020)	(0.027)	(0.010)
Mean for 2004 winners (N=1,021)	0.911	0.312	0.598	0.284	0.028	0.589	0.010

Robust standard errors clustered by school district are reported below coefficients (* $p<0.05$ ** $p<0.01$).
All regressions include the demographic controls referred to in Table 3.

where TOTAL$_{ij}$ represents the total MCAS score of student i in district j and CUTOFF$_j$ represents the cutoff score of district j, so that GAP$_{ij}$ measures the extent to which student i has exceeded his district's cutoff score. This allows students to be ordered according to GAP$_{ij}$ and implies that the probability of winning an Adams Scholarship has the property

$$P \begin{cases} = 0, & \text{if } GAP_{ij} < 0 \\ \approx 1, & \text{if } GAP_{ij} \geq 0 \end{cases}$$

Achieving the threshold of GAP$_{ij} \geq 0$ does not necessarily imply that P = 1 because some fraction of those students may not have achieved the proficient/advanced threshold. This thus constitutes a fuzzy regression discontinuity design in which the treatment is not completely determined by the assignment variable. The top left panel of Figure 2 illustrates this by showing the proportion of 2005 graduates winning the Adams Scholarship as a function of GAP$_{ij}$.[15] Students with GAP$_{ij} < 0$ have no chance of winning the scholarship, while 74.8% of those with GAP$_{ij} = 0$ win it, implying that 25.2% of the latter have failed to meet the proficient/advanced threshold.

The remaining three panels of Figure 2 graph college decisions as a function of GAP$_{ij}$, and their overall shapes are worth noting given that GAP$_{ij}$ is basically a measure of academic ability. The top right panel shows that the fraction attending college rises monotonically with ability, leveling off at about 95% for the highest ability students. The bottom panels show that the fraction attending four-year public colleges rises with ability up to a maximum of 40% and then drops dramatically for very high ability students, while the fraction attending four-year private colleges rises monotonically with ability. These bottom panels together suggest that public and private colleges have roughly similar ap-

[15] I dropped from the 2005 graduates 15 students whose scholarship status and test scores are incompatible. They were likely assigned to the wrong school district in the original data. Unsurprisingly, given the size of the sample, no results below are affected by this. For graphical purposes, I show only the portion of the graphs for which GAP$_{ij} \geq -50$.

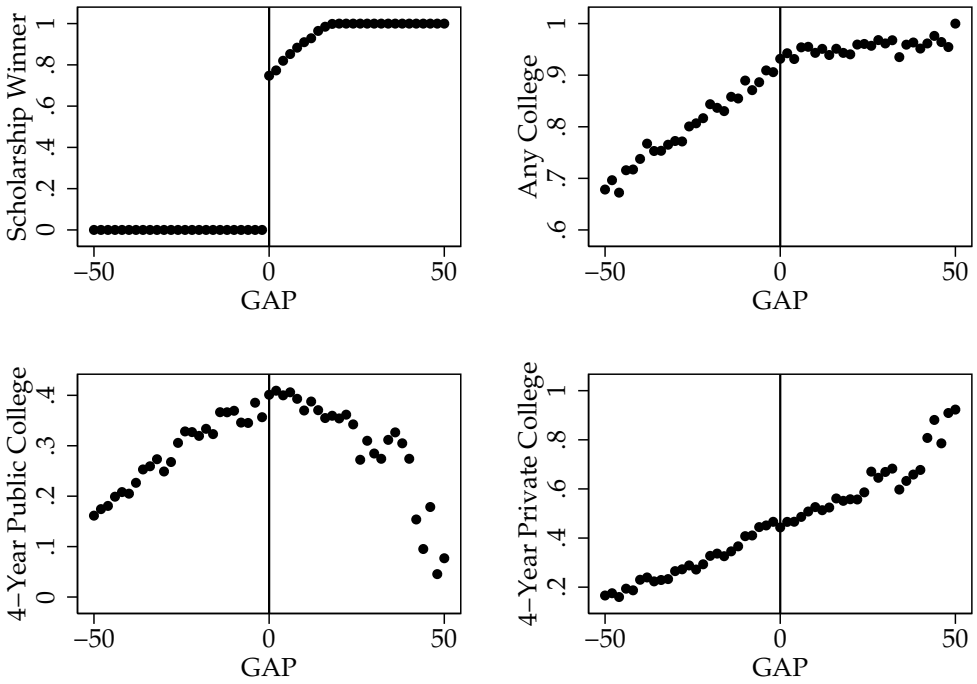

Figure 2: Class of 2005's College Decisions vs. GAP_{ij}

peal to the middle of the ability distribution, but that high ability students have strong preferences for private colleges, some subset of which are highly selective and therefore prestigious.

This fuzzy design shows no obvious discontinuity in the overall college attendance rate, though there may be discontinuities in attendance of four-year public and private colleges. That these discontinuities are visually subtle suggests identification might benefit from sharpening of the design. In a sharp regression discontinuity design, the assigning variable perfectly determines treatment status, thus eliminating the need to divide outcome differences by treatment probability differences. The challenge here is to create a variable GAP^*_{ij}, similar to GAP_{ij}, where the probability of winning an Adams Scholar-

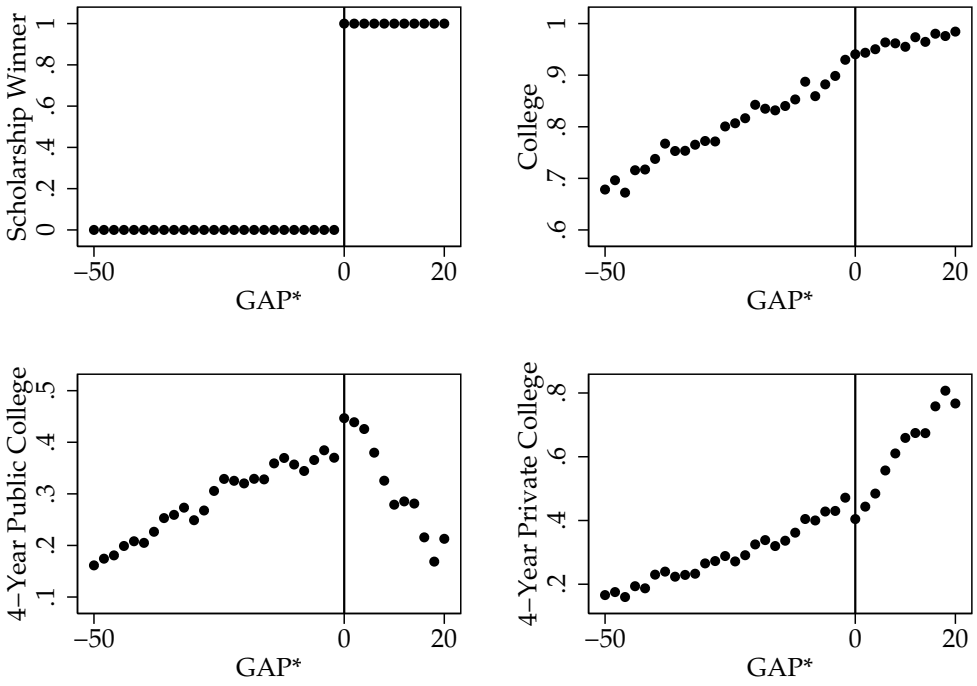

Figure 3: Class of 2005's College Decisions vs. GAP^*_{ij}

ship has the property

$$P \begin{cases} = 0, & \text{if } GAP^*_{ij} < 0 \\ = 1, & \text{if } GAP^*_{ij} \geq 0 \end{cases}$$

To do this, I first define

$$BEST_{ij} = max(MATH_{ij}, ENG_{ij})$$
$$WORST_{ij} = min(MATH_{ij}, ENG_{ij})$$

where MATH_{ij} and ENG_{ij} are a student's scores on the math and English portions of the MCAS, so that BEST_{ij} and WORST_{ij} represent the best and worst of her two scores

respectively. I then define

$$GAP^*_{ij} = min(GAP_{ij}, BEST_{ij} - 260, WORST_{ij} - 240) \tag{3}$$

which assigns to each student a number representing the distance by which she failed most or succeeded least to meet one of the thresholds (recall that 260 is the advanced threshold and that 240 is the proficient threshold).[16] By this definition, any student with $\text{GAP}^*_{ij} < 0$ fails to win a scholarship, while any student with $\text{GAP}^*_{ij} \geq 0$ has passed all the necessary thresholds and is thus guaranteed a scholarship. Figure 3 replicates Figure 2, but this time using GAP^*_{ij} instead of GAP_{ij}. The result is now a perfectly sharp regression discontinuity design, and the discontinuities in the graphs of four-year public and private college attendance have become much clearer.

To check that these discontinuities are not simply artifacts of the construction of GAP^*_{ij}, I perform the same graphical analysis on the class of 2004, the results of which appear in Figure 4. These students were not eligible for the scholarship and graphs of their college attendance outcomes show little or no discontinuities, in spite of the sharp regression discontinuity design being applied. Figure 5 presents one final graphical check of the validity of the regression discontinuity design, using demographics as dependent variables. Regression discontinuity designs depend fundamentally on the assumption that subjects' underlying characteristics change smoothly as the threshold of interest is crossed. Figure 5 suggests that the construction of GAP^*_{ij} leaves this assumption roughly intact, though there seems to be some rise in the number of students living in high-poverty school districts above the threshold.

To quantify the effect of the discontinuity more rigorously, I run regressions of the

[16] I thank David Lee for suggesting this approach to the creation of GAP^*_{ij}.

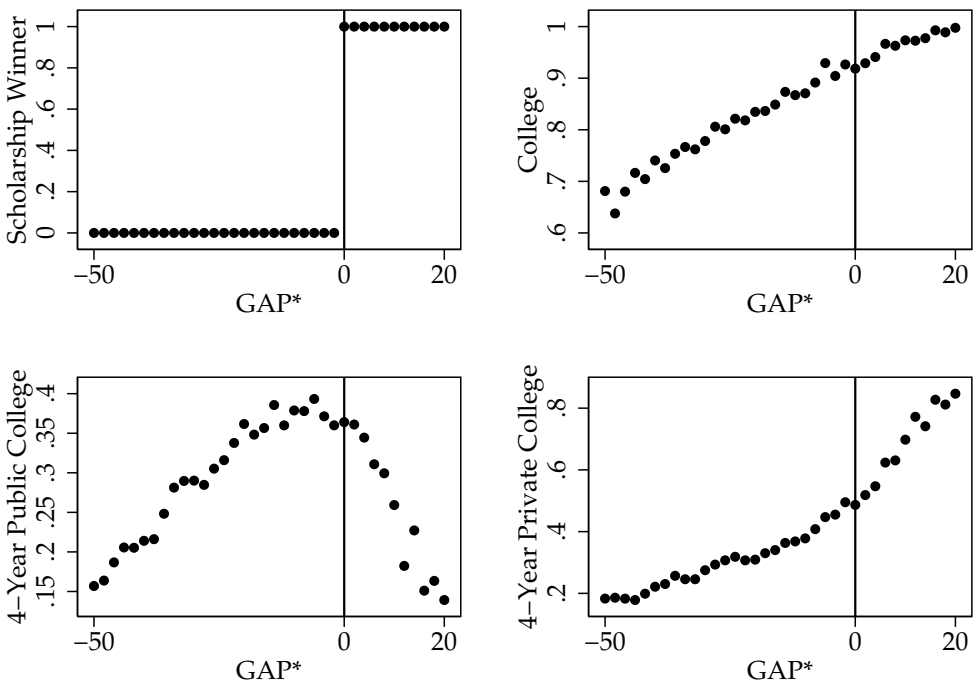

Figure 4: Class of 2004's College Decisions vs. GAP^*_{ij}

form

$$y_{ij} = \sum_{k=0}^{D} \left(\alpha_k (GAP^*_{ij})^k + \beta_k I_{GAP^*_{ij} \geq 0} \times (GAP^*_{ij})^k \right) + \epsilon_{ij} \tag{4}$$

where D determines the degree of the polynomial in GAP^*_{ij} that is fully interacted with an indicator variable for crossing the threshold of $\text{GAP}^*_{ij} = 0$. The coefficient of most interest will thus be β_0, which (as I discuss in more detail below) measures a weighted average effect of winning the scholarship.

The first four columns of Table 8 show the values of β_0 for the 2005 graduates using D = 1, 2, 3 and 4. Larger values of D change the coefficients very little, and the goodness-of-fit statistic suggested by Lee and Card (2007) reveals that $D = 4$ is generally the first specification not rejected at a 5% significance level. I thus take the fourth-degree polyno-

Table 8: RD Regressions of College Plans and Demographics

	(1)	(2)	(3)	(4)	(5)	(6)
College Choice	D=1	D=2	D=3	D=4	D=1	D=4
Any College	0.017*	0.017	0.031**	0.016	-0.005	-0.007
	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
R^2	0.109	0.109	0.110	0.110	0.029	0.127
Public College	0.033**	0.094**	0.098**	0.092**	0.097**	-0.002
	(0.010)	(0.012)	(0.014)	(0.015)	(0.017)	(0.015)
R^2	0.013	0.015	0.015	0.015	0.023	0.020
Private College	-0.016	-0.077**	-0.067**	-0.077**	-0.103**	-0.005
	(0.009)	(0.012)	(0.014)	(0.015)	(0.017)	(0.015)
R^2	0.102	0.104	0.104	0.104	0.050	0.122
Four-Year Public College	0.057**	0.052**	0.074**	0.078**	0.089**	0.004
	(0.011)	(0.011)	(0.012)	(0.013)	(0.016)	(0.014)
R^2	0.061	0.061	0.062	0.062	0.013	0.060
Two-Year Public College	-0.024**	0.041**	0.024**	0.014	0.009	-0.006
	(0.006)	(0.007)	(0.008)	(0.009)	(0.009)	(0.008)
R^2	0.084	0.088	0.089	0.089	0.033	0.074
Four-Year Private College	-0.011	-0.080**	-0.069**	-0.078**	-0.102**	-0.008
	(0.009)	(0.011)	(0.013)	(0.015)	(0.017)	(0.015)
R^2	0.122	0.125	0.125	0.125	0.054	0.146
Two-Year Private College	-0.005**	0.003	0.002	0.002	-0.001	0.003
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)
R^2	0.008	0.009	0.009	0.009	0.004	0.007
Demographics	D=1	D=2	D=3	D=4	D=1	D=4
Female	-0.008	0.005	0.012	-0.020	-0.027	-0.005
	(0.008)	(0.011)	(0.014)	(0.016)	(0.019)	(0.015)
R^2	0.001	0.001	0.002	0.002	0.002	0.004
Black	0.018*	0.019	0.007	0.013**	0.011	-0.009
	(0.008)	(0.011)	(0.006)	(0.005)	(0.010)	(0.006)
R^2	0.024	0.024	0.025	0.025	0.004	0.030
Hispanic	0.014**	0.014*	-0.011*	-0.013*	-0.004	-0.009
	(0.004)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
R^2	0.030	0.030	0.031	0.031	0.003	0.030
Poverty	0.031**	0.029*	-0.012	-0.004	0.012	-0.005
	(0.009)	(0.012)	(0.008)	(0.008)	(0.012)	(0.009)
R^2	0.050	0.050	0.051	0.051	0.007	0.052
Medium Poverty District	0.007	0.035**	0.010	-0.002	0.015	-0.007
	(0.009)	(0.012)	(0.010)	(0.011)	(0.011)	(0.011)
R^2	0.006	0.007	0.008	0.008	0.004	0.014
High Poverty District	0.046	0.057*	0.002	-0.004	0.029	-0.020
	(0.027)	(0.023)	(0.007)	(0.009)	(0.018)	(0.010)
R^2	0.013	0.013	0.016	0.016	0.001	0.020
English as 2nd Language	0.020**	0.011	-0.017*	-0.013	-0.003	-0.016*
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
R^2	0.017	0.017	0.018	0.018	0.000	0.018
Special Education	0.064**	-0.016**	-0.018**	0.041**	0.010*	0.037**
	(0.004)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
R^2	0.159	0.175	0.175	0.179	0.013	0.207
Vocational Education	-0.014	0.041**	0.003	-0.004	0.026**	-0.018
	(0.009)	(0.011)	(0.009)	(0.010)	(0.008)	(0.011)
R^2	0.047	0.050	0.052	0.052	0.018	0.063
Limited English Proficiency	0.020*	0.006	-0.007**	0.005	0.005	0.002
	(0.008)	(0.009)	(0.003)	(0.003)	(0.006)	(0.004)
R^2	0.018	0.019	0.020	0.021	0.001	0.022
N	54,484	54,484	54,484	54,484	27,885	53,715

Robust standard errors clustered by school district are reported below coefficients (* $p<0.05$ ** $p<0.01$).

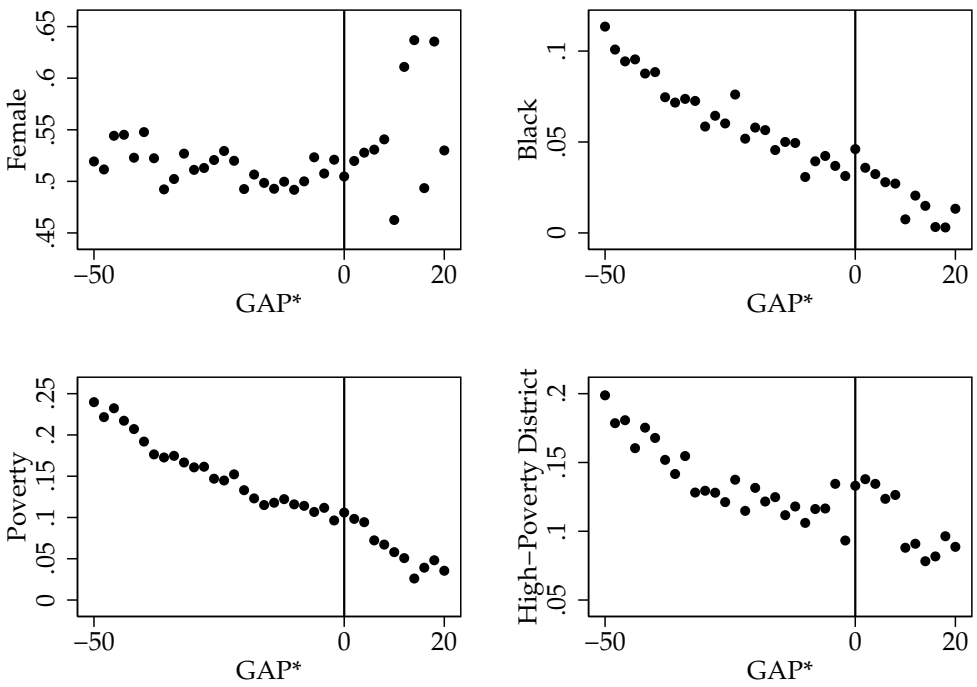

Figure 5: Class of 2005's Demographics vs. GAP$_{ij}$

mial in column (4) as my preferred specification.[17] Crossing the threshold clearly induces discontinuities in a number of outcomes for 2005 graduates. The most remarkable result is that the coefficients on four-year public and private colleges have identical point estimates with opposite signs, though the magnitude of 7.8% is higher than the 6.0% from the difference-in-difference estimate.[18] To eliminate the effect of students far below the threshold, I limit the sample in column (5) to 2005 graduates for whom $|GAP^*_{ij}| \leq 20$. In this case, a simple linear specification ($D = 1$) yields even higher point estimates of an 8.9 percentage point increase in four-year public colleges and a 10.2 percentage point drop in

[17] I ignore any specification error arising from the fact the GAP$^*_{ij}$ is not perfectly continuous but is measured only in increments of 2. For more on the complications arising due to specification error, see Lee and Card (2007).

[18] There is also some evidence in Table 8 that the scholarship increased the total college attendance rate by inducing students to attend two-year public colleges who might not have attended any college otherwise. This effect is, however, sensitive to the chosen specification.

four-year private colleges. In column (6) I replicate column (4) using 2004 graduates and, as expected, no effect is seen.

The fact that the scholarship's effect seems larger in the regression discontinuity specification than in the difference-in-difference specification could have two causes. First, the size of the discontinuity may be partly capturing discontinuous changes in underlying student characteristics. The bottom half of Table 8 shows that certain demographic characteristics, such as race and special education status, also change discontinuously at the threshold. These demographic discontinuities occur, however, in populations that represent an extremely small fraction of the total population of winners (see Table 4), making this an unlikely source of practically significant bias in the estimates.

Second and more important is that, as discussed by Lee (2007), β_0 actually estimates a weighted average treatment effect where the weights are determined by an individual's likelihood of having a value of GAP^*_{ij} close to zero. In other words, the size of the discontinuity is more closely related to the scholarship's effect on those students likely to fall near the threshold than on those far away from it. These students near the threshold represent the low end of the ability distribution of the winners (and the high end of the losers). The difference-in-difference approach measured the average treatment effect of the scholarship where the average was taken over the entire pool of scholarship winners. Comparison of these two approaches might thus suggest that the scholarship had a larger impact on students with lower academic ability levels.

6 Heterogeneity By Academic Ability

To test this hypothesis directly, I return to the difference-in-difference methodology but add one more layer of interactions, namely with a measure of academic ability. I assign to 2004 and 2005 graduates variables indicating which of the 10 ability deciles within their

class they fall into based on their total MCAS scores. I then interact these indicators fully with 2005_{ij} and WIN_{ij} to create a difference-in-difference-in-difference estimate of the effect of being a scholarship winner (compared to loser) in 2005 (compared to 2004) and in a given ability decile (compared to the other deciles). Because scholarship winners in 2005 are drawn from above the 60th ability percentile, I compute results for the top four deciles: 60-69, 70-79, 80-89, and 90-99.

Table 9 shows the result of these regressions, where each coefficient represents a separate regression run by treating that particular ability decile as the omitted category. Heterogeneity in students' responses to the Adams Scholarship is clear. The scholarship induces switching from private to public colleges in roughly 10-15% of the lowest ability scholarship winners, those in the 60-69th and 70-79th deciles. The effect on students in the 80-89th decile is 7%, or half of that magnitude. The coefficient on the highest ability decile is less than 2% and not significantly different from zero, suggesting that those students' college decisions were unaffected by scholarship receipt. Interestingly, this heterogeneity analysis also suggests that the scholarship may have raised college attendance rates by 2-3% among students in the 70-79th and 80-89th deciles.

Recall that the original difference-in-difference analysis suggested that the scholarship induced 6% of winners to switch from private to public colleges. The top panel of Table 9 reveals that this estimate is actually an average of highly responsive students among the lowest ability winners and nonresponsive students among the highest ability winners.[19] This confirms the hypothesis above that the regression discontinuity design captured an effect weighted more heavily for the lowest ability scholarship winners.

Apart from explaining the regression discontinuity results, the heterogeneity analysis

[19]High ability students may not be totally unresponsive. If I divide the highest ability students more finely, I find the coefficient on students in the 90-94th percentiles is not significantly different from zero, but that the coefficient on those in the 95-99th percentiles is significantly positive, though small. This could be evidence that the very highest ability students are attracted to honors colleges that some U. Mass. campuses reserve for their most elite students.

Table 9: Tests of Heterogeneity by Academic Ability and Income

	Any College	Public College	Private College	Four-Year Public College	Two-Year Public College	Four-Year Private College	Two-Year Private College
All Students (N=108,199)							
Winner * 2005 * (60-69)	0.007	0.138**	-0.131**	0.106*	0.032	-0.134**	0.003
	(0.025)	(0.042)	(0.035)	(0.042)	(0.023)	(0.036)	(0.010)
Winner * 2005 * (70-79)	0.027*	0.157**	-0.129**	0.147**	0.010	-0.129**	-0.001
	(0.013)	(0.024)	(0.025)	(0.023)	(0.011)	(0.026)	(0.006)
Winner * 2005 * (80-89)	0.019*	0.080**	-0.061*	0.076**	0.004	-0.066*	0.004
	(0.008)	(0.025)	(0.026)	(0.024)	(0.006)	(0.026)	(0.006)
Winner * 2005 * (90-99)	-0.012	0.014	-0.026	0.014	-0.001	-0.019	-0.007
	(0.009)	(0.046)	(0.049)	(0.043)	(0.005)	(0.049)	(0.005)
R^2	0.169	0.032	0.151	0.059	0.086	0.174	0.011
Non-Poor Students (N=91,683)							
Winner * 2005 * (60-69)	-0.002	0.133**	-0.135**	0.103*	0.030	-0.139**	0.004
	(0.030)	(0.039)	(0.039)	(0.040)	(0.027)	(0.040)	(0.011)
Winner * 2005 * (70-79)	0.026	0.148**	-0.123**	0.141**	0.007	-0.121**	-0.001
	(0.014)	(0.026)	(0.026)	(0.025)	(0.011)	(0.026)	(0.006)
Winner * 2005 * (80-89)	0.018*	0.077**	-0.059*	0.074**	0.003	-0.064*	0.005
	(0.008)	(0.025)	(0.026)	(0.023)	(0.006)	(0.025)	(0.006)
Winner * 2005 * (90-99)	-0.025**	0.010	-0.035	0.010	-0.001	-0.029	-0.006
	(0.009)	(0.048)	(0.044)	(0.045)	(0.005)	(0.044)	(0.005)
R^2	0.169	0.034	0.147	0.052	0.090	0.167	0.009
Poor Students (N=16,516)							
Winner * 2005 * (60-69)	0.046	0.161	-0.116	0.130	0.031	-0.095	-0.021
	(0.067)	(0.106)	(0.066)	(0.105)	(0.052)	(0.065)	(0.021)
Winner * 2005 * (70-79)	-0.025	0.106	-0.131*	0.158*	-0.052	-0.140*	0.009
	(0.045)	(0.066)	(0.061)	(0.069)	(0.050)	(0.059)	(0.019)
Winner * 2005 * (80-89)	0.037	-0.066	0.103	-0.118	0.052	0.122	-0.019
	(0.076)	(0.148)	(0.128)	(0.140)	(0.046)	(0.129)	(0.011)
Winner * 2005 * (90-99)	0.046	0.161	-0.116	0.130	0.031	-0.095	-0.021
	(0.067)	(0.106)	(0.066)	(0.105)	(0.052)	(0.065)	(0.021)
R^2	0.101	0.028	0.099	0.064	0.042	0.118	0.014

Robust standard errors clustered by school district are reported below coefficients (* $p<0.05$ ** $p<0.01$).
All regressions include the full set of demographic controls listed in Table 3, as well as indicator variables for the class of 2005, scholarship winner, decile of academic ability, and the interactions of these variables.

also provides some insight into the decision-making processes of high school graduates. The simplest explanation for the observed pattern of heterogeneity by academic ability is that students trade off quality and price when deciding which college to attend. Many of the highest ability students have presumably gained admission to highly selective private colleges. The perceived quality drop they would incur by switching to a public college is likely too large to be worth the small price reduction the Adams Scholarship offers. Conversely, the lowest ability scholarship winners are more likely to have gained admission to private colleges similar in quality to Massachusetts' public colleges. For some of those students, the perceived quality drop a switch to the public sector would incur is small enough that the Adams Scholarship makes such a switch worthwhile.[20] The pattern of heterogeneity in Table 9 is suggestive, though not conclusive, that students are considering such price and quality tradeoffs when making college decisions.

The heterogeneity by academic ability may also largely explain why low-income students seem more price sensitive than other students, given that ability and income are positively correlated. To test this, the bottom two panels of Table 9 repeat the regressions of the top panel with the sample of students now divided by poverty status. The coefficients derived by omitting low-income students from the sample are statistically indistinguishable from those derived from the full sample, suggesting that low-income students are not driving the heterogeneity seen in Table 9. Though the sample limited only to low-income students has little power because so few poor students win scholarships, a couple of observations may still be made. In the 60-69th and 70-79th ability deciles, where some of the poor students' coefficients are statistically significant, the point estimates are not statistically different from those of the non-poor students. This suggests

[20] I implicitly assume in these scenarios that private colleges will cost more than their public counterparts, even accounting for financial aid packages. It is of course conceivable that a student offered a full scholarship to a low quality private college might switch to a higher quality public college if the Adams Scholarship represented a sufficient price reduction.

that the earlier indication of poor students' higher price sensitivity may simply be picking up correlations between poverty and relatively low test scores. Conversely, though none are statistically significant, the point estimates for the 80-89th decile have the wrong sign, while those in the 90-99th decile are much larger than for the non-poor students. Taken as a whole, these results provide little evidence that low-income students are more price sensitive than other students of similar academic ability. These results highlight the importance in future research of attempting to separate the effects of income and academic ability.

7 Conclusions

The above analysis allows me both to evaluate how effective the Adams Scholarship was at achieving Massachusetts' stated goals and to suggest improvement for future design of merit-based scholarships. The state spent around $8 million in the scholarship's first year and estimates that annual spending will total $30 million once all four years of students are using it. The state thus spent roughly $10,250 (=$8,000,000/780) per student who switched from the private to public sector. This seems large relative to any benefit such switching might bring to the state and suggests that Massachusetts, like Georgia, should consider more carefully targeting its financial aid.

That the state spent $8 million on the 2005 scholarships allows one further calculation. According to the data, of the 5,318 scholarship users, 4,838 went to four-year colleges and 480 went to two-year colleges. Based on Table 1, the 480 winners attending two-year colleges cost the state $350,000 (=480*$740), leaving $7.65 million spent on winners attending four-year colleges, or about $1,580 (=$7,650,000/4,838) per winner. Given that the average annual tuition of the U. Mass. campuses was $1,575 while state college tuition averaged $961, this suggests that nearly all of those using the scholarship at four-year

public colleges were attending not state colleges but U. Mass. campuses where, as Table 2 shows, the upper end of the ability distribution is not so different from the private sector.[21]

This makes sense given that scholarship winners have little reason to choose state colleges over U. Mass. campuses. The former do not cost much less but are less selective and thus less well-regarded. Given that the effects were strongest for lower ability winners, a simple explanation of their high price sensitivity is that those students induced to switch were doing so from private colleges of roughly the same quality as the U. Mass. campuses. Those students of highest ability were less sensitive likely because they would have had to accept a larger drop in quality from the set of private colleges to which they gained admission.

In sum, the Adams Scholarship will spend $30 million annually to leave college attendance rates unchanged while paying 85% of recipients to attend the college they would have chosen anyway and the remaining 15% to attend colleges in the public sector rather than the private sector. This is not a sensible use of the state budget. Most states, including Massachusetts, could design more efficient and tightly targeted aid programs by first examining the college attendance patterns of their students, broken down as in Table 10 by income and rank in the distribution of academic ability.

For Massachusetts, Table 10 shows two important facts. The first is that low-income

[21] I can use this information to calculate an elasticity of substitution from private to public colleges, assuming that all students switched from four-year private colleges to U. Mass. campuses and that the Adams Scholarship was not crowded out by decreased forms of other financial aid. Furthermore, I use only the 91% of scholarship winners who had already decided to attend a four-year college, given that this is the population of interest. Within this population, Table 4 suggests that absent the scholarship, 33.7% (=30.7%/91.1%) would have attended public college and 66.3% (=60.4%/91.1%) would have attended private college. The scholarship would have shifted these proportions to 40.3% (=36.7%/91.1%) and 59.7% (=54.4%/91.1%) respectively, proportional changes of +19.6% (=(40.3-33.7)/33.7) and -10% (=(59.7-66.3)/66.3). Under the above assumptions, the Adams Scholarship reduced the price of public college by 17.1% (according to Table 1). Thus, for the population of scholarship winners intent on attending four-year colleges, the own-price elasticity of demand for attendance at U. Mass. campuses is -1.1 (=19.6/-17.1), while the cross-price elasticity of demand for attendance at private colleges (with respect to the price of public college) is 0.6 (=-10.0/-17.1). The true elasticities are even larger for the lower ability winners, and would be larger than the above estimates for the entire population of winners if the no crowd-out assumption is incorrect.

Table 10: College Attendance Rates by Academic Ability and Poverty Status (Class of 2004)

	Percentile of Academic Ability									
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
% at Any College										
Poor Students	47.3	56.4	63.6	66.0	72.4	77.3	81.1	84.9	92.2	94.5
Non-Poor Students	44.2	56.7	66.4	73.5	79.2	84.6	89.5	92.6	94.8	97.9
% at Four-Year Colleges										
Poor Students	14.9	22.3	29.4	38.1	48.2	56.6	63.4	76.4	84.4	87.8
Non-Poor Students	11.2	19.4	30.4	44.6	56.7	68.4	77.8	86.9	91.0	96.2
% at Two-Year Colleges										
Poor Students	32.3	34.1	34.3	27.8	24.3	20.7	17.7	8.5	7.8	6.7
Non-Poor Students	33.0	37.3	36.0	28.9	22.6	16.2	11.7	5.7	3.8	1.7
% at Four-Year Public Colleges										
Poor Students	4.6	9.7	14.1	19.1	25.0	29.2	32.6	29.3	30.9	20.1
Non-Poor Students	4.1	9.6	14.9	23.3	30.8	36.6	39.9	39.3	35.8	24.4
% at Four-Year Private Colleges										
Poor Students	10.3	12.6	15.3	19.1	23.1	27.4	30.8	47.2	53.5	67.7
Non-Poor Students	7.0	9.8	15.5	21.3	25.9	31.8	37.9	47.6	55.1	71.8
% at Two-Year Public Colleges										
Poor Students	28.0	27.9	28.4	24.2	21.3	18.3	16.6	6.6	6.6	5.5
Non-Poor Students	29.5	33.2	31.9	25.8	19.8	14.2	9.9	4.6	2.8	1.0
% at Two-Year Private Colleges										
Poor Students	4.4	6.2	5.9	3.6	3.0	2.4	1.2	2.0	1.2	1.2
Non-Poor Students	3.5	4.1	4.1	3.1	2.7	1.9	1.9	1.1	1.0	0.7
# of Adams Scholarship Winners										
Poor Students	0	0	0	0	0	0	60	282	216	164
Non-Poor Students	0	0	0	0	0	0	181	1,736	3,266	5,433
# of Students										
Poor Students	1,923	1,473	916	887	635	541	429	458	243	164
Non-Poor Students	2,983	4,178	3,869	4,994	4,557	4,577	4,690	5,781	4,746	5,671

students in the upper half of the ability distribution attend four-year colleges at a noticeably lower rate than do their peers of similar academic ability. This gap ranges from 7 to 15 percentage points for such students, suggesting that Massachusetts should consider targeting aid toward low-income students in those upper percentiles. If the goal of these state policies is to efficiently produce human capital, then states should target precisely those students who have high ability but low college attendance rates.

The second, and perhaps more important, lesson from Table 10 is in its bottom-most row, which shows that low-income students are heavily bunched in the lowest part of the ability distribution. Given that non-low-income students are relatively uniformly distributed along this distribution, Table 10 suggests that children of low-income families are severely disadvantaged relative to their peers by the time they reach the 10th grade. Recent research, as summarized in Cunha et al. (2005), argues that efforts at remedying human capital inequalities might yield greater returns if targeted at disadvantaged children when they are young. Under this view, the money currently spent on the Adams Scholarship and other merit-based aid programs might be better used to remedy the ability gaps that explain so much of the difference in college attendance rates between low- and high-income students.

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