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Merit Aid, College Quality and College Completion: Massachusetts' Adams Scholarship as an In-Kind Subsidy*

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Abstract

We analyze a Massachusetts merit aid program in which high-scoring students received tuition waivers at in-state public colleges with lower graduation rates than available alternative colleges. A regression discontinuity design comparing students just above and below the eligibility threshold finds that students are remarkably willing to forgo college quality for relatively little money and that marginal students lowered their college completion rates by using the scholarship. These results imply that college quality has a substantial impact on college completion rates and that students likely do not understand this fact well. The theoretical prediction that in-kind subsidies of public institutions can reduce consumption of the subsidized good is shown to be empirically important.

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1 Introduction

Recent research has emphasized troubling trends in U.S. college completion rates over the past few decades. Among students entering college, completion rates are lower today than they were in the 1970s, due largely to low completion rates of men and students from lower socioeconomic backgrounds (Belley and Lochner 2007, Bailey and Dynarski 2011). This trend has spurred a vigorous debate over the relative importance of factors that vary across students, such as academic skill and family financial resources, and factors that vary across postsecondary institutions, such as funding levels or management quality. Distinguishing the influence of student-level and institution-level factors on college completion rates is confounded by the non-random selection of students into institutions of different apparent quality. In this paper, we provide some of the clearest evidence to date that the quality of the institutions themselves affects college completion rates.

To do so, we exploit is a Massachusetts merit aid program in which high school students with test scores above multiple thresholds were granted tuition waivers at in-state public colleges of lower quality than the average alternative available to such students, where quality is measured by instructional expenditures, academic skill of the student body, and graduation rates. The scholarship, though relatively small in monetary value, induced substantial changes in college choice, allowing us to estimate the impact of college quality on students' postsecondary enrollment decisions and rates of degree completion. A regression discontinuity design comparing students just above and below the eligibility threshold finds that students are remarkably willing to forgo college quality for relatively little money and that marginal students lowered their college completion rates by using the scholarship. College completion rates decreased only for those subsets of students who appear to forgo college quality when accepting the scholarship. These results imply that college quality has a substantial impact on college completion rates and that students likely do not understand this fact well.

Our research contributes to three strands in the literature on postsecondary education and the public subsidy of such education. First, a now extensive literature documents the sensitivity of students' college enrollment decisions to financial aid generally (Deming and Dynarski 2010, Kane 2006) and merit aid more specifically (Dynarski 2000, Cornwell et al. 2009, Dynarski 2008, Kane

2007, Pallais 2009, Goodman 2008). In contrast to most of the programs studied in this literature, the Adams Scholarship targets a very highly skilled set of students, namely the top 25% of high school graduates in each school district. As a result, our estimates are generated by a part of the skill distribution not often studied. Furthermore, unlike in most aid programs, recipients were automatically notified of their eligibility without having to apply. Simplifying the aid process is known to affect students' college enrollment decisions (Bettinger et al. 2012), so that this program design may explain in part the large impacts of aid observed here. Our results also confirm quite clearly the findings of Fitzpatrick and Jones (2012) that merit aid is effective at keeping students in state but that marginal students are a small fraction of total aid recipients.

Second, we add to the growing literature on the impact of college quality on student outcomes. Much of the literature on the impact of college quality on degree completion has focused on the community college sector, reaching varying conclusions about whether access to and quality of community colleges affects educational attainment (Rouse 1995, Leigh and Gill 2003, Sandy et al. 2006, Calcagno et al. 2008, Stange 2009, Reynolds 2012). Estimates of the impact of college quality on labor market earnings are similarly varied, with some positive (Loury and Garman 1995, Brewer et al. 1999, Chevalier and Conlon 2003, Black and Smith 2004, Black and Smith 2006, Long 2008, Hoekstra 2009), some zero (Dale and Krueger 2002, Dale and Krueger 2011), and some suggesting that earnings differences dissipate once the job market properly understands graduates' underlying ability (Brand and Halaby 2006, Lang and Siniver 2011). Nearly all of these research designs attempt to eliminate selection bias either by conditioning on students' observable characteristics or by instrumenting college quality with distance from or tuition of nearby colleges. Neither approach entirely eliminates the possibility that unobserved student-level factors may be driving their estimates. The exception to this is Hoekstra (2009), who uses a discontinuity inherent in the admissions process to a flagship university to estimate the labor market return to an elite college education. We employ a similarly identification strategy and unlike Hoekstra are able to observe the college choice made by students not enrolling in the target institutions, allowing us to estimate the impact of merit aid on college quality. Though sources of exogenous variation in school and curriculum quality are more common at lower levels of schooling because of school choice lotteries (Deming et al. 2011) and test score-based admissions rules (Bui et al. 2011, Abdulkadiroglu et al. 2011, Dobbie and Fryer Jr 2011), they are rare in the postsecondary literature.

Furthermore, our results that college quality plays an important role in completion rates are consistent with important pieces of recent evidence. Controlling for rich sets of student characteristics does not eliminate wide variation among postsecondary institutions in completion rates (**?**). Students who attend college in large cohorts within states have relatively low college completion rates, likely stemming from decreased resources per student given states' tendencies to change public postsecondary budgets slowly (Bound and Turner 2007). Bound et al. (2010) argue that the vast majority of the decline in completion rates can be statistically explained by decreasing resources per student within institutions over time and, even more importantly, shifts in enrollment toward the relatively poorly funded public sector. All of this suggests that characteristics of colleges themselves, such as resources available per student, play an important role in completion rates and that student-level factors are only part of the story.

Third, we show the empirical importance of the theoretical possibility first discussed in Peltzman (1973) that in-kind subsidies of public institutions can reduce consumption of the subsidized good. Prior work has shown how public in-kind subsidies can generate at least partial crowd-out of privately provided health insurance (Cutler and Gruber 1996, Brown and Finkelstein 2008), preschools (Bassok et al. 2012) and two-year colleges (Cellini 2009). Peltzman's contribution was the prediction that, in some cases, crowdout could theoretically be large enough to reduce overall consumption of the subsidized good. Work by Ganderton (1992), using cross-state variation in tuition subsidies, and Long (2008), using much finer college-specific variation in such subsidies, suggests that this in-kind public support for postsecondary education does reduce overall spending on education. We contribute to this literature by providing the first evidence of such reduced consumption driven by an exogenous shock in the size of the in-kind subsidy. We also show that this reduced spending on higher education comes at the cost of a reduced probability of degree completion, a possibility recognized by Kane (2007) in his evaluation of the D.C. Tuition Assistance Grant program but unexplored because too little time had passed to look beyond enrollment effects.

The structure of the paper is as follows. In section 2, we describe the merit scholarship program in detail, including theoretical predictions of its possible effects following the model of Peltzman (1973). In section 3, we describe the data on students and colleges, including our measures of college quality. In section 4, we explain our empirical strategy, a regression discontinuity design that accounts for the multiple thresholds students must cross in order to be eligible for aid. In section 5, we present estimates of the impact of college quality on enrollment decisions and completion rates. In section 6, we conclude by discussing implications for postsecondary education policy.

2 The Adams Scholarship as an In-Kind Subsidy

2.1 The Adams Scholarship

All Massachusetts public high school 10th graders take the Massachusetts Comprehensive Assessment System (MCAS), which includes an English language arts portion and a mathematics portion. Scores on each portion range in multiples of two from 200 to 280, with 260-280 categorized as "advanced" and 240-258 as "proficient". In January 2004, Massachusetts Governor Mitt Romney proposed the John and Abigail Adams Scholarship Program, which would waive tuition at in-state public colleges for any student whose total MCAS score placed him or her in the top 25% of students statewide.[1] Romney's two stated goals seemed to be keeping highly talented students in state and improving the quality of the state's public postsecondary institutions. In his January 15, 2004 State of the Commonwealth speech to the Massachusetts legislature, Governor Romney explained that "I want our best and brightest to stay right here in Massachusetts."[2] Conversations with individuals involved with the scholarship's inception also suggest that Mas-

[1]The eponymous couple cared deeply about education. John Adams wrote, in the Massachusetts Constitution, that "Wisdom, and knowledge, as well as virtue... as these depend on spreading the opportunities and advantages of education in the various parts of the country, and among the different orders of the people, it shall be the duty of legislatures and magistrates, in all future periods of this commonwealth, to cherish the interests of literature and the sciences, and all seminaries of them; especially the university at Cambridge, public schools and grammar schools in the towns" (Chapter V, Section II). Abigail Adams, disturbed by the 18th century gender gap, wrote that "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" (Letter to John Thaxter, February 15, 1778).

[2]See the January 20, 2004 Boston Globe article, "Specialists Blast Romney Proposal for Free Tuition," by Jenna Russell.

sachusetts wanted the recently introduced MCAS exam to be seen as a valid measure of student achievement and was thus willing to, in effect, put its money where its mouth was.

Concerned that Governor Romney's statewide standard would assign scholarships largely to students in wealthy, high-performing school districts, the state Board of Higher Education ultimately approved a modified version of the program in October 2004.[3] Under the approved policy, which has continued through at least 2013, a student receives a tuition waiver if his or her MCAS scores fulfill three criteria. First, he or she must score advanced on one portion of the exam. Second, he or she must score proficient or advanced on the other portion of the exam. Third, the student's total MCAS score must fall in the top 25% of scores in his or her school district.[4] The scores used to determine eligibility come from each student's first attempt at taking the grade 10 MCAS tests in ELA and mathematics. To receive the scholarship, a student must be enrolled in and graduate from a Massachusetts public high school in his or her senior year. The graduating class of 2005 was the first to receive the scholarships according to these eligibility criteria.

Scholarship winners are automatically notified by letter in the fall of their senior year. The scholarship waives tuition at any of four University of Massachusetts (U. Mass.) campuses, nine (four-year) state colleges, or fifteen (two-year) community colleges.[5] Receipt of the scholarship does not, however, eliminate the cost of college attendance. Figure 1 shows the tuition and mandatory fees at the University of Massachusetts at Amherst and Bridgewater State College, the two largest campuses in their respective sectors. Strikingly, at both campuses and nearly all other public Massachusetts colleges, tuition has remained constant in nominal terms over the past decade. Mandatory fees have, however, risen dramatically.[6] The letter that Governor Romney sent to the first class of scholarship recipients promised in bold-faced and underlined letters "four years of free tuition." Due to frustration voiced by some students and families unaware of the distinction between tuition and fees, the letter to the second class of scholarship recipients clarified in its final

[3]See the October 20, 2004 Boston Globe article, "New MCAS Scholarship OK'd," by Jenna Russell.

[4]As of the class of 2006, students in charter schools or who participate in school choice or the Metco program can fulfill the third criterion by placing in the top 25% of the district they attend or the district in which they reside.

[5]Six of Massachusetts' state colleges (Salem, Bridgewater, Fitchburg, Framingham, Westfield and Worcester) were renamed "state universities" in 2010. For simplicity, we refer to them as "state colleges" throughout the paper.

[6]This peculiar detail may be due to the fact that tuitions are set by the Massachusetts Board of Higher Education and flow directly to the state's General Fund, while fees are set by each college's Board of Trustees and are retained by the colleges themselves.

paragraph that "College fees and rooming costs are not included in this scholarship award." More recent letters have emphasized this fact even more clearly.[7]

For the first class of scholarship winners, the tuition waiver was worth $1,714 annually if used at U. Mass. Amherst or $910 if used at Bridgewater State. Given mandatory fees of $7,566 at U. Mass. Amherst and $4,596 at Bridgewater State, the Adams Scholarship thus represented a less than 20% reduction in the direct cost of attendance. By the fall of 2010, fees had risen by roughly a third, so that the Adams Scholarship represented less than a 15% reduction in the cost of attendance. These percentages would be substantially lower if room, board and other expenses were included in the total cost of attendance. Conversations with individual colleges' financial aid offices also suggest that for some students this aid is factored into financial aid offers and may be partially crowded out as a result.[8] The Adams Scholarship thus lowers the cost of college attendance by well under 20%, may be partially crowded out by college financial aid offices, is worth at most $6,856 (4*$1,714) over four years, and is substantially less valuable than other well-known merit aid scholarships such as the Georgia HOPE and CalGrant awards (Dynarski 2008, Kane 2007). By all of these measures, the Adams Scholarship represents a relatively small amount of financial aid.

Finally, those eligible for the scholarship can use it for a maximum of eight fall and spring semesters only if they graduate from a Massachusetts public high school, are accepted at a Massachusetts public college or university, and enroll at that institution full-time by the fall following their high school graduation.[9] The student must also complete the Free Application for Federal Student Aid (FAFSA) and send the Adams Scholarship award letter to the financial aid or bursars

[7] See Figures A.1, A.2 and A.3 for copies of these letters.

[8] We spoke to financial aid officers at all of the U. Mass. campuses about their current policies, which they all believed have been in place since the inception of the Adams Scholarship. All four ask students to send their notification letters as soon as possible in the admissions process, as the financial aid offices do not have their own list of winners. U. Mass. Amherst said there was little scope for crowdout because most students send their letters after receiving financial aid offers, though students who send the letters early may be offered grant money in place of a tuition waiver. U. Mass. Lowell said that scholarship status was used in determining financial aid offers and that late notification of scholarship eligibility results in a recalculation of the aid offer. U. Mass. Boston and Dartmouth also said that scholarship status was used in determining financial aid offers but claimed that scholarship winners who would otherwise have qualified for tuition waivers would instead receive other funding."

[9] The most recent cohorts are allowed to use the scholarship within six years of graduating high school, but such cohorts are not included in our analysis.

office at the institution he or she plans to attend.[10] To continue receiving the Adams Scholarship, a student must continue his or her full-time enrollment at a Massachusetts public college or university, must maintain a cumulative college GPA of at least 3.0, and must complete the FAFSA annually.

2.2 A Theoretical Model of In-Kind Subsidies

Peltzman (1973) observed that in-kind subsidies of public goods could, in some circumstances, reduce consumption of those goods. Peltzman's insight was that postsecondary education is a relatively indivisible good. Once a student has chosen a given college to attend, it becomes quite costly or even impossible to supplement her education through other sources.[11] The model thus assumes that a student chooses a single college to attend, with colleges varying in the amount of education they provide.

Figure 2 shows a graphical representation of the model. Consumption is divided into two categories, higher education and all other goods. In a world without government subsidies, a student's budget constraint is thus AB so that a student chooses from a continuum of tradeoffs between higher education and other goods. This continuum best approximates reality in thick education markets where students have a wide variety of colleges to choose from. Massachusetts is one such market, where students can choose from community colleges, state colleges, public universities and private universities, the annual costs of which range from hundreds of dollars to tens of thousands of dollars.

In panel A, we first consider a student who, absent government subsidies, would consume E_1 dollars worth of college education. The government can subsidize education through two primary means. First, it can provide a voucher worth a fixed amount that students can utilize at any postsecondary institution, in which case a student's budget constraint would be shifted outward and her consumption of education would unambiguously increase (or remain the same).

[10] Scholarship users must also be a U.S. citizen or permanent resident of the U.S. and must have been a permanent legal resident of Massachusetts for at least one year prior to entering college as a freshman.

[11] The rise of online education and the increasing opportunity for students to take individual courses through different institutions makes this feature of the model less realistic than it once was. Nonetheless, the cohorts analyzed in this paper had little access to such opportunities.

Second, the government can fully or partially subsidize public institutions that provide E' dollars worth of education only if the student attends that institution. In the case of a partial in-kind subsidy, the student's budget constraint becomes $ADCB$, where accepting the subsidy requires consumption of E' dollars worth of college education at most. For the student whose indifference curves are shown in panel A, the in-kind subsidy induces her to forgo her private alternative for the public institution. This reduces her higher education consumption from E_1 to E' but increases her consumption of other goods, leaving her with higher utility.

The Adams Scholarship can be modeled as an increase in the size of the in-kind subsidy that Massachusetts already provides to students attending in-state public colleges, of size DD'. The scholarship thus increases the size of kink in the budget constraint, which is now $AD'CB$. The student in panel A is an inframarginal student, for whom the increased subsidy has no further effect on her choice of college education but does increase her consumption of other goods. The student in panel B is, conversely, a marginal student for whom the Adams Scholarship does change the consumption of college education. For that student, the previous size of the state's in-kind subsidy is insufficient to shift her consumption of college education from the amount E_2. The addition of the Adams Scholarship does, however, increase the subsidy enough to attract her to the public institution, so that her consumption of college education now decreases from E_2 to E'.

The empirical results below suggest that Peltzman's theoretical prediction, namely that in-kind subsidies of public institutions can reduce consumption of the subsidized good, is empirically important. We will show that a substantial number of students were induced by the Adams Scholarship to forgo enrollment in more expensive private colleges and instead enroll in the less expensive public sector. Our results will also highlight that these marginal students, though empirically important, are nonetheless greatly outnumbered by the inframarginal students for whom the subsidy simply increases consumption of other non-education goods. We turn now to the data that underlie these results.

3 Data, Descriptive Statistics and College Quality

3.1 Data and Descriptive Statistics

The Massachusetts Department of Elementary and Secondary Education (DESE) provided the data, which include demographic information, test scores and Adams Scholarship status for all Massachusetts public high school students expected to graduate from high school from 2005-2010. Specifically, information on student program participation, poverty status, gender, and race/ethnicity comes from the Student Information Management System (SIMS), which we link to first time 10th grade test scores as reported in the MCAS database. DESE separately provided us with a list of Adams Scholarship winners, which we merge into this larger data set. We limit our main analysis sample to high school graduates from the classes of 2005-2007, as only graduates were eligible for the Adams scholarship.[12] For all three classes we observe college enrollment, persistence and completion within four years of high school graduation. We also examine more recent classes but can only observe college enrollment, and not completion, for such students.

College outcomes come from DESE's merge of its data on high school graduates with the National Student Clearinghouse (NSC) database, which covers 94% of undergraduates in Massachusetts.[13] We observe for each high school graduate every college enrollment spell through 2011, including the specific college attended, dates of attendance, and college location and type. We also observe graduation if it occurs. We add to this additional characteristics such as college costs and quality measures from the U.S. Department of Education's Integrated Postsecondary Education Data System (IPEDS) and the 2009 Barron's rankings of colleges. We separate colleges into Adams eligible institutions (U. Mass. campuses, state colleges and community colleges) and other institutions, such as in-state private or out-of-state colleges. For each student and type of college, we construct two primary outcome indicators, one for enrolling full-time by the fall following high school graduation and one for earning a college degree within four years of high school gradua-

[12]98.3% of those who receive the Adams scholarship letter in the fall of 12th grade ultimately graduate from high school. Regression discontinuity analysis, as described further below, suggests that receipt of this letter had no impact on high school graduation rates, so this restriction should not create selection bias.

[13]The remaining 6% come largely from for-profit institutions and those whose highest degrees take less than two years to complete. Such institutions tend to enroll students with relatively low academic skill, so that the overall match rate for those eligible for the Adams Scholarship is likely substantially higher than 94%.

tion.[14] We also construct persistence measures indicating whether a student is enrolled in college during the spring semester two and four years after high school graduation.

Table 1 shows the mean characteristics of high school graduates from the classes of 2005-2007. Column (1) contains the full sample. Column (2) limits the sample to students eligible for the Adams Scholarship. Column (3) limits the sample further to those who use the scholarship to attend an in-state public college. Column (4) contains all students sufficiently close to the eligibility threshold to be used in our subsequent regression discontinuity analysis, as will be described below. Columns (1) and (2) show that Adams eligible students are half as likely than the average high school graduate to be low income, black or Hispanic, because these characteristics are all negatively associated with the test scores determining eligibility. Columns (2) and (3) show that users of the Adams Scholarship are more likely to be low income and have slightly lower test scores than the average Adams eligible student. Figure 3 explores the test score distributions of scholarship users and eligibles in greater detail. Though lower-scoring eligibles are the most likely to use the scholarship by attending an in-state public college, takeup rates among higher-scoring students are not zero.

The bottom two panels of column (2) in table 1 show that 79% of Adams eligible students enroll full-time in a four-year college by the fall following their high school graduation, but that only 52% graduate from a four-year college within four years. This four-year graduation of 66% (.52/.79) is the average of two very different graduation rates by sector. 26% of Adams eligible students enroll in in-state public four-year colleges but only 12% have graduated four years later, a four-year graduation rate of 46% (.12/.26). Conversely, 53% of Adams eligible students enroll in private or out-of-state colleges and 40% have graduated within four years, a four-year graduation rate of 75% (.40/.53). This suggests that Massachusetts' public colleges have low four-year completion rates relative to other colleges available to Massachusetts' students.

[14] We exclude part-time enrollment spells and those less than 60 days long, though this has little effect on our results.

3.2 College Quality

Figure 4 confirms this difference between college sectors, plotting by initial enrollment sector the fraction of students graduating within a certain number of years. We generate these figures using NSC's data on four-year college enrollers from Massachusetts' high school class of 2004, prior to the existence of the Adams Scholarship. Panel A shows that fewer than 40% of those who enroll in U. Mass. campuses graduate within four years. The comparable figure for Massachusetts state colleges is well under 30%. For in-state private colleges and out-of-state colleges, that figure is about 60%. Both panels A and B, the latter of which conditions the sample on students who graduate, show that a large fraction of students in in-state public colleges use a fifth or even a sixth year to graduate. Even so, six years out of high school there exist large gaps in the graduation rates between these sectors. This evidence makes clear that Massachusetts' public four-year colleges have substantially longer times to degree completion and lower ultimate completion rates than the alternative colleges available to Massachusetts students.

To explore why these sectors differ so dramatically in their on-time completion rates, Table 2 provides a more detailed description of the college market facing Massachusetts students. Quality and cost measures reported by IPEDS in the fall of 2004 are weighted by enrollment of Massachusetts students and thus represent the average student's experience of that sector. In panel A, IPEDS' measure of four-year completion rates tells a very similar story to NSC's measure, namely that U. Mass. campuses and state colleges have far lower on-time graduation rates than do in-state private and out-of-state colleges.[15] Some part of this variation may be due to the academic skill of incoming students. Students enrolling in state colleges have much lower SAT math scores than those enrolling in other sectors, although the U. Mass. campuses look fairly similar to private and out-of-state colleges in this regard. In-state private and out-of-state colleges also spend an annual average of nearly $15,000 per student on instruction, nearly twice the spending of U. Mass. campuses and more than three times the spending of state colleges. This resource gap may reduce students' access to coursework or to academic support necessary to complete such course-

[15]Note that IPEDS measures the completion rate of all undergraduates in these institutions, whereas Figure 4 measures the completion rate only of students coming from Massachusetts public high schools.

work and may thus help explain some of the completion rate gap. Relative to their competitors, Massachusetts' public colleges thus have substantially lower graduation rates, attract students of somewhat lower academic achievement and spend much less money on instruction.

Whether differences in graduation rates between these sectors is due to differences in incoming student achievement, resources available for instruction or other factors is beyond the scope of the paper. We follow Black and Smith (2006), who argue that because each such of these variables measures college quality with error, relationships between them and outcomes of interest will be biased toward zero. We adopt their suggestion to measure college quality by combining information from multiple variables in order to reduce such measurement error. Specifically, we construct college quality from our student-level data as the first component from a principal component analysis of each college's four-year graduation rate, SAT math 75th percentile of incoming freshmen, and instructional expenditures per student, all of which are measured by IPEDS as of 2004 and thus prior to the Adams Scholarship. We think of the first variable as capturing the ultimate outcome of interest, the second as capturing a measure of student quality and the third as capturing a measure of available resources.[16] The first principal component from this analysis captures 64% of the variation between these three variables and nearly equally weights all three. We standardize this quality measure to have mean zero and standard deviation one.

The final row of panel A shows that, by this measure of college quality, U. Mass. campuses and state colleges are 0.31 and 0.94 standard deviations lower than the average quality college attended by Massachusetts high school graduates. In-state private and out-of-state colleges are 0.29 standard deviations higher in quality.[17] It is important to note here that this measure of quality is not necessarily a measure of how effectively the various college sectors are using their available resources. Though the in-state public colleges have lower graduation rates and instructional expenditures, these facts may be explained in part by the fact that those colleges have much less funding per student. Panel B shows that the total cost of U. Mass. campuses and state colleges, including fees, room, board and books, are $15,000 and $11,000 respectively. This is about half

[16] Black and Smith construct their quality measure using a slightly broader set of variables. We find that all of these quality measures are so highly correlated that it makes little difference whether we include more than three of them.

[17] For examples of individual colleges and their quality measures, see Table A.1.

of the $29,000 sticker cost of their competitors.[18] When grant aid is taken into account, U. Mass. campuses charge their students an average of $8,000 a year, relative to the $15,000 charged by their competitors. Students, particularly those facing credit constraints, may thus make a very rational decision to forgo college quality in order to attend a lower-cost public option. Interestingly, the ratio of degree completion to funding levels is, if anything, higher in the public sector. If we measured college quality by degrees generated per dollar spent, the public sector would compare favorably to its competitors. That is not, however, the measure of college quality of greatest relevance to students making enrollment decisions. We thus focus on the measure of quality described above.

4 Empirical Strategy

We now turn toward estimating the causal impact of the the Adams Scholarship on students' college outcomes. Comparing outcomes of those eligible and ineligible for the Adams Scholarship would confound the impact of the scholarship with the fact that eligible students have higher academic skill than ineligible ones. We eliminate this source of omitted variable bias by using a regression discontinuity design that compares students just above and below the eligibility thresholds. Students just above and just below these thresholds should be similar to each other except for receipt of the scholarship. Though the scholarship may incentivize students to raise their test scores and qualify for the aid, there is little scope for manipulation of test scores around eligibility thresholds for three reasons. First, the earliest cohorts of students took their MCAS exams prior to the announcement of the Adams Scholarship policy. Second, at the time of test administration, the district-level 75th percentile threshold is impossible for individual students to know precisely. Third, exams are centrally scored and raw scores transformed into scaled scores via an algorithm unknown to students, their families or teachers.

Figure 5 provides a graphical interpretation of scholarship eligibility in three types of school districts. In each type of district, the straight line with a slope of -1 represents the cutoff that

[18] In-state community colleges, at which the scholarship could also be used, are essentially open admissions campuses. In fall 2004, they charged on average $831 in tuition, $2,073 in fees, and $5,797 in other expenses, so that their sticker and net prices were roughly two-thirds those of state colleges.

determines whether a student's total MCAS scores (math + ELA) places her in the top 25% of her school district. The W-shaped boundary defines the region in which students have scored "advanced" in one subject and "proficient" or "advanced" in the other. In low-performing districts with 25% cutoff scores of at most 500, that cutoff is so low that passing the proficient/advanced threshold is sufficient (and necessary) to win a scholarship. In medium-scoring districts with 25% cutoff scores between 502 and 518, that cutoff and proficient/advanced threshold interact in a complex way. In high-performing districts with 25% cutoff scores of at least 520, that cutoff is so high that passing it is sufficient to win. Scholarship winners are those students whose test scores thus fall in the shaded region of the graph.[19]

There are many strategies for dealing with multidimensional regression discontinuities, as discussed by Reardon and Robinson (2012). Examples of such situations in the economics of education include Papay et al. (2010, 2011a,b). We implement the regression discontinuity by collapsing the multiple dimensions into a unidimensional measure of each student's distance from the complex boundaries shown in Figure 5. Specifically, we characterize each student by her rectilinear distance from the nearest point on the boundary that represents a valid pair of math and ELA scores. The rectilinear distance is defined as the total distance she would have to move vertically and horizontally to reach that nearest point.[20] This measure, which we call Gap_{ijt} for student i in district j in high school class t, thus measures the total number of scaled score points by which a student exceeded the eligibility threshold. By this construction, any student with a non-negative value of Gap is eligible for the Adams Scholarship while any student with a negative value of Gap is ineligible. Students with $Gap = 0$ are those who barely qualified for the scholarship while those with $Gap = -2$ just barely missed qualifying.[21]

To estimate the causal effect of the Adams Scholarship, we use local linear regression to esti-

[19] We note here that MCAS scores have risen dramatically since the inception of the program, as shown in Figure A.4. Because so many students pass the proficient/advanced threshold, relatively few districts in our sample are low-performing as defined by Figure 5. In other words, it is the top 25% boundary that is generally of the greatest importance, which can be seen by the fact that a full 25% of students qualify for the scholarship each year (or even more, due to the state's decision to break ranking ties in favor of granting students eligibility).

[20] The rectilinear distance is commonly called the "taxicab" distance because taxicabs can move only vertically or horizontally on a grid of streets, not diagonally as would be required by a Euclidean distance measure.

[21] Recall that the MCAS scaled scores are defined as multiples of two.

mate linear probability models of the form:

$$Y_{ijt} = \beta_0 + \beta_1 Adams_{ijt} + \beta_2 Gap_{ijt} + \beta_3 Gap_{ijt} \times Adams_{ijt} + \beta_4 X_i + \delta_t + \epsilon_{ijt}. \quad (1)$$

where $Adams$ is an indicator for Adams Scholarship eligibility ($Gap_{ijt} \geq 0$), δ_t is a high school graduating class fixed effect, and X_i is a vector of the demographic controls listed in panel A of Table 1. The causal effect of winning the Adams Scholarship on an outcome, Y_{ijt}, should be estimated by β_1 if the usual assumptions underlying the validity of the regression discontinuity design are not violated. Assuming that treatment effects are homogeneous along different parts of the eligibility threshold, this coefficient measures a local average treatment effect for students near the threshold, weighted by the probability of a given student being near the threshold itself (Reardon and Robinson, 2012).

Our preferred implementation will weight these local linear regressions with an edge kernel that weights points near the threshold more heavily than those far from the threshold, as suggested by Imbens and Kalyanaraman (2012). We use as a default a bandwidth of 20 scaled score points (capturing 10 groups of students on either side of the threshold) but show later that our results are robust to using smaller bandwidths.[22] We cluster standard errors by the integer values of Gap to account for the coarse nature of the forcing variable (Lee and Card, 2008).

We perform two tests of the validity of the regression discontinuity design. First, as suggested by McCrary (2008), we examine in Figure 6 the density of the forcing variable for signs of manipulation that might invalidate the design. Panel A suggests some cause for concern, as there appear to be more students just to the right of the threshold than to its left. The same pattern appears, however, for the graduating class of 2004, suggesting that it is not a result of the Adams Scholarship policy itself. To pinpoint the cause of this discontinuous density function, Figure 7 plots the density of math and ELA scaled scores in panels A and B, as well as the underlying raw scores in panels C and D. The top two panels show a large difference in the density of students just above and below the advanced thresholds in both math and ELA. No such difference is seen in the raw

[22] Calculations of an optimal bandwidth following Imbens and Kalyanaraman (2012) yield bandwidths too small to generate estimates, perhaps suggesting their procedure does not work well with a very discrete running variable.

scores, suggesting that Massachusetts' algorithm for transforming raw scores into scaled scores is generating the discontinuous density observed in Figure 6. In other words, the observed pattern is due not to manipulation by students or teachers but to a feature of the state's scoring system that is unrelated to the Adams Scholarship itself.

This only presents a problem for our empirical design if this transformation results in systematic differences between students on either side of the eligibility threshold. We test this in Table 3, where we perform our local linear regressions but use student characteristics as outcomes. The results suggest very slight differences between students just above and below the threshold. Barely eligible students are no more likely than barely ineligible students to be Hispanic, Asian or enrolled in special education, but are about one percentage point more likely to be male, black and low income. These latter differences, though statistically significant, are extremely small in magnitude. The rightmost two columns of the table show that these demographic differences translate into no significant difference in underlying math scores and differences in ELA scores less than three hundredths of a standard deviation. Thus, though the underlying density of scaled scores appear discontinuous, this does not generate substantial observable differences between students on either side of the eligibility threshold. To confirm that these differences are insubstantial, we control in our baseline regressions for the characteristics tested in Table 3 and later show that our results are completely robust to their exclusion.

5 Results

5.1 Enrollment and Graduation Rates

To visualize the enrollment impacts of the Adams Scholarship, we plot in Figure 8 the proportion of students for each value of Gap who enroll in four-year colleges immediately following high school graduation. We also plot the regressions lines predicted by Equation 1. We focus on the high school classes of 2005-2007 for whom we can observe college graduation within four years. Figure 8 shows that students at the eligibility threshold are substantially more likely to enroll in an in-state public college than students just below the threshold. Such students are, however, similarly less likely to enroll in an in-state private or out-of-state college, the net result of which is little apparent difference in overall college enrollment rates between these two groups of students.

Panel A of Table 4 estimates these differences more precisely. Scholarship eligibility induced 8.2 percent of students at the threshold to enroll in in-state public colleges, a more than one-third increase over the 24.4 percent enrollment rate of students just below the threshold. More than three-fourths of these marginal students, or 6.3 percent, forgo attending other colleges as a result of scholarship eligibility. The net result is a 1.8 percentage point increase in the fraction of students enrolling in any four-year college. The scholarship also induced a small rise in the fraction of students enrolling in two-year colleges, where the tuition waiver could also be used, so that the overall college enrollment rate rose by 2.7 percentage points as a result of scholarship eligibility. About half of this represents, however, changes in decisions about when to enroll and not whether to enroll.[23] Panel B defines as outcomes enrollment within two years of high school graduation, which suggests that the impact on two-year college enrollment disappears and that the impact on four-year college enrollment is roughly halved. We show later that these overall college enrollment results are sensitive to bandwidth choice, with narrower bandwidths suggesting little overall impact on college enrollment rates.

In summary, the primary effect of the Adams Scholarship was to induce large numbers of students to switch into in-state public four-year colleges from other four-year colleges they otherwise would have attended.[24] Most of those students would have attended college in other states, so the scholarship does increase in-state college attendance rates by about 6 percent. These effects are in line with those found in Goodman (2008), which used a coarser outcome measure to explore these questions.

We then plot in Figure 9 the proportion of students for each value of Gap who graduate from four-year colleges within four years of high school graduation. The graph shows two striking features. First, the discontinuity in graduation rates from in-state public colleges is much smaller than the enrollment discontinuity observed in Figure 8. This implies that increased enrollment

[23]Immediate enrollment was a requirement of the scholarship.

[24]Table A.2 shows that, of the 8.2 percent of marginal students, one-third enrolled in U. Mass. Amherst, the state's flagship campus, one-third enrolled at other U. Mass. campuses, and the remaining third enrolled at the less selective four-year state colleges.

rates are not translating into increased graduation rates.[25] Second, those barely eligible for the Adams Scholarship have lower four-year graduation rates from any four-year college than those barely ineligible. In other words, the overall impact of the scholarship is to lower four-year college graduation rates.

Panel C confirms this initially surprising result. By attracting students to in-state public colleges, the Adams Scholarship increases four-year graduation rates from those colleges by 2.2 percentage points but decreases graduation rates from other colleges by 3.9 percentage points. The net result is a practically and statistically significant 1.7 percentage point decrease in the the overall graduation rate, an estimate unchanged by inclusion of two-year colleges as in column (6). We spend much of the rest of the paper attempting to understand this result.

One potential explanation for this result might be that students at in-state public colleges are more likely to take a fifth or sixth year to graduate or to transfer to other institutions, so that our estimated negative impact is actually driven by delay rather than failure to ever graduate. We explore this possibility in Table 5, which explores impacts by graduating high school class in the first three columns, groups those classes in the fourth column, and explores the most recent three cohorts in the fifth column. Panel A shows that the enrollment impact of the scholarship is large and statistically significant for all three of the cohorts being considered here. There is some indication of shrinking effect size over time, perhaps because rising fees have shrunk the proportion of college costs covered by the scholarship.

Panel B estimates the impact of scholarship eligibility on the probability that a student is enrolled in any four-year college as of the spring two and four years after high school graduation. If the scholarship were merely delaying students' graduation by attracting them to campuses where five or six years of enrollment is the norm, then we could expect to see little impact on these outcomes. Instead, the bottom coefficient in column (4) suggests that by the fourth spring after graduating high school, scholarship eligibility lowers the probability of being enrolled on any college campus by 1.1 percentage points, or two-thirds of the 1.7 percentage point impact on four-year graduation rates. Most of these students who do not graduate within four years seem to have

[25]We also note that at all points in the score distribution the graduation rates in Figure 9 are much lower than the enrollment rates shown in Figure 8.

dropped out of college entirely and are not simply on campus taking extra time to graduate. This point is further confirmed by panel C, which estimates the scholarship's impacts separately by cohort on four-, five- and six-year graduation rates from any four-year college. If delay until a fifth or sixth year were driving our results, we would expect the impact of the scholarship to diminish as we look farther out in time. Instead, the effect remains constant or even grows slightly over time, as seen in columns (1), (2) and (4). We thus conclude that dropout and not delay explains the negative estimated impacts of the scholarship on graduation rates.

5.2 College Quality and Cost

The most plausible explanation for the negative impacts on four-year graduation rates is that the scholarship induced students to forgo college quality for a relatively small tuition subsidy. Table 6 explores the precise quality and cost tradeoffs that the Adams Scholarship induces. The top row of the table presents reduced form estimates of the impact of scholarship eligibility on a variety of initial college quality and cost measures, as in Equation 1 above. The bottom row estimates these impacts for the marginal student using the following equations that instrument enrollment in an in-state public college ($AdamsCollege$) with scholarship eligibility ($Adams$):

$$Y_{ijt} = \beta_0 + \beta_1 Adams\hat{C}ollege_{ijt} + \beta_2 Gap_{ijt} + \beta_3 Gap_{ijt} \times Adams_{ijt} + \beta_4 X_i + \delta_t + \epsilon_{ijt} \quad (2)$$

$$AdamsCollege_{ijt} = \alpha_0 + \alpha_1 Adams_{ijt} + \alpha_2 Gap_{ijt} + \alpha_3 Gap_{ijt} \times Adams_{ijt} + \alpha_4 X_i + \gamma_t + \nu_{ijt} \quad (3)$$

In the first column, we generate an indicator for a college being highly competitive if Barron's 2009 rankings placed that college into one of its top three categories of "most competitive," "highly competitive," and "very competitive,". None of Massachusetts' public colleges fall into these categories, which include colleges such as Boston University, Tufts University, Simmons College, and Lesley University. All of the U. Mass. campuses and nearly all of the state colleges fall into the fourth category of "competitive," which also includes private colleges such as Suffolk University and the Wentworth Institute of Technology. The fifth category of "not competitive" includes two state colleges and all community colleges. Column (1) shows that scholarship eligibility induced an estimated 3.2% of students, or 39% of those switching colleges, to forgo institutions in those highest three categories. Students did not simply switch into the public sector from private or out-of-state colleges of similar quality. Two-fifths of the students induced to switch colleges would have enrolled in more competitive alternatives in the absence of the scholarship.

Other measures of college quality, which are defined only for students enrolling in four-year colleges, point to a similar pattern. In columns (2)-(4), the estimates suggest that students who switched into in-state public colleges because of the scholarship gave up institutions that had higher four-year graduation rates (by 18 percentage points), higher SAT math scores (by 29 points), and higher instructional spending per student (by $7,700 annually). Overall, scholarship eligibility induced the marginal student to forgo 0.8 standard deviations in college quality.

In exchange for this drop in quality, students enrolled in public colleges where the average student's net price of attendance was $10,000 a year lower than private and out-of-state alternatives, as seen in column (6). This is the most direct measure we provide of the extent to which this in-kind subsidy reduces consumption of college education, as discussed in the Peltzman model previously. This cost difference would, however, have been available to these students even in the absence of the Adams Scholarship. The scholarship itself was worth, on average, $1,400 a year to such students, as seen in column (7).[26] Combining the estimates from columns (5) and (7) suggests a willingness to forgo 0.56 (0.787/1.409) standard deviations of college quality per $1,000 in annual aid, a remarkably high number. Students are surprisingly willing to forgo college quality for relatively small amounts of financial aid.

5.3 Robustness and Heterogeneity

We show in Table 7 that all of our central results are quite robust to alternative specifications. Panel A repeats estimates shown in prior tables from our baseline specification using a bandwidth of 20 and controlling for student covariates. Neither excluding those covariates, as in Panel B, nor shrinking the bandwidth, as in panels C and D, changes our estimates in meaningful ways. Relative to these other specifications, our baseline estimates somewhat overstate the overall en-

[26]This is a weighted average of enrollment across all of the in-state public four-year colleges, where the value of the scholarship ranged from $1,417- $1,714 at U. Mass. campuses and $910-$1,030 at state colleges.

rollment impact of the scholarship and, if anything, understate its negative impact on four-year graduation rates.

In panel E, we exploit the graduating high school class of 2004, the one cohort in our data that graduated prior to the scholarship's existence. One limitation of that year's data is that the NSC's data from private colleges is missing much more frequently than it is in later years. The data on in-state public colleges has no such problem so we can explore the impact of the scholarship on public sector enrollment and completion but not its impact on overall enrollment and completion. Panel E shows no evidence of any discontinuity in enrollment in or graduation from in-state public colleges for the high school class of 2004. Figure 10 confirms this visually, plotting enrollment and graduation rates from in-state public colleges for the untreated class of 2004 and the treated classes of 2005-7. That the discontinuity appears only in the years when the scholarship existed strengthens the case that it is due to the policy itself and not some other artifact of the data.

Panel A of Figure 10 also suggests that the impact of the scholarship on enrollment decisions was not confined to students near the eligibility threshold. The magnitude of the difference between the treated classes and untreated class above the threshold is quite similar at most points to the estimated discontinuity at the threshold itself. Our estimated local average treatment effects are thus quite similar to average treatment effects we would derive from a difference-in-difference approach to estimating the change over time in in-state public enrollment between scholarship eligibles and ineligibles, as in Goodman (2008). Those estimates suggest that, over the entire test score distribution, the Adams Scholarship induced about 1,000 additional students to enroll in in-state public colleges.

Examination of IPEDS data confirms this. Figure 11 plots the reported freshman enrollment across all Massachusetts public four-year colleges, both for all students and for those from Massachusetts. There is a clear trend break in 2005, when the Adams Scholarship begins, due entirely to increased numbers of Massachusetts freshman and of magnitude nearly identical to that we estimate based on Figure 10. One important implication of this figure is that the additional students induced into in-state public colleges did not crowd out other students, instead simply adding to each campus at most a few hundred students who would not otherwise have enrolled there.

In Table 8, we take advantage of the unusual design of the eligibility criteria in order to explore heterogeneity in the scholarship's impacts and strengthen our case that college quality is the best explanation for the graduation impacts we observe. To do so, we start by noting that unidimensional regression discontinuity designs generally estimate only a single local average treatment effect near the threshold. We can, however, estimate multiple local average treatment effects by exploiting the fact that along the eligibility boundary students vary widely in their underlying academic skill. This variation comes from three features of the policy design. First, different school districts have different top 25% cutoffs. Second, the jagged shape of the boundary for low- and medium-performing districts implies that two students on the threshold can have different total scaled scores. Third, two students with different underlying math and ELA skills can have the same total scaled score because of the algorithm for transforming raw scores into scaled scores.

To exploit these potential differences between students, we standardize each student's math and ELA score, then take their average as a measure of underlying skill. Students whose skill places them in the bottom third of the distribution within the RD sample we label as "low-scoring." Students in the top two-thirds we label as "high-scoring." In panel A, we interact these two indicators with our baseline regression specification to generate estimates of the scholarship's impact separately for these two groups of students. Three striking facts emerge. First, the scholarship affects low-scoring students' enrollment decisions significantly more than high-scoring students' decisions, with low-scoring students more likely to switch into in-state public colleges and to enroll in college at all as a result. Second, nearly half of the high-scoring students who switch into in-state public colleges do so by forgoing highly competitive colleges, whereas none of the low-scoring students do so. Third, only high-scoring students' graduation rates decrease as a result of scholarship eligibility, whereas low-scoring students' graduation rates are unaffected.

These last two points provide further evidence that college quality explains the scholarship's negative effect on graduation rates. The high-scoring students are the only ones who forgo the opportunity to attend higher quality colleges and are the only ones whose graduation rates suffer as a result. Low-scoring students would, in the absence of the scholarship, have enrolled in colleges of similar quality to Massachusetts' public colleges or in no college at all. The scholarship does not induce a loss of college quality for them and has no impact on their graduation rates. Heterogeneity by student poverty reveals similar patterns that poor students' enrollment reacts more strongly than nonpoor students' enrollment and that nonpoor students are the only ones to forgo higher quality colleges and thus lower their graduation rates.[27]

Having shown that scholarship eligibility both induced students to forgo college quality and lowered their graduation rates, in Table 9 we directly estimate the impact of college quality on those graduation rates. To do so, we use scholarship eligibility as an instrument for the different measures of college quality listed in each column. Below are the associated IV and first-stage equations.

$$GraduateIn4_{ijt} = \beta_0 + \beta_1 College\hat{Q}uality_{ijt} + \beta_2 Gap_{ijt} + \beta_3 Gap_{ijt} \times Adams_{ijt} + \beta_4 X_i + \delta_t + \epsilon_{ijt} \quad (4)$$

$$CollegeQuality_{ijt} = \alpha_0 + \alpha_1 Adams_{ijt} + \alpha_2 Gap_{ijt} + \alpha_3 Gap_{ijt} \times Adams_{ijt} + \alpha_4 X_i + \gamma_t + \nu_{ijt} \quad (5)$$

The first row of Table 9 provides the first stage coefficients by replicating the estimates seen in previous tables of the impact of scholarship eligibility on the given measure of college quality. The second row provides reduced form estimates by replicating the impact of scholarship eligibility on four-year graduation rates from panel C of Table 4, with columns (2)-(4) limiting the sample to students who enroll in four-year colleges. The third row contains the instrumental variables estimates themselves, the ratios of the reduced form estimates to the first stage estimates. The final row shows the OLS estimate of the same relationship without using the instrument.

The magnitudes of the IV estimates are striking. For the marginal student induced by the scholarship to attend in-state public college, attending such a college lowered the probability of graduating on time by a remarkable 20 percentage points. Given that the overall graduation rate for students just below the threshold is 42%, this represents a nearly 50% decrease.[28] The coeffi-

[27]Our analysis shows that estimated effects do not vary by gender so we do not bother to show those estimates. Results are available from the authors upon request.

[28]See the last figure in Table 4, panel C, column (3). This calculation assumes that the marginal student would have graduated at the same rate as the average student. Regardless of whether this assumption is correct, a 20 percentage point drop is extraordinarily large.

cient in column (2) implies that, for these marginal students, attending a college with a four-year graduation rate one percentage point higher would translate into a 1.7 percentage point increase in the probability of graduating in four years. Differences in college-level graduation rates translate more than one-for-one into individual-level graduation rates for this subset of students.

Columns (3)-(5) yield similar results with different scales. Attending a college with one point higher SAT scores raises the probability of graduating by one percentage point. Attending a college that spends $1,000 more per student on instruction raises the probability of graduating by 4 percentage points. Combining these three quality measures, attending a college of one standard deviation higher quality raises the probability of graduating by 38 percentage points. This is roughly three times larger than the effect estimated in Long (2008) by OLS and by instrumenting college quality by the average quality of nearby colleges.[29] All of these IV estimates are substantially larger than their OLS counterparts, suggesting either that omitted variable bias is driving the latter toward zero or that the marginal student induced to switch college due to scholarship eligibility is more sensitive to college quality than the average student.

6 Conclusions

We find that a relatively small amount of financial aid induces a large number of high-skilled students in Massachusetts to enroll in in-state public colleges. Many of these students forgo the opportunity to attend higher quality colleges and, in doing so, lower their own graduation rates. We argue that this is some of the clearest evidence to date that college quality has an important role in determining whether students complete their degrees. This also provides a clear example of the theoretical prediction in Peltzman (1973) that in-kind subsidies of public institutions can reduce consumption of the subsidized good. We draw three broader conclusions from these findings.

First, this particular merit aid policy likely reduces social welfare. The program's costs are not listed in budget appropriations because the tuition waivers represent not expenditures but foregone revenue. The Board of Higher Education has, however, estimated that the total annual value

[29] See the first row of Table 6 in that paper.

of the waivers is roughly $13 million.[30] Roughly three-fourths of these funds flow to inframarginal students who would have attended in-state public colleges in the absence of the scholarship.[31] As a result of this and the low graduation rates of in-state public colleges, the scholarship only increases the number of college graduates Massachusetts produces by about 200 students per year, some of whom will not stay in state and some of whom would have returned to the state had they attended college elsewhere. The scholarship also reduces by about 200 students per year the number of colleges degrees earned by Massachusetts high school graduates.[32] All in all, these considerations suggest the state is spending large amounts of money for little net benefit or even net harm to its students.

Second, our estimates suggest that students have a poor understanding of the importance of college quality. The scholarship's sustained impact over multiple cohorts suggest that students did not simply misunderstand the letter's promise of "four years of free tuition." They may have reacted strongly because of the excitement of receiving aid with a formal name attached, as documented in Avery and Hoxby (2004). Regardless for the reason, many of these students' decisions would likely fail a simple cost-benefit calculation. We calculate that reducing one's probability of graduating by 20 percentage points, as the scholarship did for marginal students, results in a $200,000 expected lifetime earnings penalty for Massachusetts residents.[33] Even ignoring the graduation margin, simply attending a college of 0.8 standard deviations lower quality results in an $80,000 expected lifetime earnings penalty.[34] Those penalties far outweigh the value of the tuition waiver, which is at most worth under $7,000. It is possible that some students were so financially constrained or had such high discount rates that switching into scholarship eligible

[30]This estimate was communicated to us in a phone call. Our own calculations based purely on the observed enrollment of Adams eligible students suggests the annual costs are closer to $25 million. Assuming the state's number is correct, this large difference is likely generated by students who do not collect their scholarships due to failure to notify their colleges of the award, failure to file a FAFSA, or failure to maintain the necessary minimum GPA.

[31]The scholarship raised enrollment in in-state public colleges by 8 percentage points from a base of 24 percentage points, as seen in Table 4. Calculations using tuitions instead of enrollment yield a similar ratio.

[32]These calculations assume the local average treatment effect estimated in Table 4 applies to the entire population of about 15,000 Adams Scholarship recipients each year.

[33]According to calculations based on the American Community Survey (ACS) in Massachusetts, the lifetime earnings difference between those holding only B.A.s and those with only some college is about $970,000.

[34]Black and Smith (2006) estimate that a one standard deviation decrease in college quality is associated with a 4.2% decrease in earnings, or about $100,000 for Massachusetts B.A. holders with average lifetime earnings of $2.5 million. We assume their estimate for men holds for women as well.

institutions was a rational decision. More likely, the marginal student did not understand that forgoing college quality would lower her chance of earning a college degree.

Third, this poor understanding of the importance of college quality suggests a possible scope for policy interventions to make information about colleges both more readily available and more salient. The Obama administration has recently unveiled a "College Scorecard" website that allows students to search for information on a small number of college characteristics, with net price and six-year graduation rates highlighted as the first two such variables.[35] Students and parents should be encouraged to take full advantage of this and other such tools, either by the government or by the high school guidance departments charged with helping students navigate the complex college application process.

Finally, these results highlight the critical importance of improving postsecondary institutions whose completion rates are low. Whether college quality operates through access to coursework, campus resources, peer effects or other channels is beyond the scope of this paper. Deeper exploration of the institution-level factors preventing college completion is needed, as this work suggests that student characteristics alone are insufficient to explain the low rates of college completion currently observed in the U.S.

[35] As of the writing of this paper, the site was located at `http://www.whitehouse.gov/issues/education/higher-education/college-score-card`.

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Figure 1: Tuition and Fees at Two Typical Adams Colleges

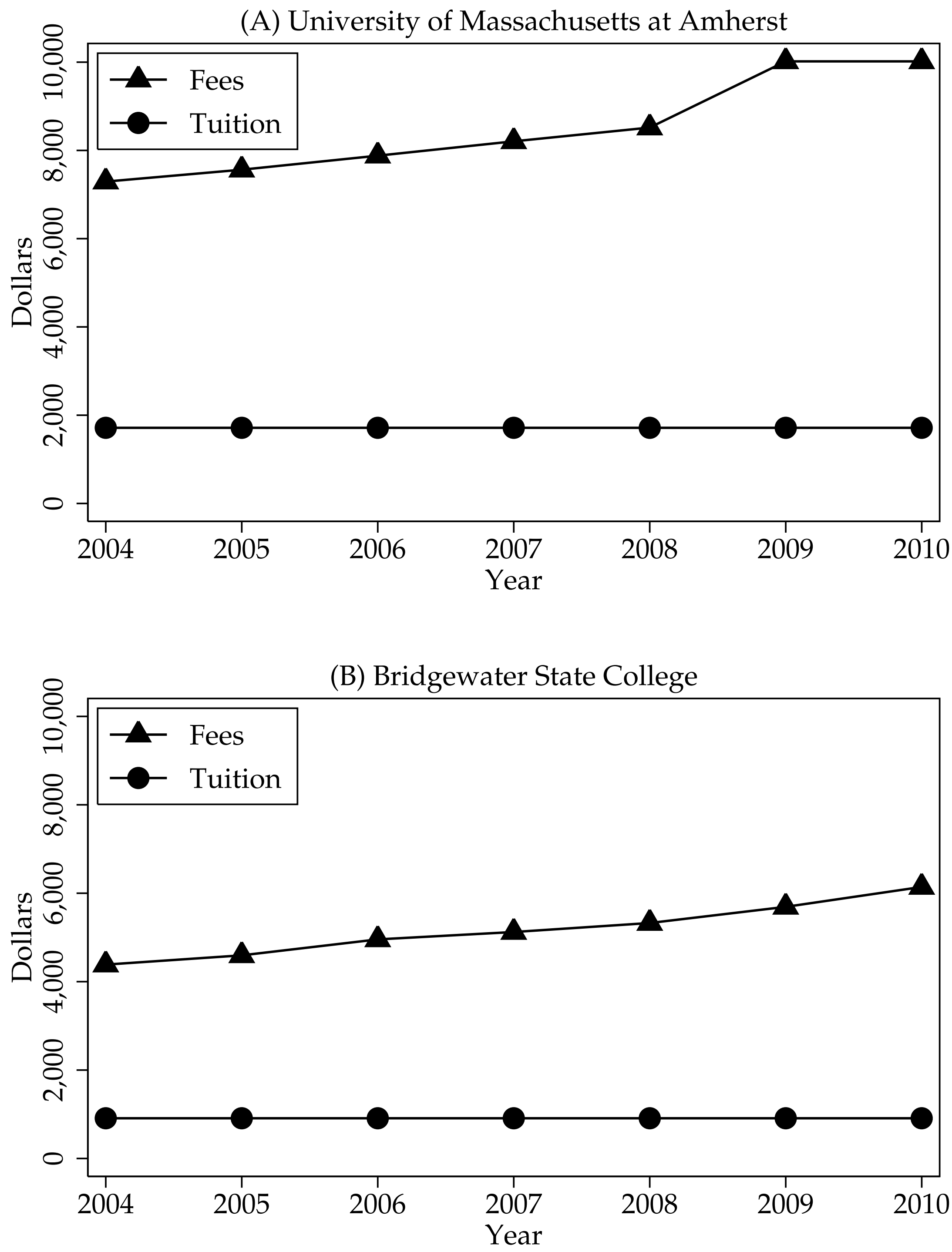

Figure 2: The Adams Scholarship as an In-Kind Subsidy

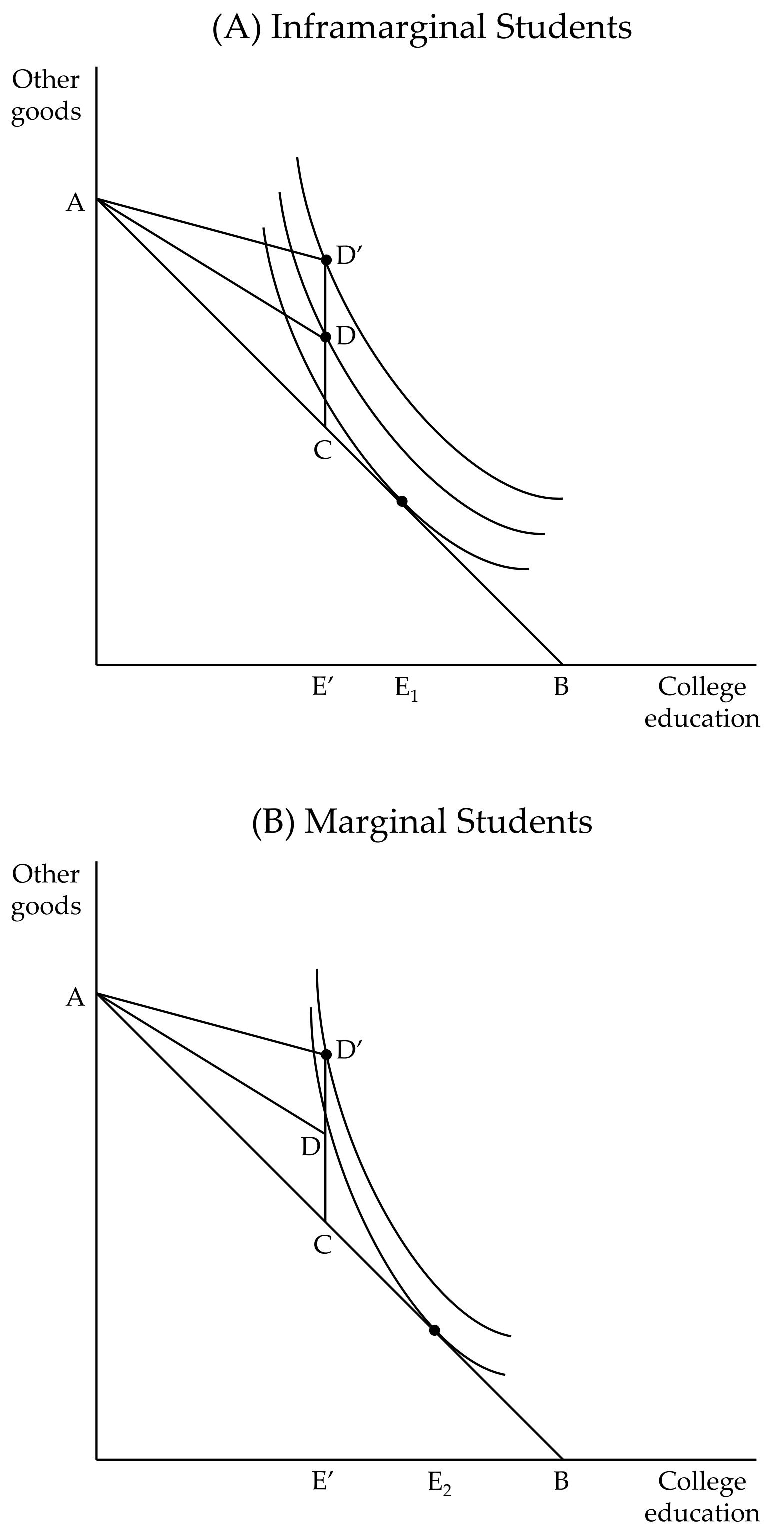

Figure 3: Test Score Distribution of Scholarship Eligibles and Users

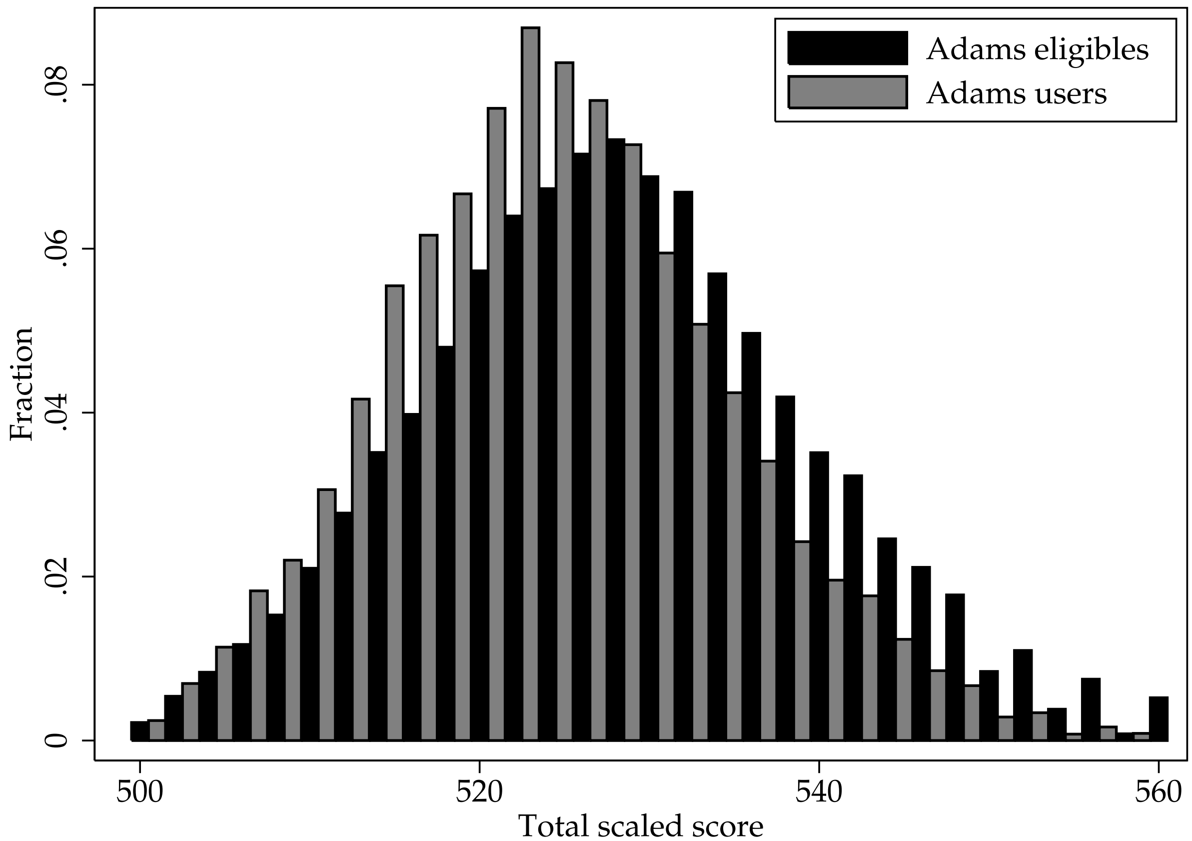

Figure 4: Time to Graduation by Four-Year College Sector, Class of 2004

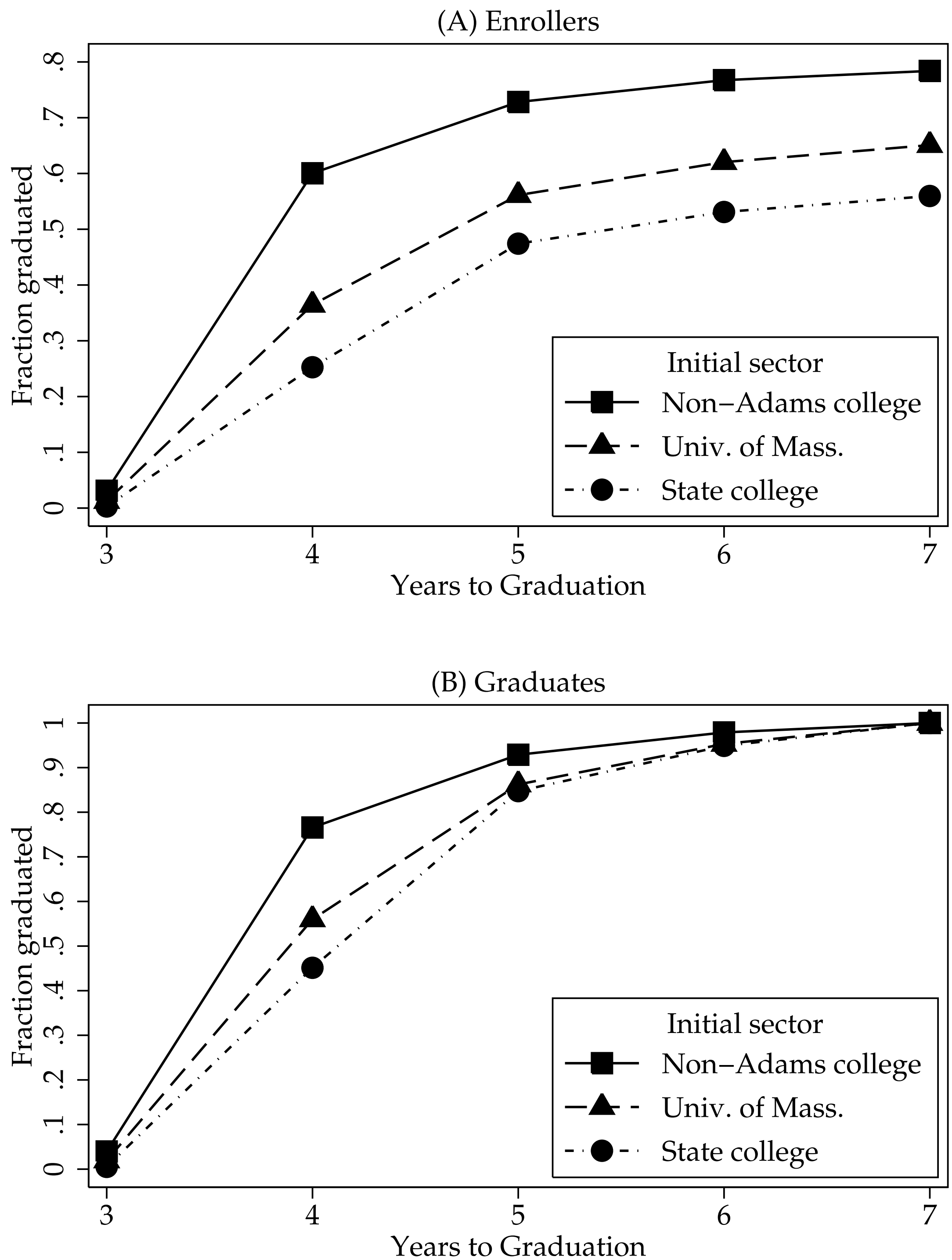

Figure 5: Graphical Representation of the Eligibility Threshold

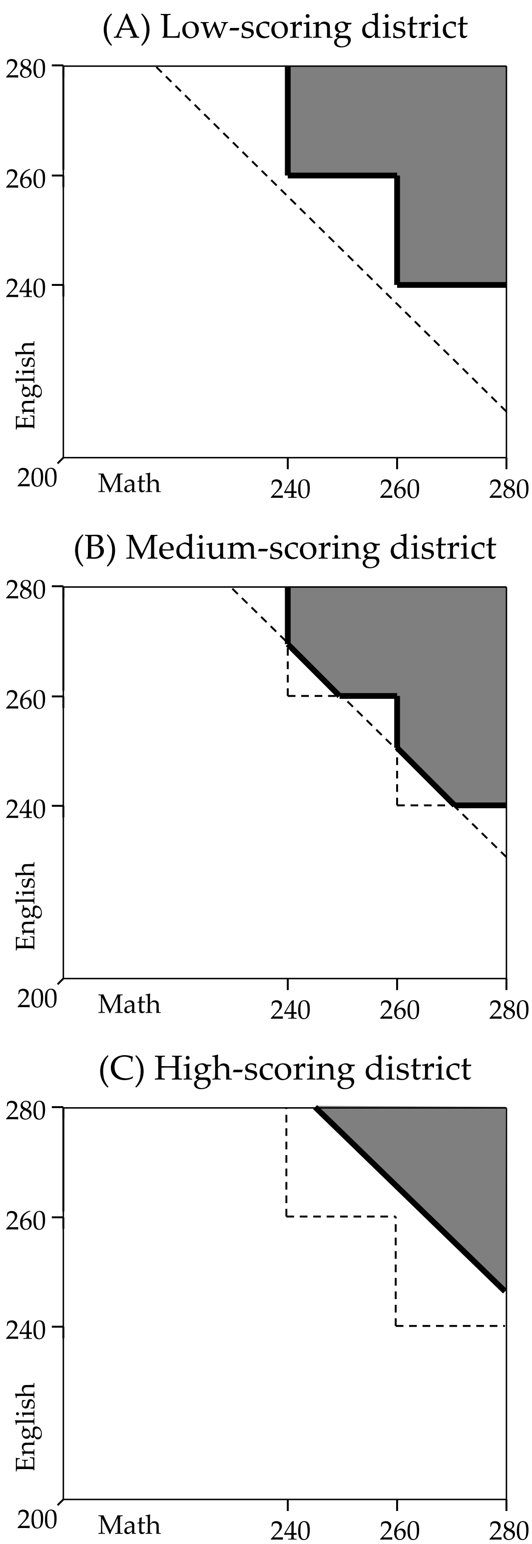

Figure 6: Density of Forcing Variable

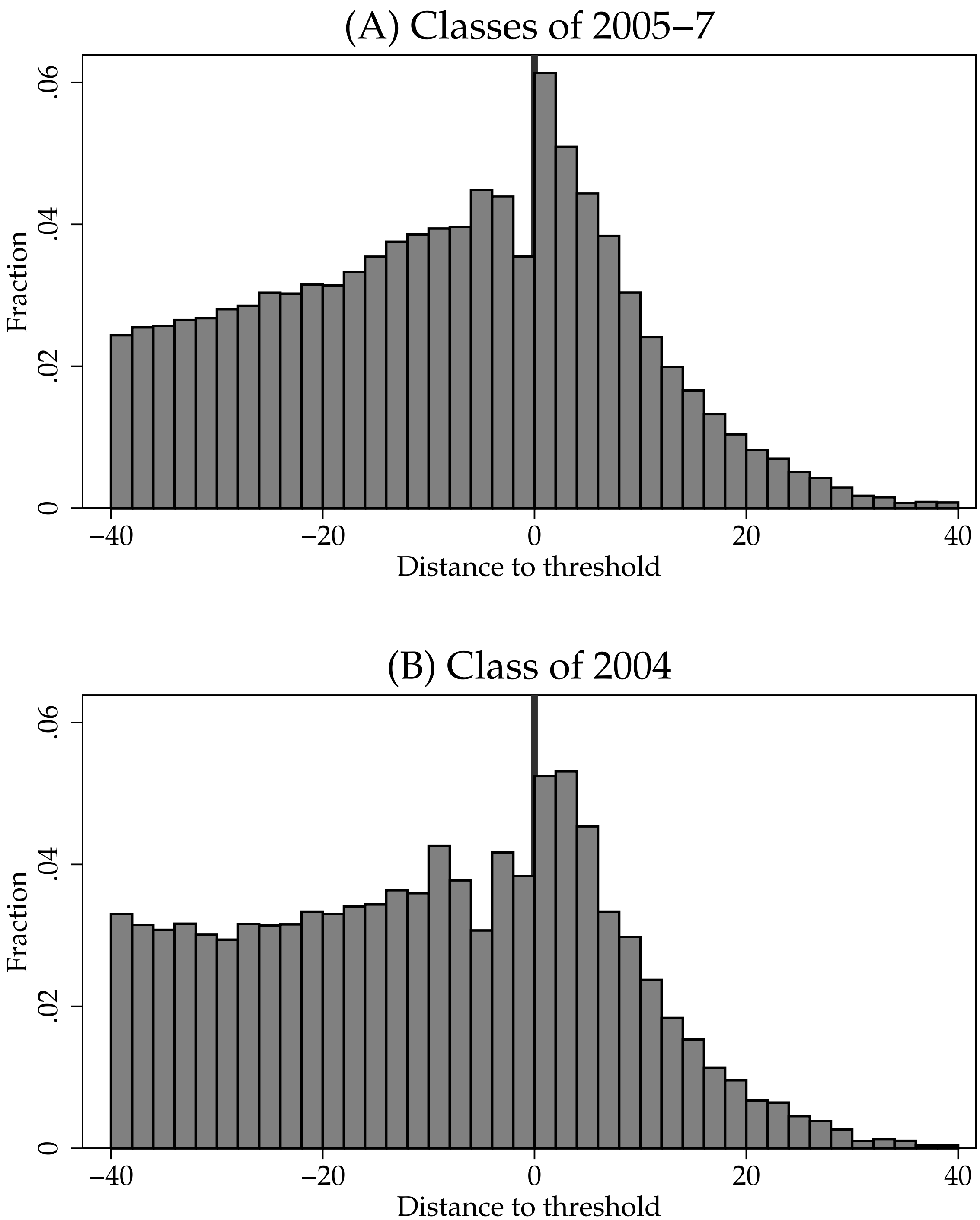

Figure 7: Density of Underlying Test Scores

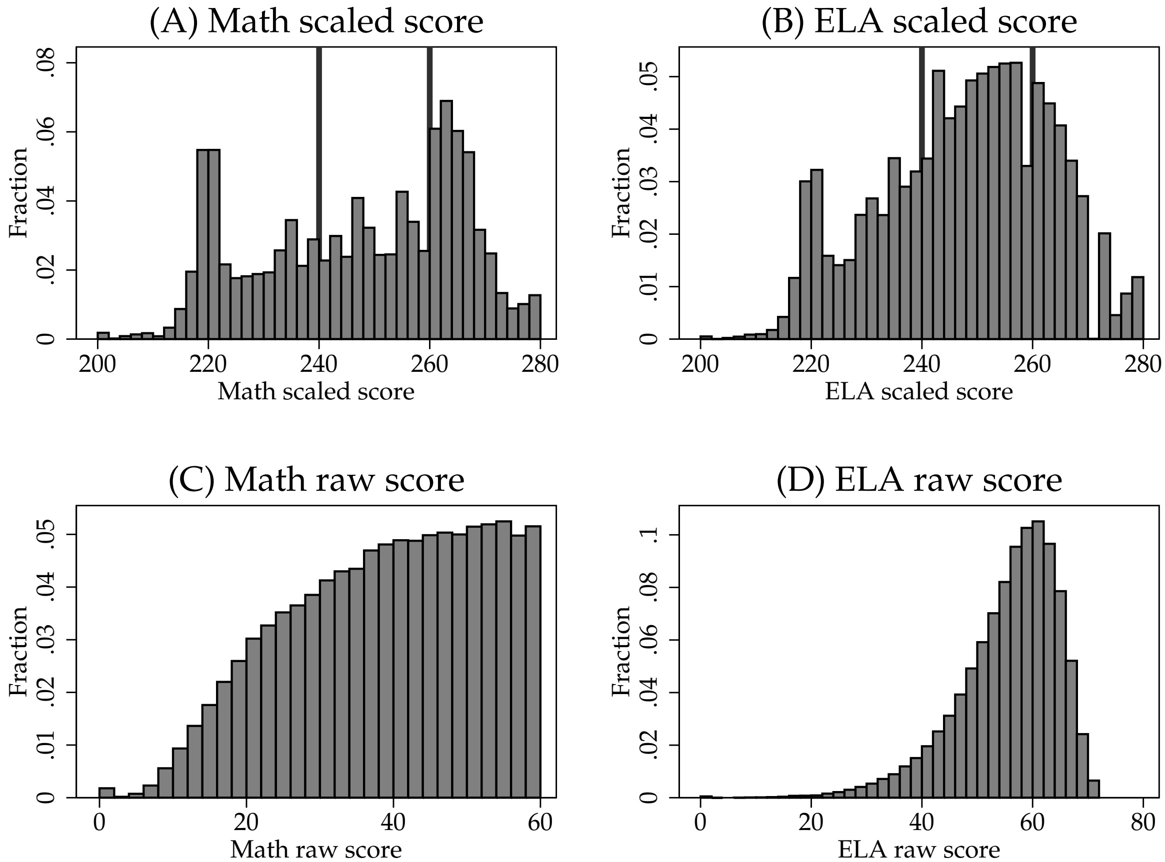

Figure 8: Enrollment at Four-Year Colleges

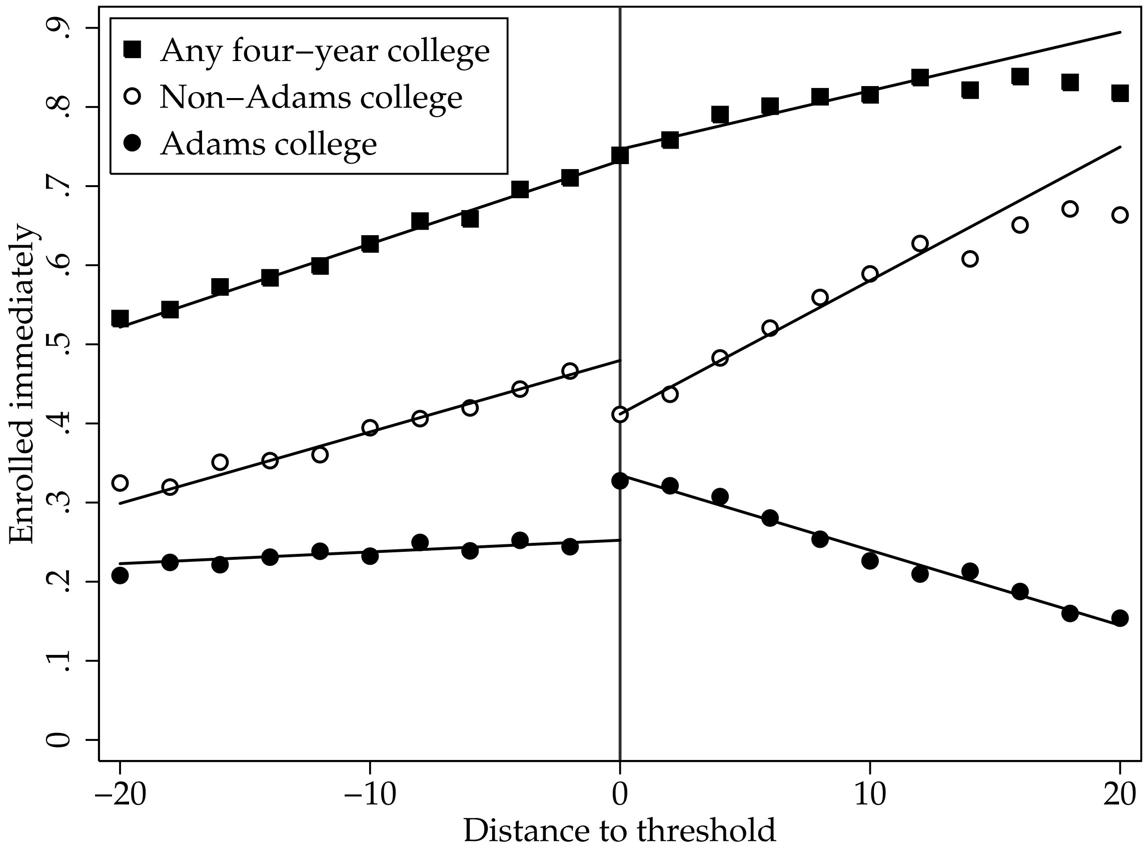

Figure 9: Graduation from Four-Year Colleges

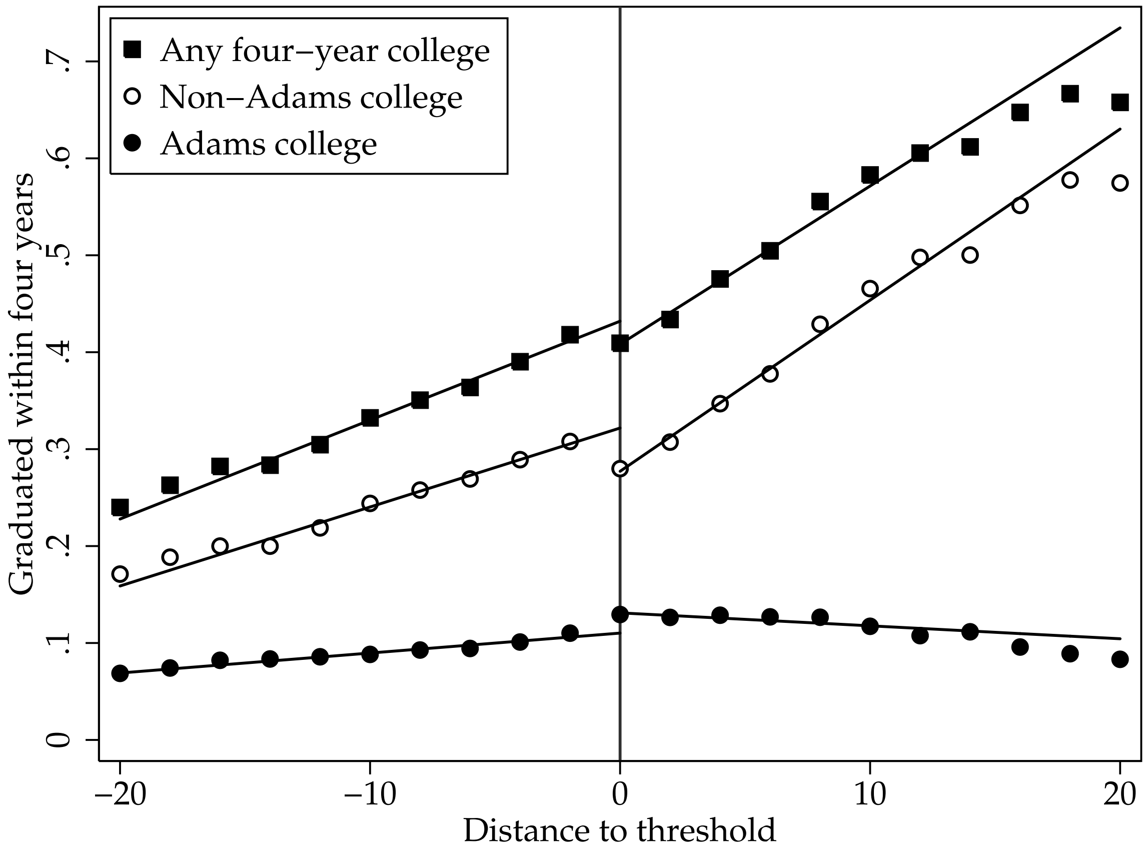

Figure 10: Treatment vs. Pre-Treatment Classes

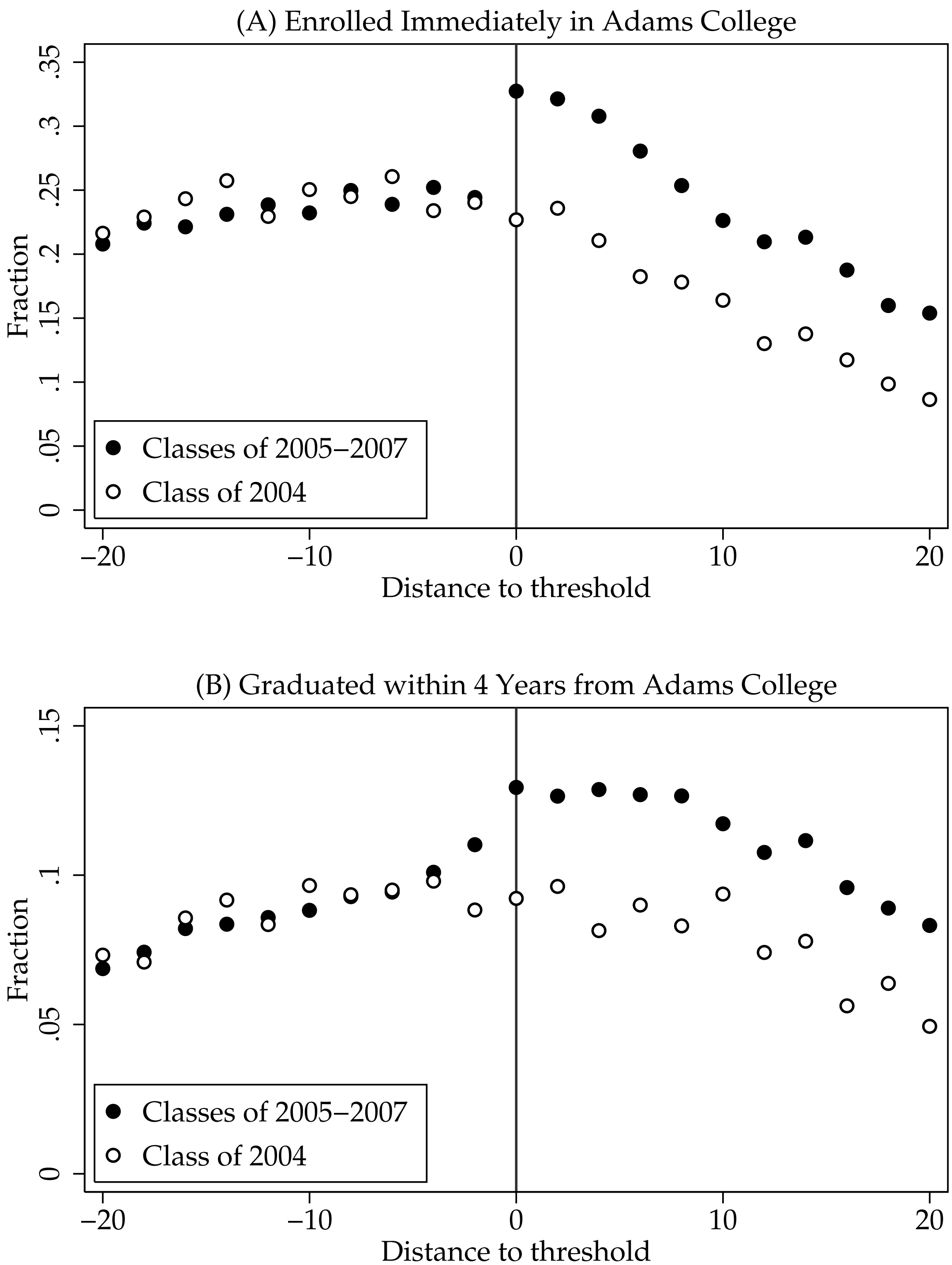

Figure 11: Freshman Enrollment in Four-Year Adams Colleges

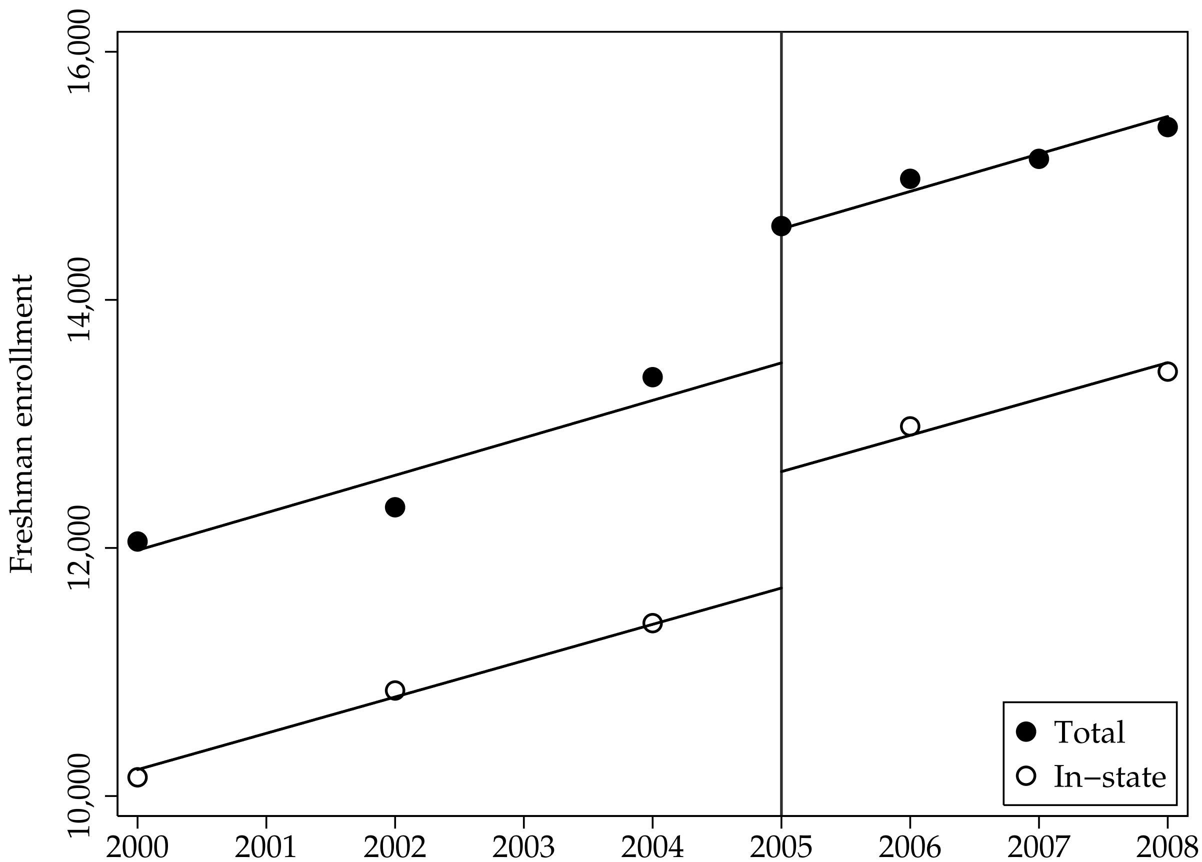

Table 1: Summary Statistics

	(1) Full sample	(2) Adams eligible	(3) Adams users	(4) RD sample
(A) Demographics				
Female	0.51	0.54	0.51	0.52
Black	0.07	0.03	0.04	0.04
Hispanic	0.07	0.03	0.03	0.04
Asian	0.05	0.07	0.06	0.05
Other race	0.00	0.00	0.00	0.00
Low income	0.18	0.09	0.12	0.11
Limited English proficient	0.03	0.01	0.01	0.01
Special education	0.12	0.01	0.01	0.03
Math z-score	-0.00	1.06	0.96	0.68
ELA z-score	0.00	0.92	0.81	0.59
(B) Adams Scholarship				
Total scaled score	493.09	528.02	523.91	515.00
Adams eligible	0.26	1.00	1.00	0.46
(C) Enrolled immediately				
Adams college	0.19	0.26	1.00	0.25
Non-Adams college	0.33	0.53	0.00	0.45
Four-year college	0.52	0.79	1.00	0.70
(D) Graduated within 4 years				
Adams college	0.07	0.12	0.41	0.10
Non-Adams college	0.21	0.40	0.02	0.31
Four-year college	0.28	0.52	0.43	0.41
N	170,770	43,683	11,498	88,870

Notes: Mean values of each variable are shown by sample. Column (1) is the full sample of high school graduates from the classes of 2005-2007. Columns (2) contains those eligible for the Adams Scholarship. Column (3) contains those who use the Adams Scholarship to attend a U. Mass. campus or state college. Column (4) restricts the sample to students within 20 scaled points of the eligibility threshold. College outcomes all refer to four-year colleges.

Table 2: Quality and Cost by Four-Year College Sector, Class of 2004

	(1) Univ. of Mass.	(2) State college	(3) Non-Adams college
(A) Quality			
Four-year graduation rate	0.34	0.24	0.53
SAT math 75th percentile	610	550	619
Instructional expenditures	8,223	4,341	14,500
College quality	-0.31	-0.94	0.29
(B) Costs			
Tuition	1,438	850	19,585
Required fees	6,164	3,741	667
Additional expenses	7,005	6,634	8,614
Total cost	14,607	11,223	28,866
Grant aid	6,649	5,711	14,139
Net price	7,958	5,512	14,727
Loans	3,710	2,592	4,162
N	4,826	3,484	16,879

Notes: Mean values of each variable are shown by sector for the first college of 2004 high school graduates who enroll on time in a four-year college. Quality and cost data are measured by IPEDS in the fall of 2004, with costs measured in 2004 dollars.

Table 3: Covariate Balance, Regression Discontinuity Sample

	(1) Female	(2) Black	(3) Hispanic	(4) Asian	(5) Other race	(6) Low income	(7) Limited Eng. prof.	(8) Special education	(9) Raw math Z-score	(10) Raw ELA Z-score
Adams eligible	-0.009*	0.009***	0.002	0.002	0.001	0.014***	0.003**	0.001	0.015	-0.027**
	(0.005)	(0.002)	(0.004)	(0.002)	(0.001)	(0.004)	(0.001)	(0.001)	(0.018)	(0.010)
$\bar{Y}$	0.516	0.038	0.036	0.049	0.002	0.111	0.006	0.020	0.715	0.614
N	83,821	83,821	83,821	83,821	83,821	83,821	83,821	83,821	83,821	83,821

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). Estimates are generated by local linear regression with an edge kernel of bandwidth 20 scaled score points, including as controls only cohort indicators. The sample consists of the high school classes of 2005-2007. Listed below each coefficient is the mean of the outcome for students just below the Adams threshold.

Table 4: Impact of Aid Eligibility on Enrollment and Graduation, By College Sector

	(1) Adams college, four-year	(2) Non-Adams college, four-year	(3) Any four-year college	(4) In-state, four-year	(5) Any two-year college	(6) Any college
(A) Enrolled immediately						
Adams eligible	0.082***	-0.063***	0.018***	0.065***	0.009***	0.027***
	(0.007)	(0.004)	(0.005)	(0.009)	(0.002)	(0.004)
$\bar{Y}$	0.244	0.466	0.710	0.410	0.072	0.782
(B) Enrolled within 2 years						
Adams eligible	0.075***	-0.062***	0.011	0.053***	0.002	0.013**
	(0.008)	(0.004)	(0.007)	(0.010)	(0.003)	(0.005)
$\bar{Y}$	0.298	0.532	0.785	0.498	0.083	0.868
(C) Graduated within 4 years						
Adams eligible	0.022***	-0.039***	-0.017***	0.015***	0.001	-0.016***
	(0.003)	(0.006)	(0.004)	(0.002)	(0.001)	(0.004)
$\bar{Y}$	0.110	0.308	0.418	0.215	0.028	0.446
N	83,821	83,821	83,821	83,821	83,821	83,821

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). Each coefficient is generated by local linear regression with an edge kernel of bandwidth 20 scaled score points, with controls for cohort, gender, race, low-income status, limited English proficiency, special education status, and math and ELA raw scores. The sample consists of the high school classes of 2005-2007. Panel A defines enrollment as within the fall following high school graduation. Panel B defines enrollment as within two years of the fall following high school graduation. Panel C defines college graduation as within four years of high school graduation. Listed below each coefficient is the mean of the outcome for students just below the Adams threshold.

Table 5: Enrollment, Persistence and Graduation by High School Class

	(1) 2005	(2) 2006	(3) 2007	(4) 2005-7	(5) 2008-10
(A) Enrolled immediately					
Adams college	0.093***	0.085***	0.074***	0.082***	0.051***
	(0.013)	(0.006)	(0.010)	(0.007)	(0.010)
$\bar{Y}$	0.249	0.255	0.226	0.244	0.237
Any four-year college	0.021	0.013*	0.029***	0.018***	0.023***
	(0.015)	(0.008)	(0.005)	(0.005)	(0.005)
$\bar{Y}$	0.691	0.714	0.726	0.710	0.704
(B) Enrolled as of					
Spring of year 2	-0.001	-0.014	0.015***	-0.002	
	(0.016)	(0.010)	(0.005)	(0.003)	
$\bar{Y}$	0.648	0.701	0.676	0.676	
Spring of year 4	-0.012	-0.017**	-0.001	-0.011***	
	(0.010)	(0.006)	(0.008)	(0.004)	
$\bar{Y}$	0.666	0.673	0.619	0.654	
(C) Graduated					
Within 4 years	-0.033***	-0.010	-0.007	-0.017***	
	(0.009)	(0.008)	(0.010)	(0.004)	
$\bar{Y}$	0.422	0.410	0.423	0.418	
Within 5 years	-0.030***	-0.022***		-0.027***	
	(0.009)	(0.007)		(0.006)	
$\bar{Y}$	0.559	0.557		0.558	
Within 6 years	-0.032***			-0.032***	
	(0.006)			(0.006)	
$\bar{Y}$	0.613			0.613	
N	25,787	28,187	29,847	83,821	101,515

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). All models include student demographic characteristic controls as listed in Panel (A) of Table 3. For details about the regression model, see the note to Table 4. In panel (B) and (C), outcomes are defined as one for enrollment or graduation from any four-year college. Listed below each coefficient is the mean of the outcome for students just below the Adams threshold.

Table 6: Impact of Aid on Initial College Quality and Cost

	(1) Highly comp.	(2) Four-year grad. rate	(3) SAT math	(4) Instr. spending	(5) College quality	(6) Net price	(7) Adams aid
Adams eligible (RF)	-0.032***	-0.018***	-2.776	-0.737**	-0.076**	-0.963***	0.115***
	(0.008)	(0.005)	(1.824)	(0.321)	(0.028)	(0.067)	(0.009)
Adams college (IV)	-0.390***	-0.183***	-28.915*	-7.675***	-0.787***	-10.027***	1.409***
	(0.070)	(0.040)	(17.089)	(2.937)	(0.242)	(0.313)	(0.026)
$\bar{Y}$	0.298	0.472	615.137	12.801	0.089	15.351	0.328
St.Dev.		0.211	60.749	12.450	0.921	6.042	
N	83,821	59,082	59,082	59,082	59,082	59,074	83,821

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* $p<.10$ ** $p<.05$ *** $p<.01$). Each coefficient is generated by local linear regression with an edge kernel of bandwidth 20 scaled score points, with controls for cohort, gender, race, low-income status, limited English proficiency, special education status, and math and ELA raw scores. The sample consists of the high school classes of 2005-2007. The highly competitive category includes institutions in the top three Barron's categories (most, highly, and very competitive). The remaining outcomes are defined only for students who enrolled on time in four-year colleges. College quality is the standardized first principal component of the four-year graduation rate, the 75th percentile SAT math score, and instructional expenditures per student. Adams aid is measured for the marginal student by imputing aid to all students below the threshold attending Adams colleges. All financial outcomes are measured in thousands of dollars. Listed below each coefficient is the mean and standard deviation of the outcome for students just below the Adams threshold.

Table 7: Robustness Checks

	(1) Enrolled immediately, Adams college	(2) Enrolled immediately, four-year college	(3) Enrolled immediately, highly competitive	(4) Graduated within 4, Adams college	(5) Graduated within 4, four-year college
(A) BW = 20, controls					
Adams eligible	0.082***	0.018***	-0.032***	0.022***	-0.017***
	(0.007)	(0.005)	(0.008)	(0.003)	(0.004)
(B) BW = 20, no controls					
Adams eligible	0.083***	0.014**	-0.036***	0.021***	-0.023***
	(0.007)	(0.007)	(0.007)	(0.003)	(0.005)
(C) BW = 15					
Adams eligible	0.084***	0.010*	-0.040***	0.018***	-0.028***
	(0.007)	(0.005)	(0.009)	(0.003)	(0.005)
(D) BW = 10					
Adams eligible	0.086***	0.006	-0.043***	0.013***	-0.032***
	(0.006)	(0.005)	(0.009)	(0.002)	(0.005)
(E) Untreated cohort					
Adams eligible	-0.004			-0.002	
	(0.010)			(0.005)	

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). Panel A uses local linear regression with an edge kernel of bandwidth 20 scaled score points, including as controls cohort indicators, gender, race, low-income status, limited English proficiency, special education status, and math and ELA z-scores. Panel B replicates panel A but with only cohort indicators as controls. Panels C and D replicate panel B with edge kernels of bandwidth 15 and 10 respectively. Panel E replicates panel B but uses the untreated high school class of 2004.

Table 8: Heterogeneity by Student Skill and Poverty

	(1) Enrolled immediately, Adams college	(2) Enrolled immediately, four-year college	(3) Enrolled immediately, highly competitive	(4) Graduated in 4 years, four-year college
(A) By academic skill				
Eligible * high-scoring	0.068***	0.010*	-0.032***	-0.017***
	(0.006)	(0.005)	(0.008)	(0.005)
Eligible * low-scoring	0.104***	0.071***	0.003	-0.002
	(0.007)	(0.004)	(0.003)	(0.003)
p	0.000	0.000	0.001	0.032
N	83,821	83,821	83,821	83,821
(B) By poverty status				
Eligible * nonpoor	0.075***	0.013**	-0.035***	-0.018***
	(0.008)	(0.006)	(0.008)	(0.004)
Eligible * poor	0.127***	0.053***	-0.005	-0.004
	(0.007)	(0.014)	(0.010)	(0.013)
p	0.000	0.018	0.017	0.314
N	83,821	83,821	83,821	83,821

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). High- and low-scoring students are those whose average MCAS z-scores are respectively above and below the 33rd percentile of such scores in each cohort in the discontinuity sample. Each regression fully interacts the baseline regression model described in Table 4 with indicators for student skill or poverty status.

Table 9: Impact of College Quality on Four-Year Graduation Rates

Y = Graduation within 4 years from four-year college	(1) Adams college	(2) Four-year grad. rate	(3) SAT math	(4) Instr. spending	(5) College quality
First stage	0.082***	-0.018***	-2.776	-0.737**	-0.076**
	(0.007)	(0.005)	(1.824)	(0.321)	(0.028)
Reduced form	-0.017***	-0.029***	-0.029***	-0.029***	-0.029***
	(0.004)	(0.006)	(0.006)	(0.006)	(0.006)
IV	-0.204***	1.653***	0.010**	0.039***	0.384***
	(0.037)	(0.245)	(0.005)	(0.011)	(0.083)
OLS	-0.020**	0.865***	0.002***	0.005***	0.162***
	(0.009)	(0.012)	(0.000)	(0.000)	(0.005)
N	83,821	59,082	59,082	59,082	59,082

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). Each column presents an instrumental variables regression of graduation within four years on the endogenous regressor listed at the top of each column, where the endogenous regressor has been instrumented with Adams eligibility. The first three rows show the first stage, reduced form and instrumental variables estimates respectively. The final row shows the OLS estimate of the same regressions without using the instrument.

Figure A.1: Award Letter to Class of 2005

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE DEPARTMENT
STATE HOUSE • BOSTON, MA 02133
(617) 725-4000

MITT ROMNEY
GOVERNOR

KERRY HEALEY
LIEUTENANT GOVERNOR

December 9, 2004

Dear [redacted] :

Congratulations! You are one of the first recipients of the John and Abigail Adams Scholarship. The Adams scholarship is good for **four years of free tuition** at any University of Massachusetts campus, or any state or community college. Your outstanding MCAS results automatically qualify you to receive this award.

We created this merit scholarship program to reward your hard work and achievement, and to encourage you to go to college at one of our top-notch public higher education institutions.

With the support of the Board of Higher Education, the Class of 2005 is now the first to be awarded this opportunity. It is the strongest expression we can make of our commitment to attracting students like you- the best and brightest in the state- to our Commonwealth's public higher education system.

I encourage you to apply to any of the campuses on the attached list. Congratulations again, and best wishes for your continued success.

Sincerely,

Mitt Romney

Figure A.2: Award Letter to Class of 2006

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE DEPARTMENT
STATE HOUSE • BOSTON 02133
(617) 725-4000

MITT ROMNEY
GOVERNOR

KERRY HEALEY
LIEUTENANT GOVERNOR

December 9, 2005

Dear [redacted]:

Congratulations! You are a recipient of the John and Abigail Adams Scholarship. The Adams scholarship offers **four years of free tuition** to full-time students attending any University of Massachusetts campus, or any state or community college, beginning with the fall 2006 semester. Your outstanding MCAS results have qualified you to receive this award.

We created this merit scholarship program to reward your hard work and achievement. With the support of the Board of Higher Education, the Class of 2006 is now the second class to be awarded this opportunity. It is the strongest expression we can make of our commitment to attracting students like you — the best and brightest in the state — to our Commonwealth's public higher education system.

I encourage you to read the enclosed material and apply to any of the campuses on the attached list. Please present a copy of this letter once you are accepted to the college of your choice as proof of your award. College fees and rooming costs are not included in this scholarship award, so it is in your interest to complete the Free Application for Federal Student Aid (FAFSA) to help with these costs.

Congratulations again, and best wishes for your continued success.

Sincerely,

Mitt Romney

Figure A.3: Award Letter to Class of 2012

Massachusetts Executive Office of Education

One Ashburton Place, Room 1403, Boston, Massachusetts 02108 *Telephone: (617) 979-8340*

PAUL REVILLE
Secretary of Education

October 2011

Dear [redacted]:

Congratulations!

You have qualified to receive a John and Abigail Adams Scholarship, which entitles you to four years of free tuition **upon your acceptance to** a participating Massachusetts public institution of higher education, including a University of Massachusetts campus, a Massachusetts state university, or a community college.

Now in its eighth year, the Adams Scholarship rewards high academic achievement on MCAS tests, and provides families of college-bound students with financial assistance. Please note that the Adams Scholarship covers **tuition only**, and does not include college fees.

Please review the enclosed guidelines carefully to determine whether you meet the eligibility requirements. If you do, I encourage you to apply to one of the campuses on the attached list.

It is **extremely important** that you **make a copy** of this letter and keep the letter and copy in a safe place. In order to receive the scholarship, **you must submit this letter** to the financial aid office of the Massachusetts public college or university to which you have been accepted and complete the online Free Application for Federal Student Aid (FASFA).

Congratulations again, and best wishes for your continued success in college and beyond.

Sincerely,

Paul Reville
Secretary of Education

Mitchell D. Chester, Ed.D.
Commissioner of Elementary and Secondary Education

Dr. Richard Freeland
Commissioner of Higher Education

Figure A.4: Adams Eligibility by High School Class

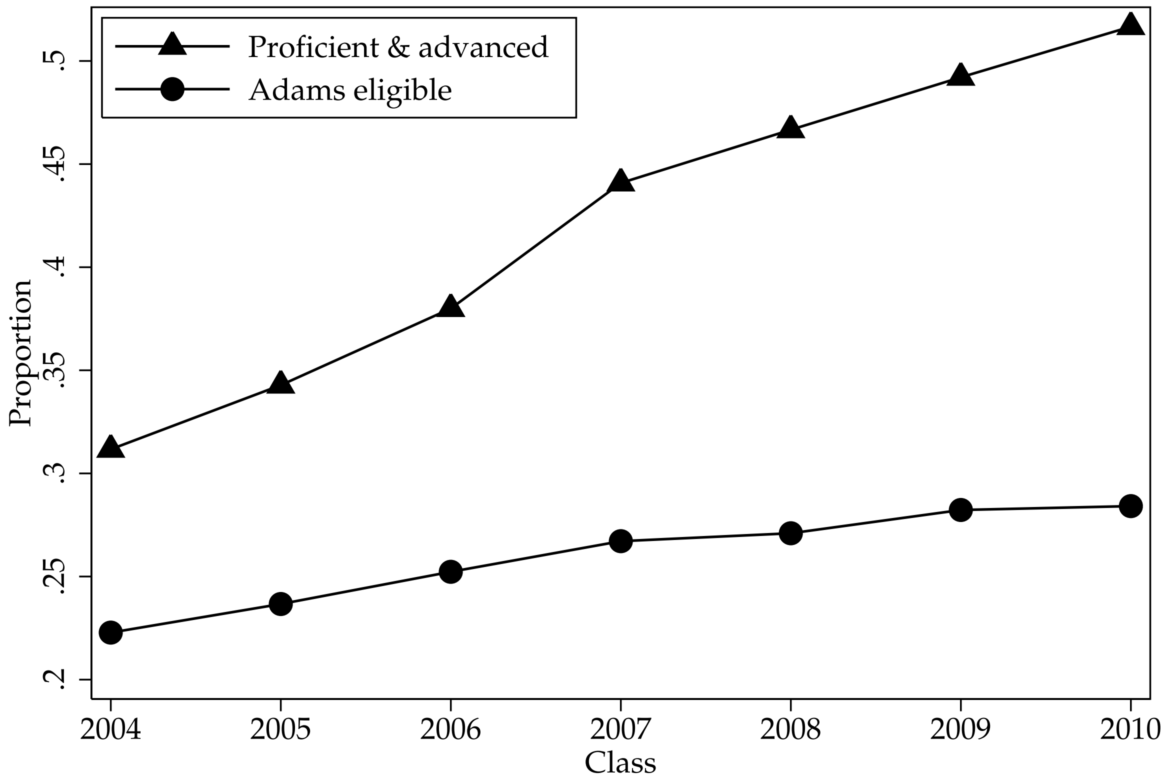

Table A.1: College Quality Measures, Selected Institutions

	(1) 2004 MA freshmen	(2) Four-year grad. rate	(3) SAT math score, p75	(4) Instr. spending	(5) College quality	(6) Net price
(A) Adams colleges						
U. Mass. Amherst	2607	.43	630	9.9	.03	8.6
U. Mass. Dartmouth	1078	.26	580	5.3	-.71	10.7
U. Mass. Lowell	792	.24	610	6.4	-.57	7.6
U. Mass. Boston	348	.12	560	8.8	-1.02	8.3
Bridgewater State	958	.23	560	3.7	-.93	7.7
(B) Other public colleges						
Univ. of New Hampshire	502	.54	620	8.9	.17	19.7
Univ. of Rhode Island	285	.35	600	7.3	-.37	19.4
Univ. of Connecticut	275	.45	650	13.2	.26	18.3
Univ. of Vermont	226	.5	630	10.8	.18	18.1
(C) Private colleges						
Suffolk University	420	.35	550	12.2	-.53	23.3
Syracuse University	216	.66	670	16.8	.88	17.7
Boston University	587	.62	690	32.5	1.33	17.2
Tufts University	186	.84	740	29.1	1.96	15.1
Harvard University	124	.86	790	107.8	4.38	12.3

Notes: College characteristics are taken from IPEDS and are measured in the fall of 2004. Instructional spending and net price are measured in thousands of dollars.

Table A.2: On-Time Enrollment and Graduation, By Adams College

	(1) Adams college	(2) Any U. Mass.	(3) U. Mass. Amherst	(4) U. Mass. Dartmouth	(5) U. Mass. Lowell	(6) U. Mass. Boston	(7) Any state college	(8) Bridgewater State Coll.
(A) Enrolled immediately								
Adams eligible	0.082***	0.057***	0.028***	0.015***	0.008***	0.007***	0.024***	0.008***
	(0.007)	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.005)	(0.002)
$\bar{Y}$	0.244	0.147	0.078	0.033	0.025	0.011	0.097	0.024
(B) Graduated within 4 years								
Adams eligible	0.022***	0.014***	0.010***	0.004***	0.000	0.000	0.008***	0.001
	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.000)	(0.002)	(0.001)
$\bar{Y}$	0.110	0.074	0.052	0.013	0.006	0.002	0.036	0.010
N	83,821	83,821	83,821	83,821	83,821	83,821	83,821	83,821

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). All models include student demographic characteristic controls as listed in Panel (A) of Table 3. For details about the regression model, see the note to Table 4. Listed below each coefficient is the mean of the outcome for students just below the Adams threshold.