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

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Sarah Cohodes
Harvard University

Joshua Goodman
Harvard Kennedy School

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

Sarah Cohodes
Harvard University
cohodes@fas.harvard.edu

Joshua Goodman†
Harvard University
Joshua_Goodman@hks.harvard.edu

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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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†Corresponding author.

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 further clear evidence 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 graduation rates, academic skill of the student body, and instructional expenditures. 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 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.

This paper represents an extension and improvement of Goodman (2008), which studied the same merit aid program at an earlier time and using less informative outcomes data. In particular, that earlier paper could only measure whether graduating high school seniors claimed they would be enrolling in public or private colleges. There was no information on the identities of the individual institutions, no information on whether they were in state or out of state, no verification that students' self-reports reflected actual enrollment behavior, and no way to track persistence and graduation. This paper, in contrast, uses substantially more detailed administrative data that allows identification of the specific institutions students actually enroll in, as well measurement of persistence and graduation rates. This allows for clear estimation of the quality and cost trade-offs students are making, the impact of this merit aid on in-state enrollment and, perhaps most importantly, the impact of this aid on college graduation rates.

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 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 (Bowen et al. 2009). 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 Massachusetts 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

[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.

[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.

(four-year) state colleges, or fifteen (two-year) community colleges.[5] As such, 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." Receipt of the scholarship does not, however, eliminate the cost of college attendance. To clarify the distinction between tuition and fees, the letter to the second class of scholarship recipients added to its final paragraph the disclaimer that "College fees and rooming costs are not included in this scholarship award." More recent letters have emphasized this fact even more clearly.[6]

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.[7] For the first class of scholarship winners in 2005, 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 roughly 20% reduction in the direct cost of attendance. By the fall of 2011, fees had risen by more than a third, so that the Adams Scholarship represented a less than 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

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

[7]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.

[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."

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 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

[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.

[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.

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). 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 2004-2011. 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. In both math and ELA, we observe scaled scores that determine scholarship eligibility, as well as the raw scores on which those scaled scores are based. We also construct a z-score in each subject by standardizing the raw scores by grade and year to have mean zero and standard deviation one. DESE separately provided us with a list of Adams Scholarship winners, which we merge into this larger data set.

We use two main analysis samples, the graduating high school classes of 2005-06, for whom we observe six-year college graduation rates, and the graduating high school classes of 2005-08, for whom we observe four-year college graduation rates. We limit the sample to high school graduates, as only graduates were ultimately eligible for the Adams scholarship.[12] We also examine more recent classes but can only observe college enrollment, and not completion, for such

[12]Of those who receive the Adams scholarship letter in the fall of 12th grade, 98% ultimately graduate from high school. We find no evidence that receipt of this letter affected high school graduation rates, so this restriction does not create selection bias.

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 2012, 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 graduation.[14] We also construct a persistence measure indicating whether a student is enrolled in college during the spring semester four years after high school graduation.

Table 1 shows the mean characteristics of the two analysis samples. Columns 1-3 contain the classes of 2005-06 and columns 4-6 contain the classes of 2005-08. Column 1 contains the full sample, column 2 limits the sample to students eligible for the Adams Scholarship, and column 3 limits the sample to those within a certain distance of the eligibility threshold, as will be described below. Panel A shows 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. Panel B shows that 25% of high school graduates are eligible for the scholarship and that those eligible score about one standard deviation higher on their MCAS exams than the average high school graduate. Those who use the Adams Scholarship to attend an in-state public four-year college score 0.1 standard deviations lower than the average Adams eligible students, suggesting that scholarship users are drawn more heavily from the lower-skilled part of the eligible distribution.

[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%.

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

Panel C shows that 79% of Adams eligible students enroll full-time in a four-year college by the fall following their high school graduation, which we refer to as immediate enrollment. Of these, one third (26%) enroll in in-state, public, four-year colleges, which we subsequently refer to as Adams colleges. Panels D and E show that only 54% graduate from a four-year college within four years of high school graduation but that 71% have graduated by their sixth year out. Statistics for the sample comprising the classes of 2005-08 look quite similar. Comparison of the graduation statistics to the enrollment statistics across college sectors in these samples suggest that Adams colleges have substantially lower graduation rates than do the in-state private and out-of-state colleges that we refer to as non-Adams colleges.

3.2 College Quality

Figure 3 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 about 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 non-Adams 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 scores than those enrolling in other sectors, although the U. Mass. campuses look fairly similar to non-Adams colleges in this regard. Non-Adams 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 coursework 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 are 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

[15]Note that IPEDS measures the completion rate of all undergraduates in these institutions, whereas Figure 3 measures the completion rate only of students coming from Massachusetts public high schools.

[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.

state colleges are 0.32 and 0.94 standard deviations lower than the average quality college attended by Massachusetts high school graduates. Non-Adams colleges are 0.29 standard deviations higher in quality. 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 Adams 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 of the \$29,000 sticker cost of their competitors.[17] 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.

To paint a fuller portrait of the college market facing Massachusetts high school graduates, Table A.1 provides specific examples of four-year colleges commonly attended by such students as of 2004. Panel A lists all four U. Mass. campuses and Bridgewater State College, the largest of the state colleges. Panel B lists a variety of non-Adams colleges. In 2004, U. Mass. Amherst, the college most commonly attended by Adams Scholarship recipients, had a four-year graduation rate of 43% and almost perfectly average overall quality. The other Adams colleges had substantially lower graduation rates and overall quality. Non-Adams colleges similar in graduation rate and quality to U. Mass. Amherst include Johnson & Wales University and Merrimack College in the private sector and the University of Connecticut, the University of Vermont and the University of New Hampshire in the out-of-state public sector. Elite private colleges such as Boston University,

[17] 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.

Tufts University and Harvard University have four-year graduation rates 50-100% higher than U. Mass. Amherst, perhaps because they attract more academically skilled students or because they spend three or more times the amount of money on student instruction.

4 Empirical Strategy

We now turn toward estimating the causal impact of 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 4 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 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. 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 4. 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.

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). In a prior version of the paper, we characterized each student by her scaled score distance from the nearest point on the threshold representing a valid pair of math and ELA scaled scores. Because of the algorithm by which Massachusetts transforms raw scores into scaled scores, that approach generated a running variable whose distribution was somewhat lumpy. In this version of the paper, we therefore characterize each student by the distance of her raw math score from her district's threshold, given her raw ELA score.[18] The results presented here are quite similar to those in the prior version of the paper, suggesting that the particular form of the running variable does not greatly affect our conclusions.

To estimate the causal effect of the Adams Scholarship, we use local linear regression to estimate 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 Gap_{ijt} is the running variable described above, $Adams$ 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

[18] Computing the distance to nearest point on the threshold representing a valid pair of math and ELA raw scores is particularly challenging given that such thresholds are substantially more jagged than the ones shown in Figure 4.

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 use 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 15 math raw score points but show later that our results are quite robust to using other bandwidths.[19] We also show that inclusion of controls has no effect on our estimates. We cluster standard errors by 12th grade high school to account for within school correlations in the error term ϵ_{ijt}, due to factors such as information sharing among students or guidance counselor quality.

We perform two tests of the validity of the regression discontinuity design. First, as suggested by McCrary (2008), we examine the density of the running variable for signs of manipulation that might invalidate the design. Figure 5 shows that the raw scores underlying construction of the running variable are extremely smooth in the 2005-06 sample. Panel A in Figure 6 shows the density of the running variable itself, namely the distance of each student's raw math score from her district's threshold, given her raw ELA score. This distribution looks largely smooth except for a small spike at zero itself. This spike comes from the fact that a district's 75% threshold is mechanically more likely to fall on test scores that are more common in that district. Panel B in Figure 6 is consistent with this fact, showing that no such spike occurs in the low-performing districts for which only the proficient/advanced threshold, and not the 75% threshold, defines the boundary. Figures A.5 and A.6 show very similar patterns for the 2005-08 sample. To further allay concerns about that spike, we later show that our central results are robust to excluding students directly on the boundary, a so-called "donut" regression discontinuity.

Second, we test in Table 3 whether observed covariates vary discontinuously at the eligibility threshold, using the default specification of a local linear regression with bandwidth of 15 points. The first eight columns test the basic covariates, including gender, race, low income, limited English proficiency and special education status. None of those covariates shows a statistically significant discontinuity in either the 2005-06 or the 2005-08 sample and the estimates are precise

[19]Calculations of an optimal bandwidth following Imbens and Kalyanaraman (2012) yield bandwidths too small to generate estimates.

enough to rule out economically significant discontinuities as well. To test whether these covariates are jointly discontinuous, we generate in columns 9 and 10 predicted math and ELA z-scores by regressing scores from the class of 2004 on the demographic controls listed in the previous eight columns. We then use the resulting regression estimates to predict scores for students in subsequent classes. The estimates in columns 9 and 10 suggest no discontinuity in predicted test scores and the estimates are precise enough to rule out differences around the eligibility threshold of more than 0.02 standard deviations in academic skill. Figure 7 shows graphically the average predicted scores of students in each bin defined by distance from the eligibility threshold, confirming the lack of any clear difference in academic skill between students just above and just below the threshold in the 2005-06 sample. The 2005-08 sample looks quite similar, as seen in Figure A.7.

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 2005-06 graduates for each value of *Gap* who enroll in four-year colleges immediately following high school graduation.[20] There is clear visual evidence that students at the eligibility threshold are substantially more likely to enroll in an Adams (i.e., in-state public) college than students just below the threshold. Such students are, however, similarly less likely to enroll in a non-Adams (i.e., 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.

The first row of Table 4 estimates these differences in the 2005-06 sample. Scholarship eligibility induced 6.6 percent of students at the threshold to enroll in Adams colleges, a more than one-fourth increase over the 23.9 percent enrollment rate of students just below the threshold. Table A.2 shows that nearly half of these marginal students enrolled in U. Mass. Amherst, the flagship campus with an honors college, and another third enroll in the various state colleges. More than five-sixths of these marginal students, or 5.7 percent, forgo attending other colleges as a result of

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

scholarship eligibility. The net result is a statistically insignificant 0.9 percentage point increase in the fraction of students enrolling in any four-year college. Many of these marginal students switch their enrollment from out-of-state colleges, leading to a 4.5 percentage point increase in the fraction of students enrolling in-state four-year colleges. The Adams Scholarship therefore does induce a substantial number of students to enroll in the public sector and succeeds in keeping some students in state who otherwise would have left.

The scholarship also induces a marginally significant 0.8 percentage point increase in the fraction of students enrolling in two-year community colleges. That, combined with the slight rise in four-year college enrollment rates, implies that the scholarship raises overall immediate college enrollment rates by 1.7 percentage points. In the second row, we define as the outcome enrollment within two years of high school graduation, rather than immediately following graduation. The estimates in columns 1 and 3 fall by 0.7 and 0.9 percentage points respectively, suggesting that a small number of marginal students induced to enroll immediately in Adams colleges because of the scholarship would have enrolled within the next two years in the absence of the scholarship. The estimates in column 3 suggest that the scholarship may have accelerated enrollment in four-year colleges for a small number of students but did not induce enrollment in four-year colleges for any students who would not have enrolled within two years. Interestingly, the two-year college effect is unchanged by the shift in definition from immediate enrollment to enrollment within two years. This suggests that scholarship eligibility did induce a small number of students to enroll in community colleges who would not otherwise have enrolled within two years.

Turning from enrollment to graduation, we plot in Figure 9 the proportion of students for each value of Gap who graduate from four-year colleges within six years of high school graduation. Students just above the eligibility threshold are more likely to have graduated from Adams colleges than those just below the threshold, an unsurprising result given that the former are much more likely to enroll in that sector than the latter. Scholarship eligibility also lowers graduation rates from non-Adams colleges, for the same reason that eligibility reduces initial enrollment in that sector. More surprising is that the decrease in graduation rates from non-Adams colleges is larger in magnitude than the increase in graduation rates from Adams colleges. The net result is that scholarship eligibility lowers overall graduation rates, as the top line in the Figure 9 shows.

The third through fifth rows of Table 4 confirm this result. The third row uses as an outcome an indicator for the student being enrolled in a given college sector as of the spring of the fourth year after her high school graduation, which we interpret as a measure of persistence. The fourth and fifth rows use as outcomes indicators for whether a student has graduated from a given college sector within four or six years. The three rows tell a consistent story. Though scholarship eligibility increases enrollment in Adams colleges by nearly seven percentage points, it increases persistence and six-year graduation rates by only three percentage points, suggesting that the majority of marginal students do not successfully graduate from that sector. Scholarship eligibility reduces persistence and graduation rates in the private sector by about five percentage points. The net result is that scholarship eligibility reduces the probability of earning a four-year college degree within six years by about two percentage points. That the persistence and four-graduation rate measures show similar declines suggests this is not merely a matter of delaying graduation but instead is driven by a subset of students who have dropped out of the four-year college sector entirely.

We note three other important findings. First, although scholarship eligibility increased the number of students enrolling in state, it has no ultimate effect on the probability of earning a degree in state. The marginal student brought back into Massachusetts by this merit aid does not seem to earn a degree. Second, none of the increased enrollment in community colleges translates into increased completion of two-year college degrees, even six years out of high school. Third, as a result, scholarship eligibility lowers by two percentage points the probability that a student has any college degree six years later.

Table 5 shows that the enrollment and graduation effects found in the 2005-06 sample are quite similar to those in the 2005-08 sample, though the effects are generally slightly smaller in magnitude. Table 6 explores these differences in more detail, with the first four columns examining enrollment and graduation effects for each high school class separately, the fifth pooling the classes of 2005-08, and the sixth showing only enrollment effects for the classes of 2009-11, the most recent for which data are available. Panel A shows that scholarship eligibility increased enrollment in four-year Adams colleges for all graduating high school classes. There is, however, a gradual monotonic decrease in the impact of scholarship over time, with the effect in 2005 three times that of the effect over 2009-11. This gradually shrinking effect size may be driven by the fact that rising fees have shrunk the proportion of college costs covered by the scholarship. Also worth noting is that much of increase in overall four-year college enrollment is driven by the first treated class, with subsequent classes showing smaller and insignificant impacts on this margin.

Panel B estimates the impact of scholarship eligibility on persistence and graduation after four, five and six years. Two findings are worth noting. First, that the magnitude of the persistence and various graduation rates do not vary much within classes implies that the negative impact of scholarship eligibility on graduation rates is driven largely by dropout rather than delay. Second, that the negative graduation effect is not driven solely by the first high school class makes much less likely the possibility that the effect was generated by confusion about the meaning of "free tuition" in the scholarship letter. If such language was deceiving students into making uninformed decisions, we would expect such negative graduation effects to diminish across classes as information about the true value of the scholarship spread. There is no clear evidence of such a pattern.

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 15 points and controlling for student covariates. Changing the bandwidth to 10 or 20 has no impact on the estimates. Excluding those covariates, as in panel B, also has little impact. Panel C performs a "donut" regression discontinuity, excluding students directly on the eligibility threshold out of concern about the small spike seen in the density of the running variable at zero. This actually increases the magnitude of the estimated enrollment and graduation effects. Excluding wider ranges of values near the threshold has little additional impact. Our results are not, therefore, dependent on students directly on or very close to the eligibility threshold.

In Figure 10, we exploit as a placebo test the graduating high school class of 2004, the one cohort in our data that graduated prior to the scholarship's existence. In panel A, we see no evidence of a discontinuity in Adams college enrollment for the class of 2004, whereas the discontinuity is extremely clear for the classes of 2005-06. In panel B, we also see that students below the threshold have similar six-year graduation rates across the three classes, whereas students above the threshold in 2005-06 have lower rates than such students in 2004. Panel D of Table 7 formalizes these observations, running our baseline specification on the class of 2004. There is no evidence of an enrollment discontinuity, with estimates for 2004 actually having a negative sign. The point estimates for persistence are either zero or, if anything, positive. The graduation rate estimates are statistically insignificant though slightly negative. This may be due to the negative enrollment estimates from column 1, which are likely statistical artifacts. 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 other unaccounted for factors.

Our RD estimates, as well as those based on Figure 10, suggest that the Adams Scholarship induced about 1,000 additional students to enroll in in-state public colleges. IPEDS data reported by Massachusetts' public colleges themselves 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 our estimate. This implies 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 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, a result in line with Goodman (2008). The scholarship did increase in-state college enrollment rates but had little impact on in-state graduation rates. Scholarship eligibility actually reduced overall graduation rates, for reasons we now turn to.

5.2 College Quality and Cost

The most plausible explanation for the negative impacts on graduation rates is that the scholarship induced students to attend colleges with substantially lower graduation rates than they otherwise would have. Table 8 explores the quality and cost tradeoffs that the Adams Scholarship induces. The top row of each panel presents reduced form estimates of the impact of scholarship eligibility on a variety of college quality and cost measures, as in Equation 1 above. For this analysis, we assign students to the four-year college to which enroll immediately following high school graduation. The bottom row estimates these impacts for the marginal student using the following equations that instrument enrollment in an in-state public college with scholarship eligibility:

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

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

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 in panel A shows that, for the classes of 2005-06, scholarship eligibility induced an estimated 2.8% of students, or 43% 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 immediately enrolling in four-year colleges, point to a similar pattern. In column 2, the estimates suggest that students induced by the scholarship to switch into Adams colleges would otherwise have attended colleges with four-year graduation rates nearly 17 percentage points higher. These marginal students would also have attended colleges with higher SAT math scores (by 28 points) and higher instructional spending per student (by $3,700 annually), though this last estimate is not statistically significant. Combining these three measures as described above, column 5 shows that scholarship eligibility induced the marginal student to forgo 0.64 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.[21] Combining the estimates from columns 5 and 7 suggests a willingness to forgo 0.47 (0.643/1.376) standard deviations of college quality per $1,000 in annual aid, a remarkably high number. For the 2005-08 sample in panel B, the equivalent estimate is 0.4 (0.544/1.360) standard deviations of college quality per $1,000 in annual aid. Students are surprisingly willing to forgo college quality and attend institutions with low graduation rates for relatively small amounts of financial aid.

To strengthen our case that the decrease in college quality induced by the scholarship explains the observed graduation impacts, we explore heterogeneity by academic skill in Table 9. To do so, we take advantage in panel A of the fact that the eligibility threshold varied by school district due to the requirement that students be in the top 25% of their district peers. We therefore divide students into quintiles by graduating class according to the district-specific threshold determining eligibility. We then fully interact our baseline specification from prior tables with indicators for being from the bottom quintile, middle three quintiles, and top quintile of school districts. We also include the direct effects of those indicators. These three groups are roughly equivalent to the low-, medium- and high-performing districts described earlier.

For students from the bottom districts, who are on average lower income and less academically skilled, scholarship eligibility increases enrollment in Adams colleges by nine percentage points, two-fifths of which comes from students who would not otherwise have enrolled imme-

[21] 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.

diately in any four-year college. Eligibility does not, however, reduce such students' probability of attending a highly competitive college likely because they did not apply or gain admission to such institutions in the first place. In the absence of the scholarship, these students would be attending four-year colleges of similar quality to the Adams colleges, or none at all. For these students, eligibility has no impact, positive or negative, on persistence and only a small and statistically insignificant negative impact on six-year graduation rates. Students from the top districts do not react at all to the aid. They do not enroll in Adams colleges at higher rates, do not forgo highly competitive colleges, and do not persist or graduate at lower rates as a result of scholarship eligibility. Such students do not react presumably because they are wealthier on average and because their alternative college options are so much higher quality than the Adams colleges that the scholarship is insufficient incentive to switch.

Students from the middle districts, conversely, do react strongly to the aid. Eligibility raises enrollment in Adams colleges by nearly eight percentage points.[22]. Little or none of this comes from students enrolling in four-year colleges who would not have otherwise. Strikingly, half of those marginal students who switch into Adams colleges do so by forgoing highly competitive colleges, unlike students from bottom or top districts. And, unlike students from bottom or top districts, only these students have clearly lower persistence and graduation rates as a result of scholarship eligibility. That these students from middle districts are the only ones induced to forgo college quality and are the only ones whose graduation rates suffer strengthens the case that college quality explains the scholarship's negative graduation effect.

The remaining three panels in Table 9 explore heterogeneity by student characteristics, including poverty, race/ethnicity and gender. The enrollment decisions of poor students, defined as those receiving subsidized lunches, reacts somewhat more strongly than do those of nonpoor students. Consistent with the evidence from panel A, poor students, who tend to come from bottom quintile districts, do not forgo highly competitive colleges while nonpoor students do. Even starker differences in enrollment reactions are seen across racial or ethnic groups. Non-white

[22]The Adams college enrollment results for these three groups of students are consistent with panel A of Figure 10, which suggests that the impact of the scholarship on enrollment decisions above the threshold is quite similar to the estimated discontinuity at the threshold but does shrink for the most highly skilled students.

students, defined here as black or Hispanic, increase enrollment in Adams colleges by nearly 18 percentage points, relative to six percentage points for white students. Only white students forgo highly competitive colleges and only white students see clear persistence and graduation rate decreases. Unfortunately, the number of poor or nonwhite students in the sample is generally too small for differences between them and nonpoor or white students to be statistically significant. There are no statistically significant differences in the impact of scholarship eligibility by gender.

Having shown that scholarship eligibility both induced students to forgo college quality and lowered their graduation rates, in Table 10 we directly estimate the impact of college quality on those graduation rates. For such estimates to be valid, the exclusion restriction must hold, namely that scholarship eligibility affects graduation rates only through the college quality channel. We consider two potential violations of this exclusion restriction. First, scholarship eligibility may affect not only marginal students but inframarginal ones as well. Our estimates suggest that roughly four-fifths of scholarship users would have attended Adams colleges in the absence of the scholarship.[23] If the financial aid were changing their graduation rates, the IV estimates would confound that channel with the quality channel. We believe this is unlikely both because the amount of money involved here is small relative to the costs of college and because that small amount of additional aid should, if anything, help students graduate by allowing them not to work while on campus. If the graduation rates of inframarginal students were improved by this aid, the coefficients below would actually underestimate the impact of college quality on the graduation rate of marginal students. A second potential violation of the exclusion restriction could occur if the scholarship changed factors other than college quality for the marginal students. If, for example, switching to an Adams college and remaining in state increased the probability of living at home, our estimates might confound that channel with the college quality channel. We find that story unlikely as well, given that our effects are being driven largely by students attending the U. Mass. Amherst campus in western Massachusetts, which for most students is at least an hour's drive from home.

To use scholarship eligibility as an instrument for the different measures of college quality

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

listed in each column, we run the following 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 10 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 graduation rates from Tables 4 and 5. 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. For each sample, the first column measures the impact of attending an Adams college for all students, while the second column conditions the sample on those immediately enrolling in a four-year college. The third and fourth columns use institutional graduation rates and our quality index as quality measures, also conditioning the sample on those immediately enrolling in a four-year college for whom such measures are observed.

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 in six years by a remarkable 34 percentage points in the 2005-06 sample, or 29 percentage points when the sample is limited to enrollers. In the 2005-08 sample, attending an Adams college lowered four-year graduation rates by 20 percentage points, or 29 percentage points for enrollers. The coefficients in columns 3 and 7 imply that, for these marginal students, attending a college with a four-year graduation rate one percentage point higher would translate into a 1.6-1.7 percentage point increase in graduation probabilities. Differences in college-level graduation rates translate more than one-for-one into individual-level graduation rates for this subset of students. Columns 4 and 8 suggest that attending a college of one standard deviation higher quality raises the probability of graduating by 45-52 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.[24] 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 of the waivers is roughly $13 million.[25] Roughly three-fourths of these funds flow to inframarginal students who would have attended in-state public colleges in the absence of the scholarship. As a result of this and the low graduation rates of in-state public colleges, the scholarship has little impact on the number of college graduates Massachusetts produces each year. The scholarship also reduces by about 200 students per year the number of colleges degrees earned by Massachusetts high school graduates.[26] 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

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

[25]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.

[26]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.

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 about 30 percentage points, as the scholarship did for marginal students, results in a $300,000 expected lifetime earnings penalty for Massachusetts residents.[27] Even ignoring the graduation margin, simply attending a college of 0.5 standard deviations lower quality results in an $50,000 expected lifetime earnings penalty.[28] Those penalties far outweigh the value of the tuition waiver, which is at most worth less than $7,000. It is possible that some students were so financially constrained or had such high discount rates that switching into scholarship eligible 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 college quality 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.[29] 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 ex-

[27] 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.

[28] 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.

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

ploration 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.

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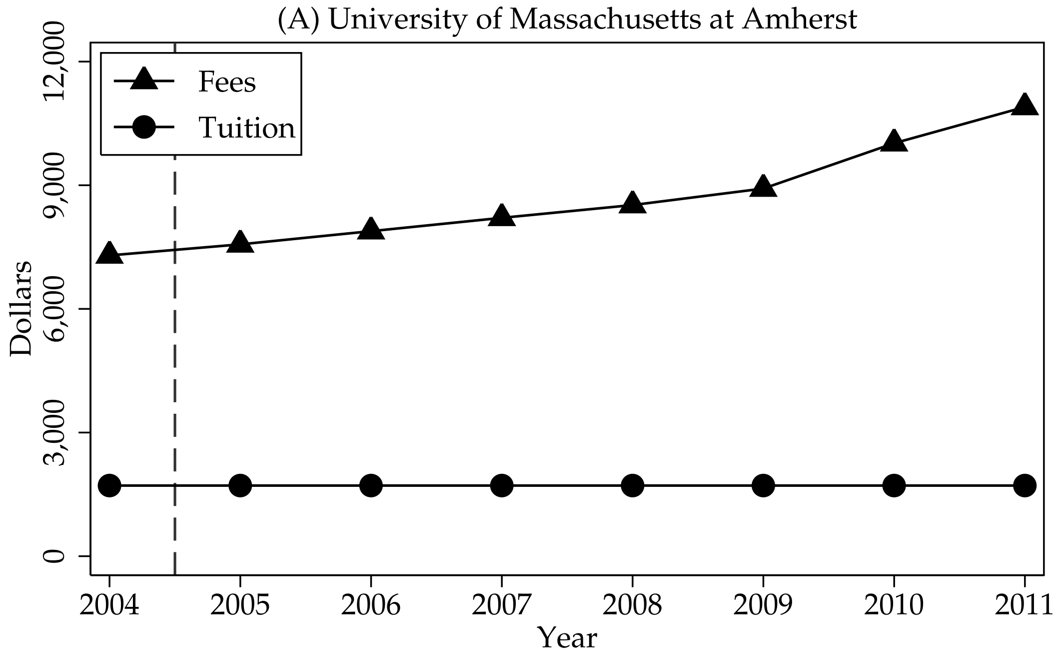
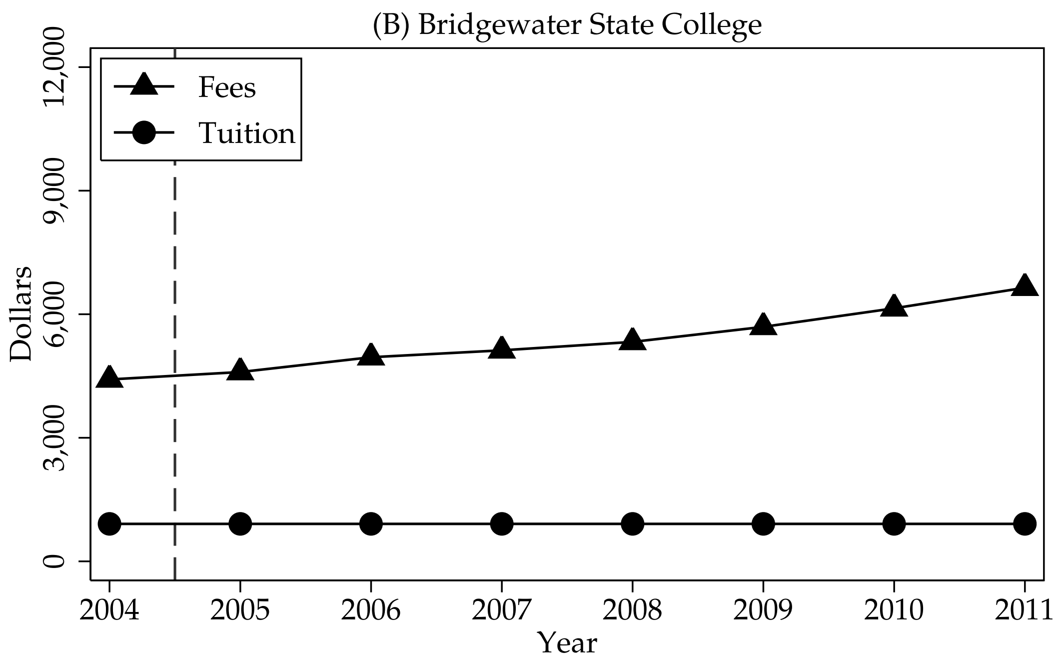
Figure 1: Tuition and Fees at Two Typical Adams Colleges

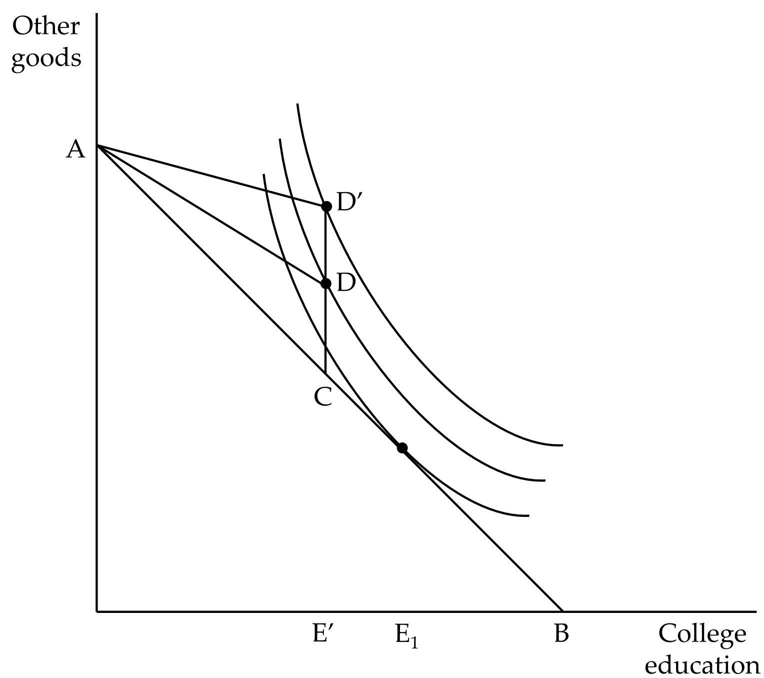




Note: Tuition and fee data come from `http://www.mass.edu/campuses/tuitionfees.asp`, accessed on May 28, 2013.

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

(A) Inframarginal Students



(B) Marginal Students

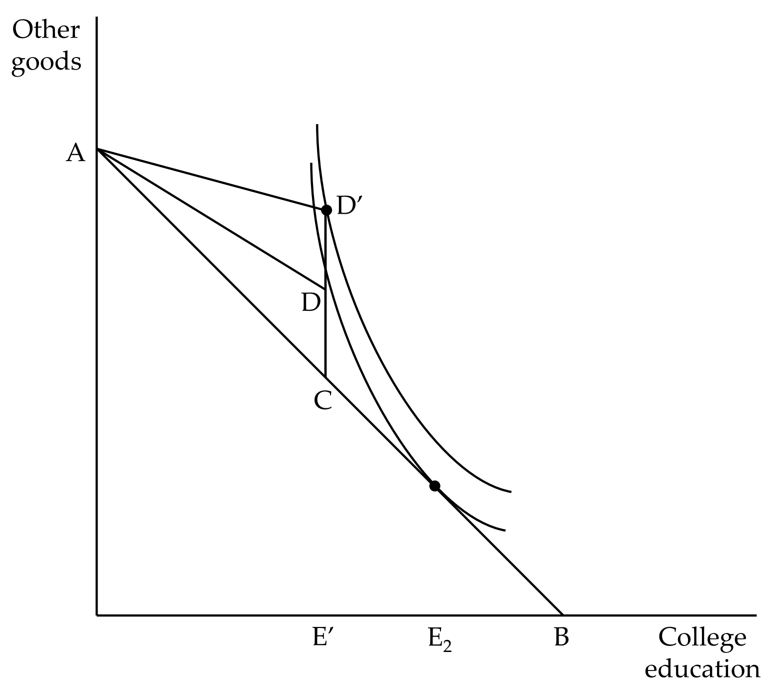


Figure 3: Time to Graduation by Four-Year College Sector, Class of 2004

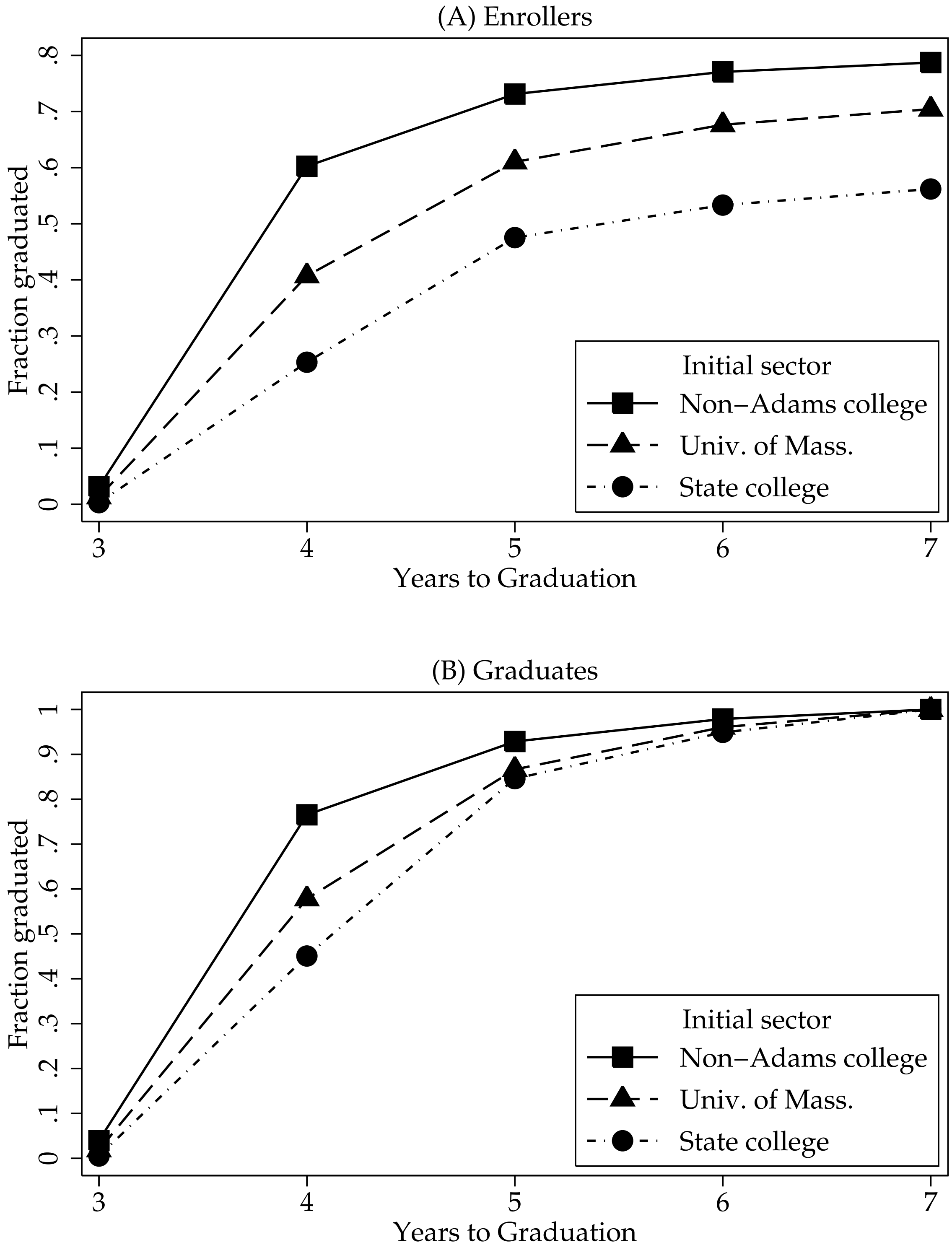


Figure 4: Graphical Representation of the Eligibility Threshold

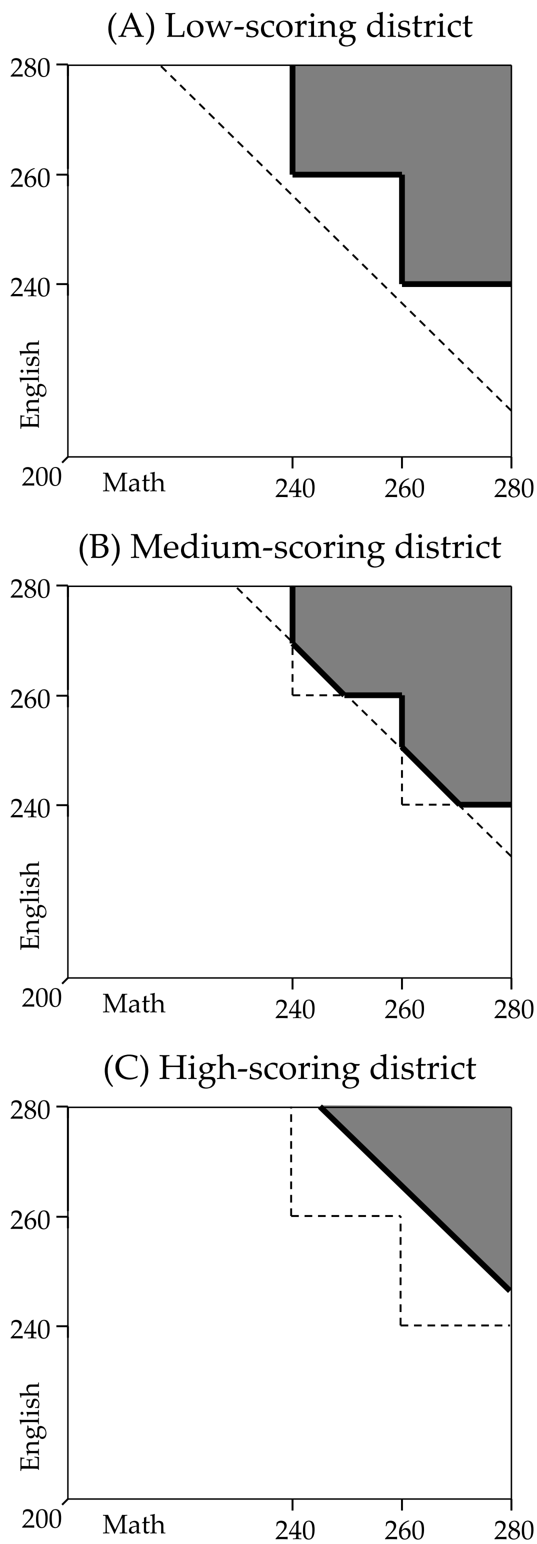
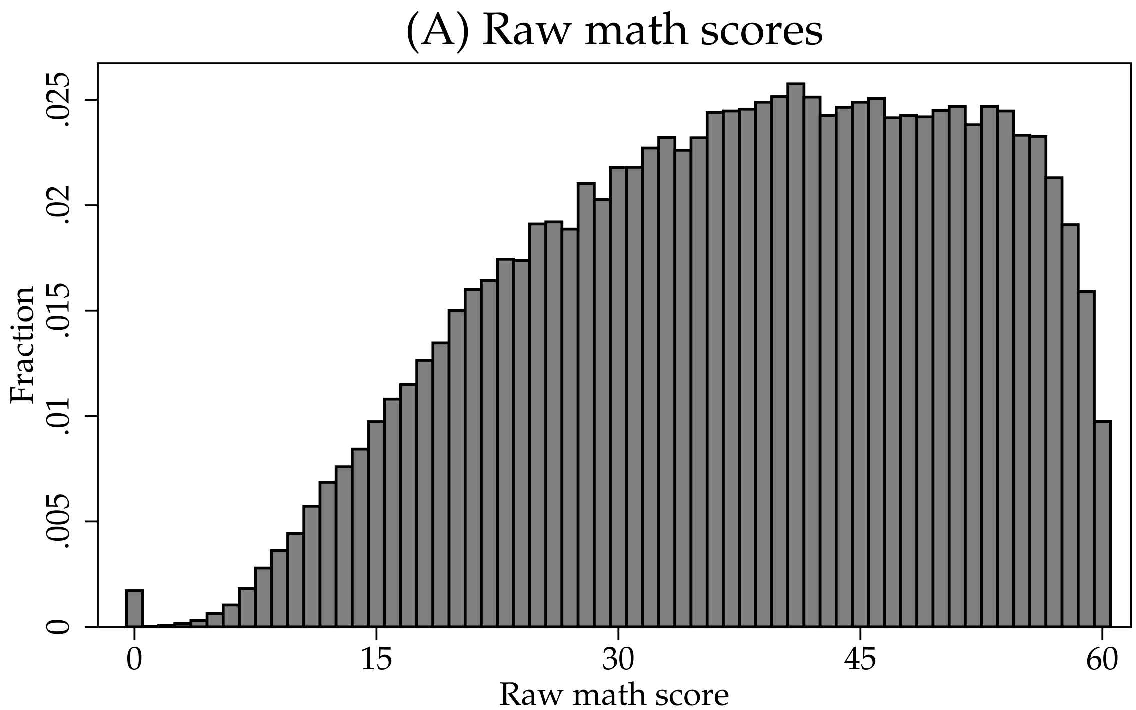


Figure 5: Density of Raw Scores, Classes of 2005-06



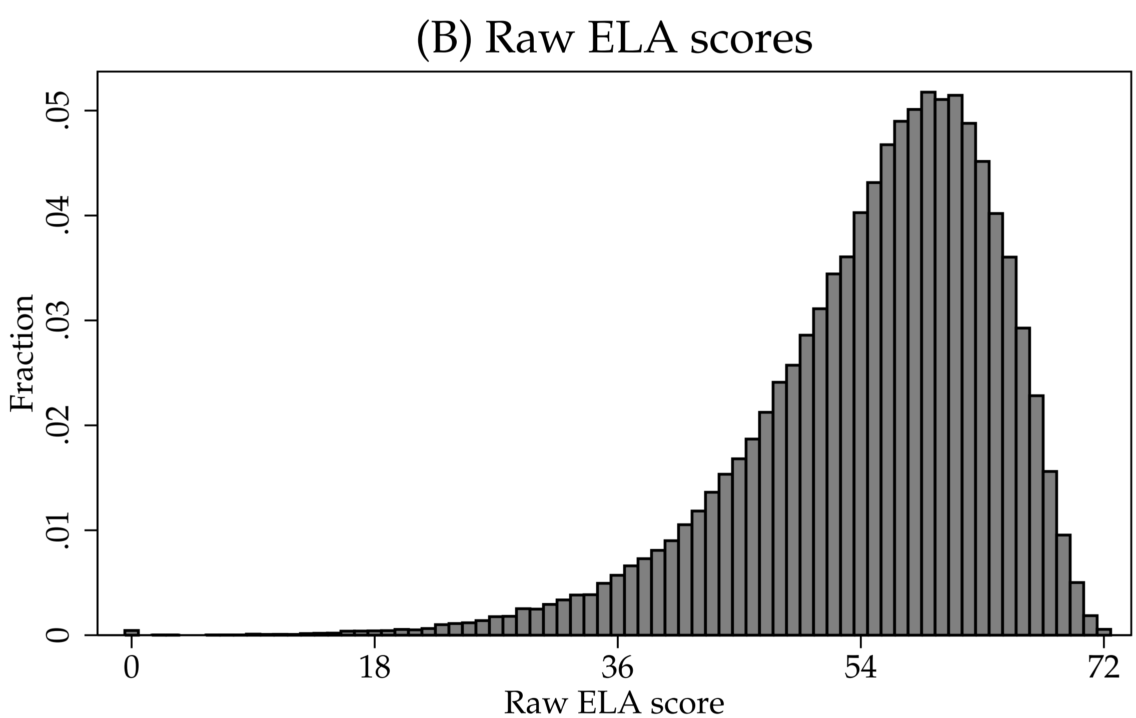


Figure 6: Density of Forcing Variable, Classes of 2005-06

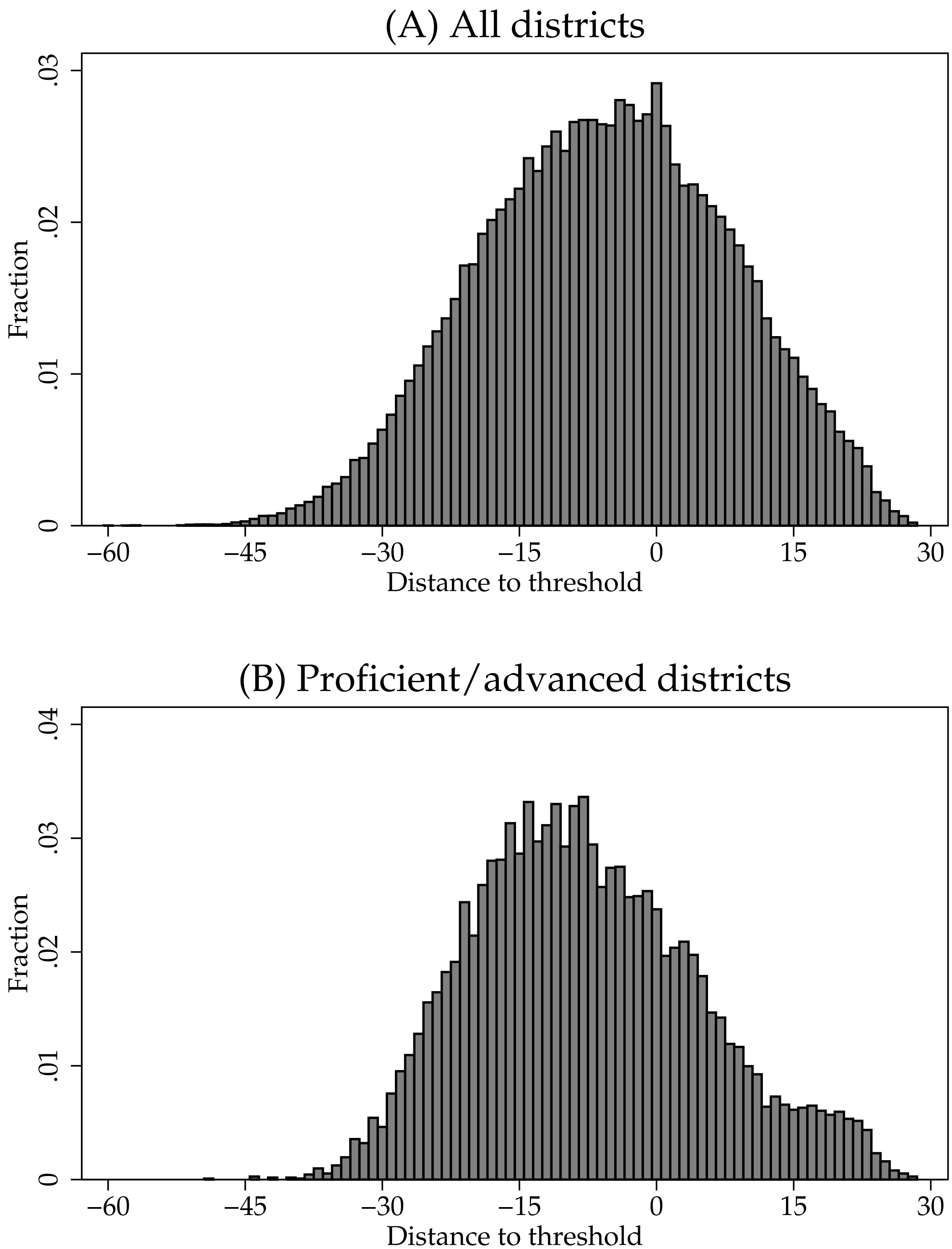


Figure 7: Smoothness of Covariates, Classes of 2005-06

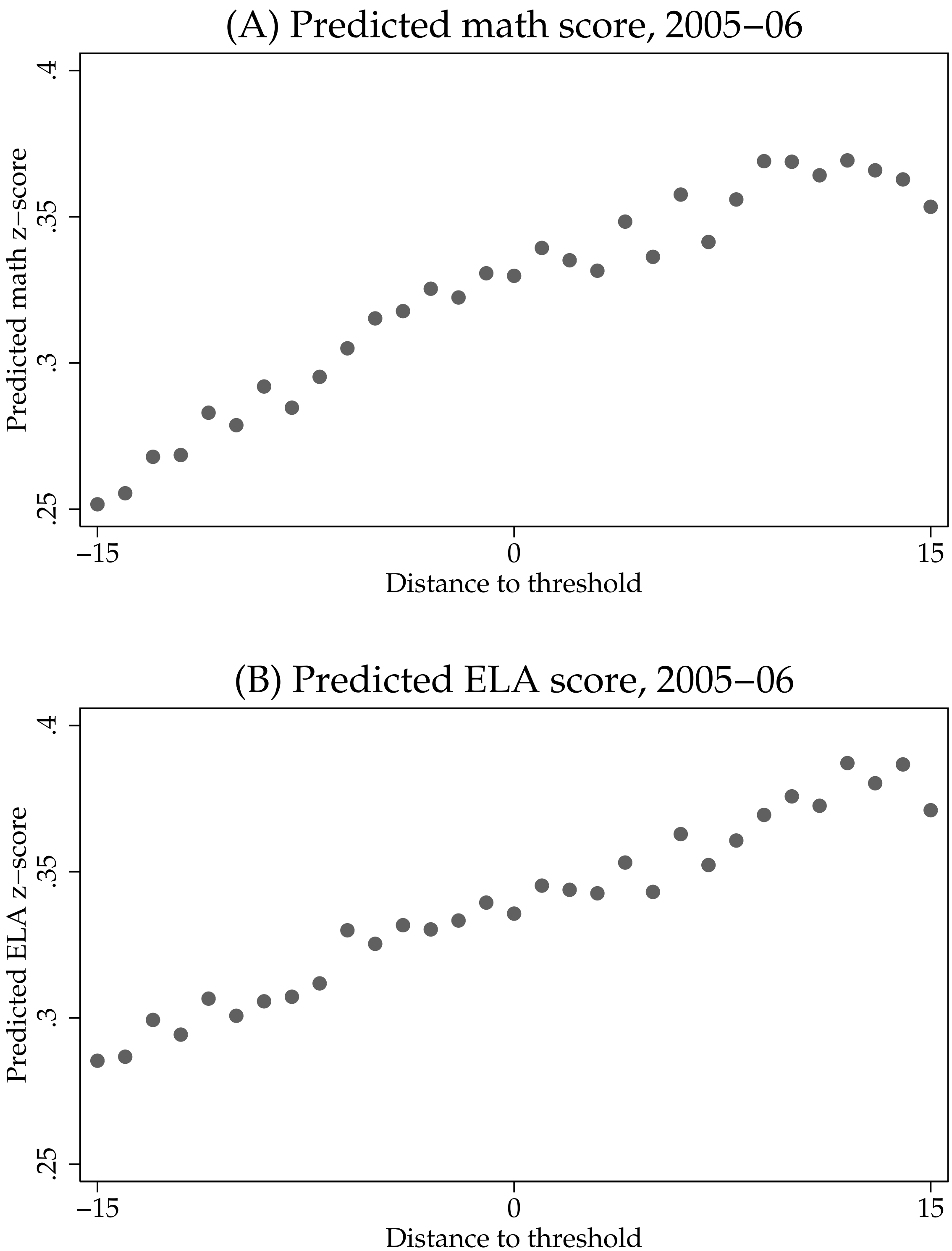


Figure 8: Enrollment at Four-Year Colleges, Classes of 2005-06

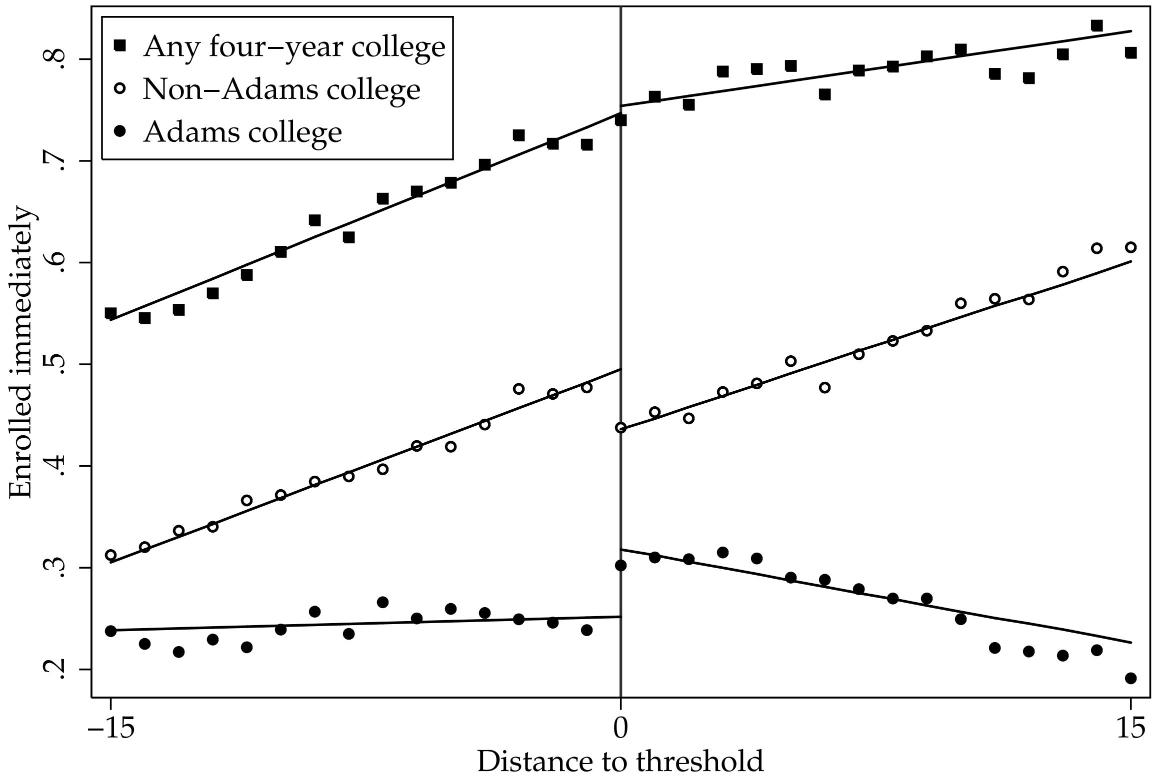


Figure 9: Graduation from Four-Year Colleges, Classes of 2005-06

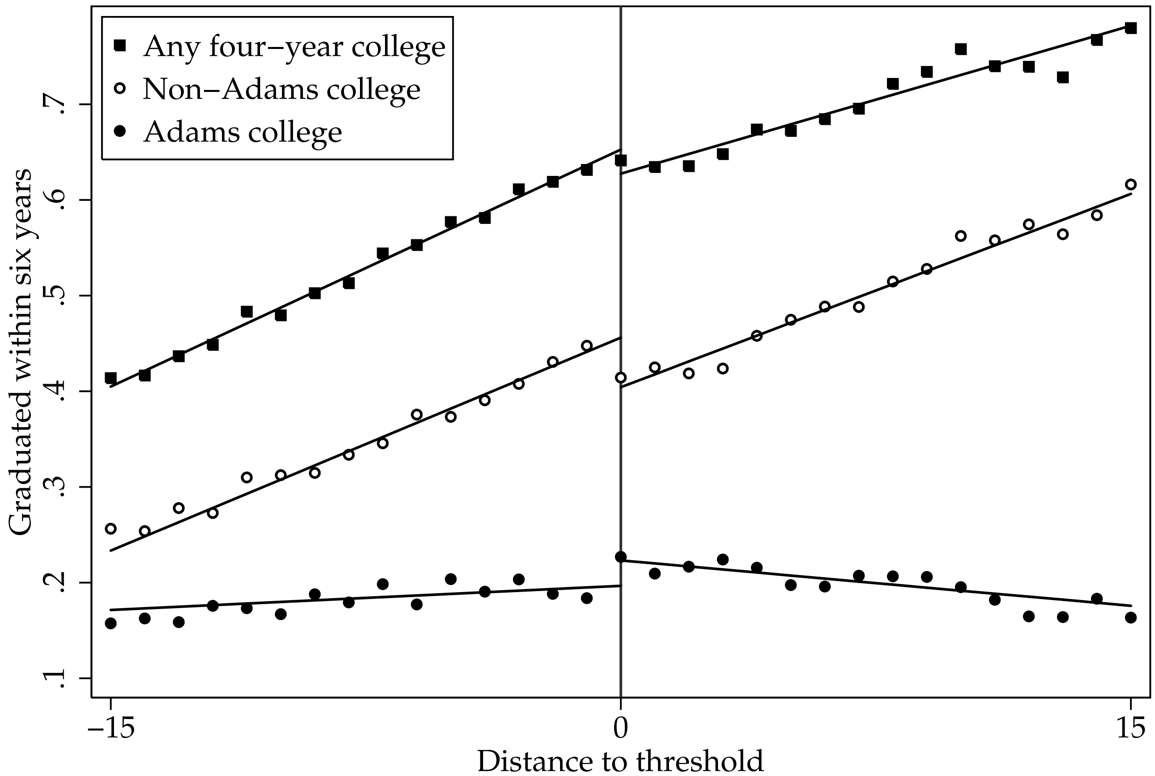


Figure 10: Treatment vs. Pre-Treatment Classes

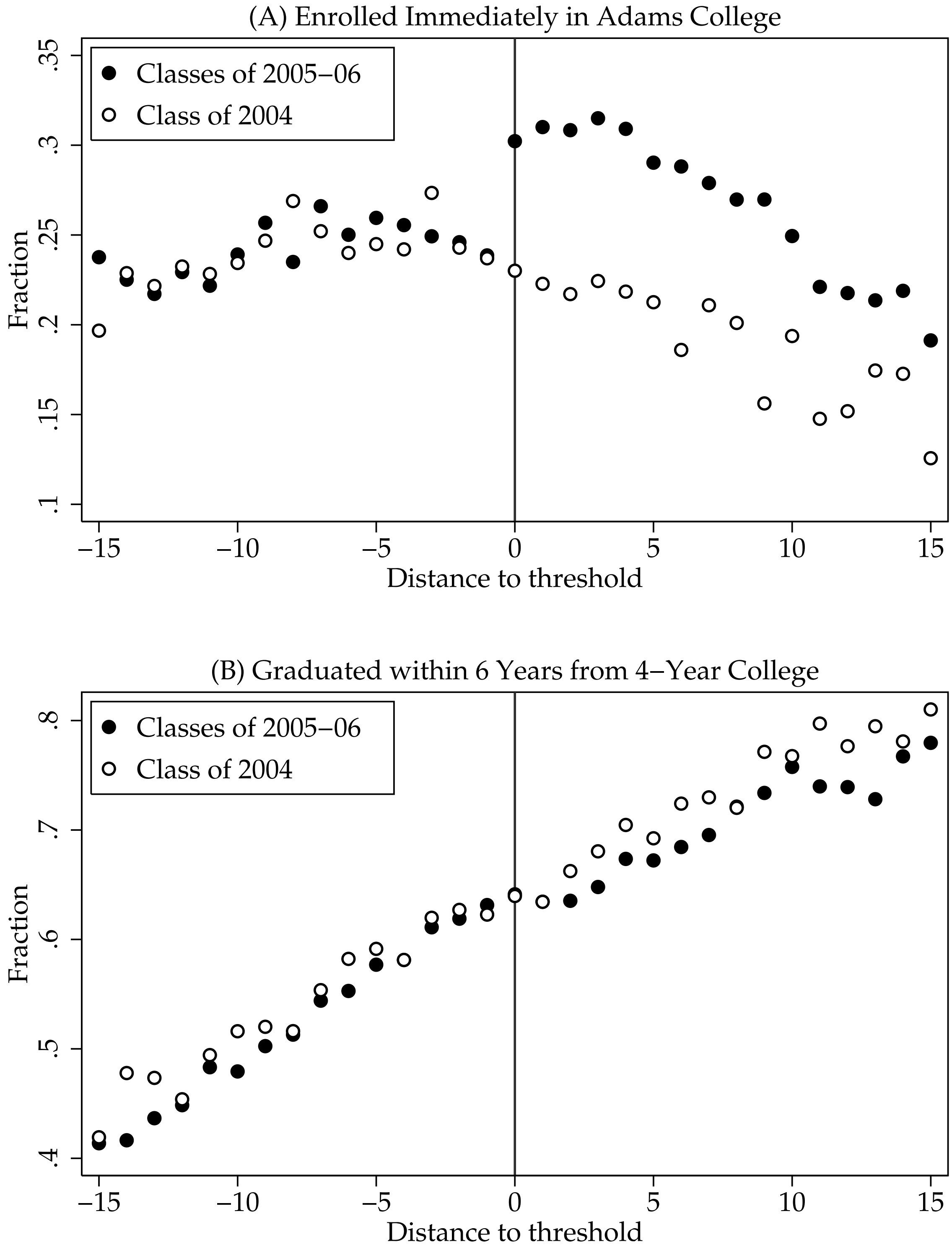


Figure 11: Freshman Enrollment in Four-Year Adams Colleges

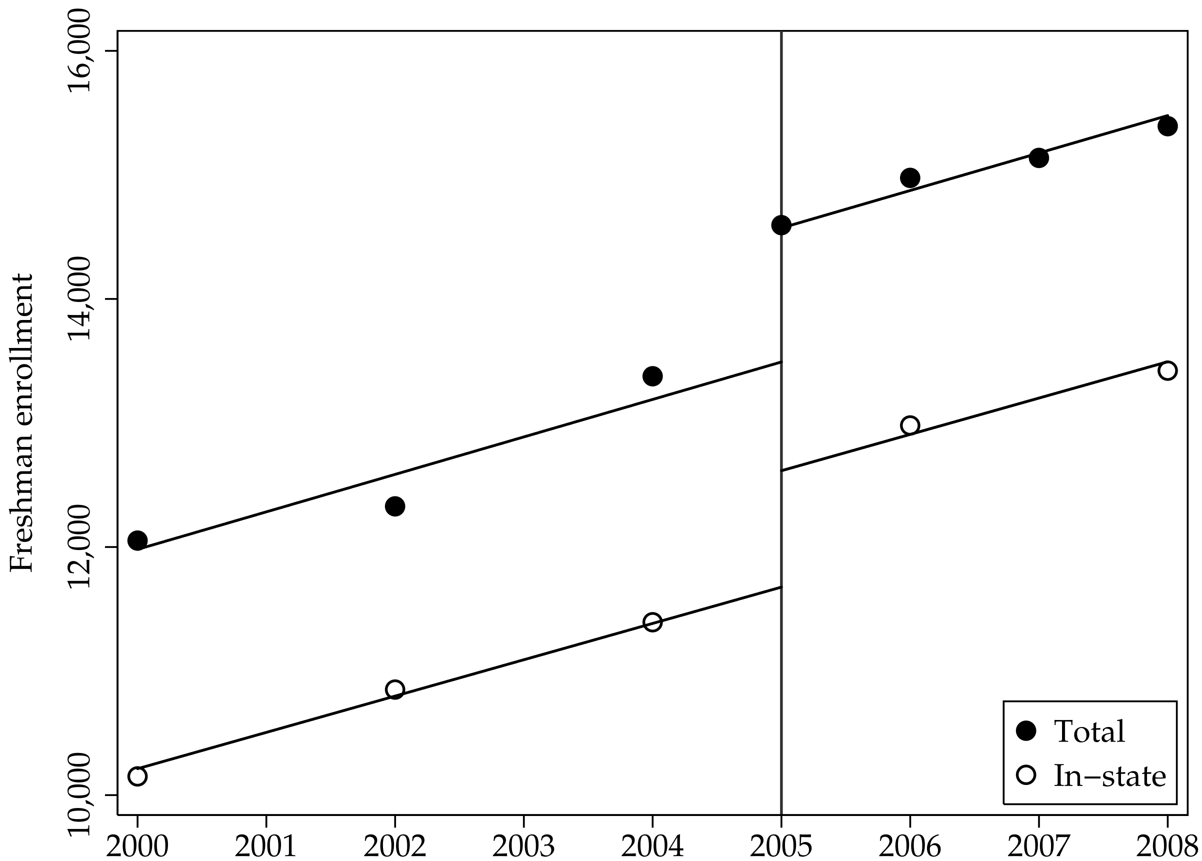


Table 1: Summary Statistics

	Classes of 2005-06			Classes of 2005-08		
	Full sample (1)	Adams eligibles (2)	RD sample (3)	Full sample (4)	Adams eligibles (5)	RD sample (6)
(A) Demographics						
Female	0.51	0.54	0.52	0.51	0.54	0.52
Black	0.07	0.03	0.04	0.07	0.03	0.04
Hispanic	0.07	0.03	0.03	0.07	0.03	0.04
Asian	0.05	0.07	0.05	0.05	0.07	0.05
Other race	0.00	0.00	0.00	0.01	0.01	0.01
Low income	0.17	0.09	0.10	0.18	0.10	0.11
Limited English proficient	0.03	0.01	0.01	0.02	0.01	0.01
Special education	0.12	0.01	0.03	0.13	0.01	0.03
(B) Aid eligibility						
Adams eligible	0.25	1.00	0.45	0.26	1.00	0.45
Total scaled score	491.82	527.69	514.68	494.24	527.69	515.30
Total z-score	0.19	1.07	0.75	0.18	1.02	0.72
Total z-score, Adams users	0.97	0.97	0.92	0.93	0.93	0.88
(C) Enrolled immediately						
Adams college	0.19	0.26	0.26	0.18	0.26	0.26
Non-Adams college	0.33	0.53	0.45	0.34	0.54	0.45
Four-year college	0.51	0.79	0.71	0.52	0.80	0.71
(D) Graduated within 4 years						
Adams college	0.07	0.12	0.11	0.07	0.13	0.11
Non-Adams college	0.21	0.42	0.32	0.21	0.40	0.30
Four-year college	0.28	0.54	0.42	0.29	0.52	0.41
(E) Graduated within 6 years						
Adams college	0.14	0.19	0.19			
Non-Adams college	0.28	0.51	0.41			
Four-year college	0.42	0.71	0.60			
N	111,816	27,487	49,424	230,880	60,355	105,736

Notes: Mean values of each variable are shown by sample. Column (1) is the full sample of high school graduates from the classes of 2005-06. Column (2) restricts that sample to students eligible for the Adams Scholarship. Column (3) restricts the full sample to those within 15 points of the eligibility threshold. Columns (4)-(6) are defined similarly but for the high school classes of 2005-08. In panel (B), the last outcomes conditions on students using the Adams Scholarship to attend a four-year college. In panels (C)-(E), college outcomes all refer to four-year colleges.

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

	Univ. of Mass. (1)	State college (2)	Non-Adams college (3)
(A) Quality			
Four-year graduation rate	0.34	0.24	0.53
SAT math 75th percentile	610	550	619
Instructional expenditures	8,225	4,341	14,504
College quality	-0.32	-0.94	0.29
(B) Costs			
Tuition	1,438	850	19,586
Required fees	6,165	3,741	667
Additional expenses	7,004	6,634	8,613
Total cost	14,607	11,223	28,866
Grant aid	6,649	5,711	14,141
Net price	7,957	5,511	14,725
Loans	3,710	2,592	4,161
N	4,826	3,486	16,885

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

	Female (1)	Black (2)	Hispanic (3)	Asian (4)	Other race (5)	Low income (6)	Ltd. Eng. prof. (7)	Special ed. (8)	Predicted math score (9)	Predicted ELA score (10)
(A) Classes of 2005-06										
Adams eligible	-0.007	0.006*	0.001	-0.006	-0.001	0.005	0.001	0.002	-0.007	-0.007
	(0.009)	(0.003)	(0.004)	(0.004)	(0.001)	(0.006)	(0.001)	(0.003)	(0.005)	(0.005)
$\bar{Y}$	0.508	0.038	0.033	0.052	0.005	0.103	0.005	0.018	0.331	0.339
N	49,424	49,424	49,424	49,424	49,424	49,424	49,424	49,424	49,424	49,424
(B) Classes of 2005-08										
Adams eligible	0.009	0.004	-0.000	-0.000	0.000	0.003	0.001	0.000	-0.005	-0.002
	(0.006)	(0.002)	(0.003)	(0.003)	(0.001)	(0.004)	(0.001)	(0.002)	(0.003)	(0.003)
$\bar{Y}$	0.498	0.041	0.040	0.051	0.008	0.118	0.004	0.026	0.313	0.322
N	105,736	105,736	105,736	105,736	105,736	105,736	105,736	105,736	105,736	105,736

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* $p<.10$ ** $p<.05$ *** $p<.01$). Demographic controls listed at the top of each column are used as outcomes. Predicted math and ELA scores used as outcomes in the last two columns are generated by regressing standardized scores from the class of 2004 on the demographic controls listed in the previous eight columns. We then use the resulting estimates to predict scores for students in subsequent classes. Each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class. In panel (A), the sample consists of the high school classes of 2005-06. In panel (B), the sample consists of the high school classes of 2005-08. Listed below each coefficient is the mean of the outcome for students just below the eligibility threshold.

Table 4: Impact of Aid Eligibility on Enrollment and Graduation, Classes of 2005-06

	Adams college, four-year (1)	Non-Adams college, four-year (2)	Any four-year college (3)	In-state, four-year (4)	Any two-year college (5)	Any college (6)
Enrolled immediately	0.066***	-0.057***	0.009	0.045***	0.008*	0.017**
	(0.009)	(0.009)	(0.008)	(0.009)	(0.005)	(0.007)
$\bar{Y}$	0.239	0.477	0.716	0.409	0.068	0.784
Enrolled within 2 years	0.059***	-0.058***	0.000	0.029***	0.007*	0.008
	(0.009)	(0.009)	(0.007)	(0.009)	(0.004)	(0.006)
$\bar{Y}$	0.292	0.547	0.796	0.502	0.073	0.870
On campus, year 4	0.029***	-0.048***	-0.019**	0.005	0.004	-0.015*
	(0.008)	(0.009)	(0.008)	(0.008)	(0.004)	(0.008)
$\bar{Y}$	0.230	0.456	0.685	0.425	0.044	0.730
Graduated within 4 years	0.020***	-0.034***	-0.015	0.006	-0.000	-0.015
	(0.006)	(0.009)	(0.009)	(0.007)	(0.003)	(0.009)
$\bar{Y}$	0.095	0.338	0.433	0.216	0.029	0.462
Graduated within 6 years	0.027***	-0.049***	-0.022***	0.004	0.001	-0.021**
	(0.007)	(0.009)	(0.008)	(0.008)	(0.003)	(0.008)
$\bar{Y}$	0.184	0.448	0.631	0.367	0.031	0.662
N	49,424	49,424	49,424	49,424	49,424	49,424

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* p<.10 ** p<.05 *** p<.01). Each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. The sample consists of the high school classes of 2005-06. In the first row, the outcome is defined as enrollment by the fall following high school graduation. In the second row, the outcome is defined as enrollment within two years of the fall following high school graduation. In the the third row, the outcome is defined as being enrolled in college in the spring of the fourth year after high school graduation. In the fourth and fifth rows, the outcome is defined as college graduation within four and six years of high school graduation, respectively. Listed below each coefficient is the mean of the outcome for students just below the eligibility threshold.

Table 5: Impact of Aid Eligibility on Enrollment and Graduation, Classes of 2005-08

	Adams college, four-year (1)	Non-Adams college, four-year (2)	Any four-year college (3)	In-state, four-year (4)	Any two-year college (5)	Any college (6)
Enrolled immediately	0.059***	-0.049***	0.010*	0.041***	0.011***	0.021***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.003)	(0.005)
$\bar{Y}$	0.235	0.484	0.719	0.416	0.072	0.791
Enrolled within 2 years	0.057***	-0.055***	-0.000	0.032***	0.009***	0.009**
	(0.006)	(0.006)	(0.005)	(0.006)	(0.003)	(0.004)
$\bar{Y}$	0.281	0.543	0.788	0.490	0.082	0.870
On campus, year 4	0.027***	-0.044***	-0.017***	0.011*	0.004*	-0.013**
	(0.005)	(0.006)	(0.005)	(0.006)	(0.002)	(0.005)
$\bar{Y}$	0.220	0.432	0.653	0.400	0.035	0.688
Graduated within 4 years	0.018***	-0.030***	-0.012**	0.008*	-0.001	-0.013**
	(0.004)	(0.006)	(0.006)	(0.005)	(0.002)	(0.006)
$\bar{Y}$	0.099	0.325	0.424	0.212	0.029	0.453
N	105,736	105,736	105,736	105,736	105,736	105,736

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* p<.10 ** p<.05 *** p<.01). Each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. The sample consists of the high school classes of 2005-08. In the first row, the outcome is defined as enrollment by the fall following high school graduation. In the second row, the outcome is defined as enrollment within two years of the fall following high school graduation. In the the third row, the outcome is defined as being enrolled in college in the spring of the fourth year after high school graduation. In the fourth row, the outcome is defined as college graduation 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 6: Enrollment, Persistence and Graduation by High School Class

	2005 (1)	2006 (2)	2007 (3)	2008 (4)	2005-8 (5)	2009-11 (6)
(A) Enrolled immediately						
Adams college	0.071***	0.063***	0.060***	0.046***	0.059***	0.022***
	(0.014)	(0.011)	(0.012)	(0.011)	(0.006)	(0.006)
$\bar{Y}$	0.235	0.242	0.222	0.241	0.235	0.234
Any four-year college	0.027**	-0.004	0.012	0.008	0.010*	-0.008
	(0.013)	(0.010)	(0.011)	(0.010)	(0.005)	(0.006)
$\bar{Y}$	0.692	0.733	0.730	0.716	0.719	0.713
(B) Graduated, four-year college						
On campus, year 4	0.001	-0.034***	-0.019	-0.011	-0.017***	
	(0.014)	(0.010)	(0.012)	(0.010)	(0.005)	
$\bar{Y}$	0.679	0.690	0.631	0.620	0.653	
Within 4 years	-0.016	-0.014	-0.009	-0.010	-0.012**	
	(0.014)	(0.012)	(0.012)	(0.012)	(0.006)	
$\bar{Y}$	0.418	0.444	0.411	0.420	0.424	
Within 5 years	-0.014	-0.030***	-0.016		-0.021***	
	(0.014)	(0.012)	(0.012)		(0.007)	
$\bar{Y}$	0.570	0.595	0.562		0.576	
Within 6 years	-0.018	-0.025**			-0.022***	
	(0.013)	(0.011)			(0.008)	
$\bar{Y}$	0.630	0.632			0.631	
N	22,513	26,911	26,291	30,021	105,736	89,108

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* p<.10 ** p<.05 *** p<.01). Each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. Each column consists of a different high school class or set of classes. In panel (B), the outcomes are defined as being on campus or graduating from any four-year college, regardless of initial enrollment choice. Listed below each coefficient is the mean of the outcome for students just below the eligibility threshold.

Table 7: Robustness Checks

	Classes of 2005-06			Classes of 2005-08		
	Enrolled immediately, Adams college	On campus in year 4, four-year college	Graduated within 6, four-year college	Enrolled immediately, Adams college	On campus in year 4, four-year college	Graduated within 4, four-year college
	(1)	(2)	(3)	(4)	(5)	(6)
(A) Controls						
Bandwidth = 10	0.070***	-0.021**	-0.020**	0.059***	-0.019***	-0.011
	(0.011)	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)
Bandwidth = 15	0.066***	-0.019**	-0.022***	0.059***	-0.017***	-0.012**
	(0.009)	(0.008)	(0.008)	(0.006)	(0.005)	(0.006)
Bandwidth = 20	0.065***	-0.015*	-0.019***	0.057***	-0.015***	-0.011**
	(0.008)	(0.008)	(0.007)	(0.006)	(0.005)	(0.005)
(B) No controls						
Bandwidth = 10	0.070***	-0.022**	-0.022**	0.059***	-0.018***	-0.009
	(0.011)	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)
Bandwidth = 15	0.066***	-0.021**	-0.025***	0.059***	-0.017***	-0.012**
	(0.009)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)
Bandwidth = 20	0.065***	-0.017**	-0.022***	0.057***	-0.016***	-0.012**
	(0.008)	(0.008)	(0.007)	(0.006)	(0.005)	(0.005)
(C) Gap > 0						
Bandwidth = 10	0.080***	-0.029**	-0.033***	0.070***	-0.027***	-0.021**
	(0.012)	(0.011)	(0.012)	(0.008)	(0.008)	(0.008)
Bandwidth = 15	0.076***	-0.023**	-0.031***	0.069***	-0.023***	-0.021***
	(0.010)	(0.009)	(0.009)	(0.007)	(0.006)	(0.006)
Bandwidth = 20	0.074***	-0.017**	-0.026***	0.067***	-0.019***	-0.019***
	(0.009)	(0.008)	(0.008)	(0.007)	(0.006)	(0.006)
(D) Class of 2004						
Bandwidth = 10	-0.013	0.012	-0.012			
	(0.015)	(0.015)	(0.016)			
Bandwidth = 15	-0.019	0.001	-0.014			
	(0.012)	(0.012)	(0.013)			
Bandwidth = 20	-0.024**	-0.002	-0.010			
	(0.010)	(0.011)	(0.011)			

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* p<.10 ** p<.05 *** p<.01). In panel (A), each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 10, 15 or 20 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. Panel (B) replicates panel (A) but excludes demographic controls. Panel (C) replicates panel (A) but excludes students directly on the eligibility threshold. Panel (D) replicates panel (A) but uses the untreated high school class of 2004. In the first three panels, the sample in columns 1-3 consists of the high school classes of 2005-06 and in columns 4-6 consists of the high school classes of 2005-08.

Table 8: Impact of Aid on Initial College Quality and Cost

	Highly comp. (1)	Four-year grad. rate (2)	SAT math (3)	Instr. spending (4)	College quality (5)	Net price (6)	Adams aid (7)
(A) Classes of 2005-2006							
Adams eligible (RF)	-0.028***	-0.014***	-2.427*	-0.316	-0.055***	-0.869***	0.091***
	(0.009)	(0.004)	(1.326)	(0.254)	(0.019)	(0.127)	(0.013)
Adams college (IV)	-0.427***	-0.166***	-28.329*	-3.688	-0.643***	-10.146***	1.376***
	(0.131)	(0.038)	(14.776)	(2.813)	(0.192)	(0.719)	(0.050)
$\bar{Y}$	0.323	0.487	621.235	13.630	0.176	15.244	0.324
St.Dev.		0.210	62.384	13.361	0.963	5.844	
N	49,424	34,921	34,921	34,921	34,921	34,916	49,424
(B) Classes of 2005-2008							
Adams eligible (RF)	-0.024***	-0.013***	-2.006**	0.072	-0.041***	-0.915***	0.080***
	(0.006)	(0.003)	(0.953)	(0.256)	(0.015)	(0.095)	(0.009)
Adams college (IV)	-0.409***	-0.175***	-26.382**	0.951	-0.544***	-12.032***	1.360***
	(0.103)	(0.032)	(11.855)	(3.399)	(0.178)	(0.660)	(0.036)
$\bar{Y}$	0.317	0.484	620.012	13.847	0.149	15.958	0.318
St.Dev.		0.216	63.366	12.700	0.953	6.332	
N	105,736	75,243	75,243	75,243	75,243	75,234	105,736

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* $p<.10$ ** $p<.05$ *** $p<.01$). Panel (A) contains the high school classes of 2005-06 and panel (B) contains the classes of 2005-08. In the top row of each panel, each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. The bottom row of each panel instruments enrollment in a four-year Adams college with aid eligibility, using the same specification. 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 immediately in four-year colleges. College quality is the standardized first principal component of each institution's four-year graduation rate, the 75th percentile SAT math score, and instructional expenditures per student, measured as of 2004. 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 eligbility threshold.

Table 9: Heterogeneity by Student Characteristics

	Enrolled immediately, Adams college (1)	Enrolled immediately, four-year college (2)	Enrolled immediately, highly competitive (3)	On campus in year 4, four-year college (4)	Graduated in 6 years, four-year college (5)
(A) By district threshold					
Eligible * bottom quintile	0.091***	0.037**	0.019	0.001	-0.013
	(0.018)	(0.017)	(0.017)	(0.019)	(0.018)
Eligible * middle quintiles	0.076***	0.011	-0.040***	-0.024**	-0.022**
	(0.012)	(0.009)	(0.010)	(0.010)	(0.011)
Eligible * top quintile	0.003	-0.002	0.004	-0.002	-0.006
	(0.015)	(0.012)	(0.020)	(0.013)	(0.012)
p (Bottom = Middle)	0.499	0.186	0.004	0.227	0.675
p (Top = Middle)	0.000	0.378	0.053	0.193	0.302
(B) By poverty status					
Eligible * nonpoor	0.062***	0.006	-0.033***	-0.019**	-0.020**
	(0.010)	(0.008)	(0.010)	(0.009)	(0.009)
Eligible * poor	0.104***	0.028	0.007	-0.030	-0.046*
	(0.026)	(0.025)	(0.020)	(0.026)	(0.026)
p (Poor = Non-poor)	0.134	0.428	0.082	0.691	0.351
(C) By race/ethnicity					
Eligible * white	0.058***	0.007	-0.031***	-0.021**	-0.024***
	(0.010)	(0.008)	(0.009)	(0.009)	(0.009)
Eligible * non-white	0.177***	0.035	0.005	-0.000	-0.007
	(0.025)	(0.026)	(0.036)	(0.030)	(0.031)
p (White = Non-white)	0.000	0.292	0.315	0.521	0.611
(D) By gender					
Eligible * male	0.072***	0.011	-0.043***	-0.021*	-0.026**
	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)
Eligible * female	0.059***	0.006	-0.013	-0.018*	-0.018
	(0.011)	(0.010)	(0.012)	(0.011)	(0.011)
p (Male = Female)	0.407	0.750	0.087	0.852	0.649
N	49,424	49,424	49,424	49,424	49,424

Notes: Heteroskedasticity robust standard errors clustered by distance from the threshold are in parentheses (* p<.10 ** p<.05 *** p<.01). The sample consists of the high school classes of 2005-06. Each panel's baseline specification uses local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. Each panel then fully interact that baseline specification with indicators for the given categories. Panel (A) divides school districts into quintiles within each high class by the total scaled score that defines the top 25% for aid eligibility. Panel (B) divides students into non-poor and poor, the latter defined by receipt of free or reduced price lunch status. Panel (C) divides students into white and non-white, the latter defined by being black or Hispanic. Panel (D) divides students by gender. Below each panel is the p-value from a test of the equality of the two listed coefficients.

Table 10: Impact of College Quality on Graduation Rates

	Classes of 2005-2006 Y = Graduation within 6 years				Classes of 2005-2008 Y = Graduation within 4 years			
	Adams college (1)	Adams college (2)	Four-year grad. rate (3)	College quality (4)	Adams college (5)	Adams college (6)	Four-year grad. rate (7)	College quality (8)
First stage	0.066***	0.086***	-0.014***	-0.055***	0.059***	0.076***	-0.013***	-0.041***
	(0.009)	(0.012)	(0.004)	(0.019)	(0.006)	(0.008)	(0.003)	(0.015)
Reduced form	-0.022***	-0.025***	-0.025***	-0.025***	-0.012**	-0.022***	-0.022***	-0.022***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.006)	(0.007)	(0.007)	(0.007)
IV	-0.337***	-0.288***	1.735***	0.448***	-0.203**	-0.285***	1.627***	0.524**
	(0.127)	(0.097)	(0.632)	(0.174)	(0.098)	(0.083)	(0.503)	(0.204)
OLS	0.036***	-0.163***	0.565***	0.116***	-0.029***	-0.213***	0.893***	0.175***
	(0.010)	(0.007)	(0.014)	(0.005)	(0.010)	(0.008)	(0.010)	(0.005)
N	49,424	34,921	34,921	34,921	105,736	75,243	75,243	75,243

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* p<.10 ** p<.05 *** p<.01). Columns 1-4 contain the high school classes of 2005-06 and columns 5-8 contain the classes of 2005-08. Each column presents an instrumental variables regression of graduation within four or six years on the endogenous regressor listed at the top of each column, where the endogenous regressor has been instrumented with aid eligibility. Each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. 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

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

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	Mitchell D. Chester, Ed.D.	Dr. Richard Freeland
Secretary of Education	Commissioner of Elementary and Secondary Education	Commissioner of Higher Education

Figure A.4: Adams Eligibility by High School Class

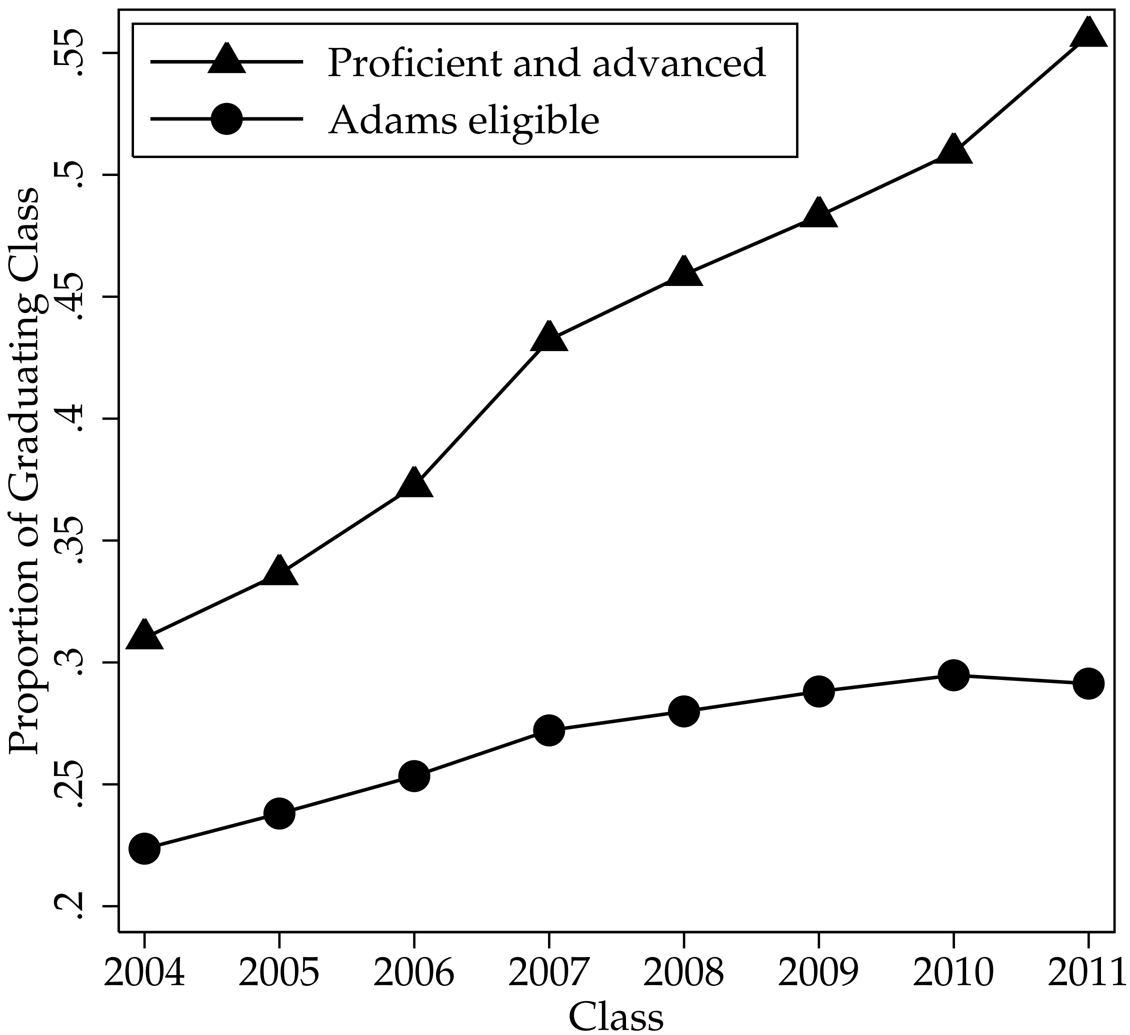
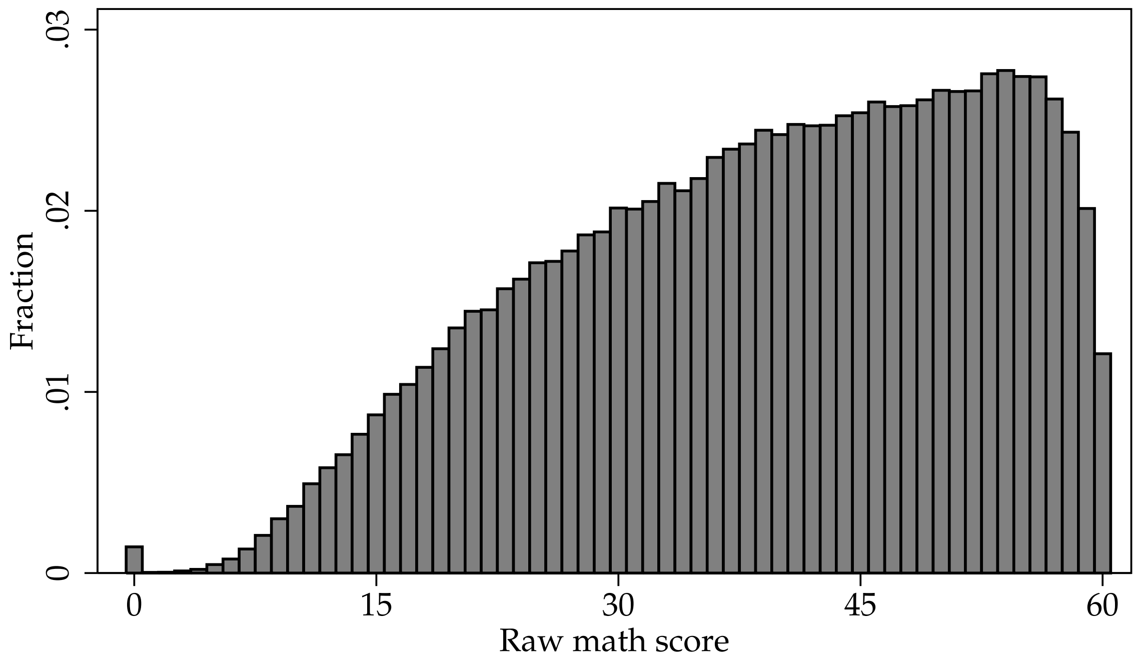


Figure A.5: Density of Raw Scores, Classes of 2005-08

(A) Raw math scores



(B) Raw ELA scores

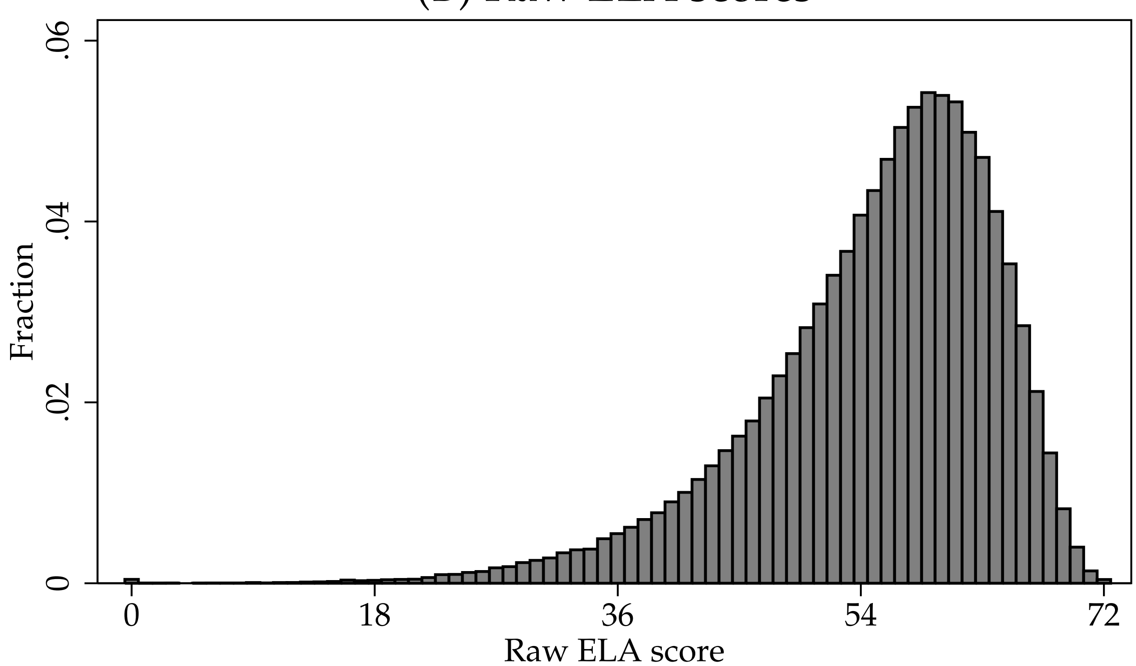
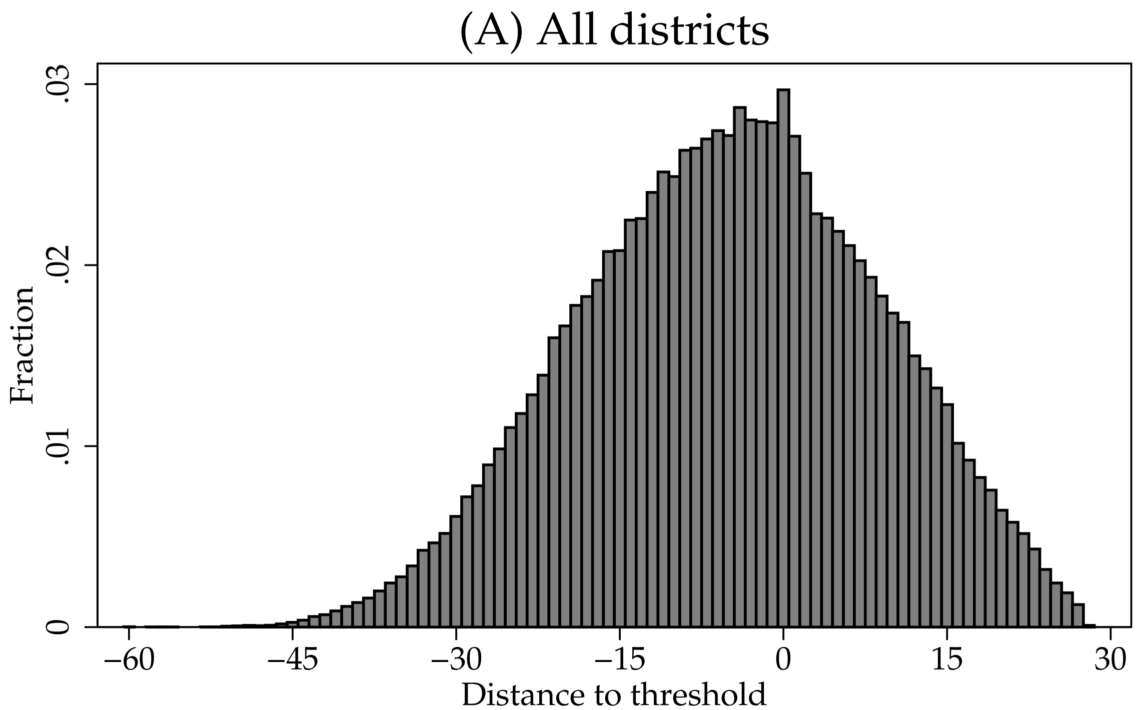


Figure A.6: Density of Forcing Variable, Classes of 2005-08



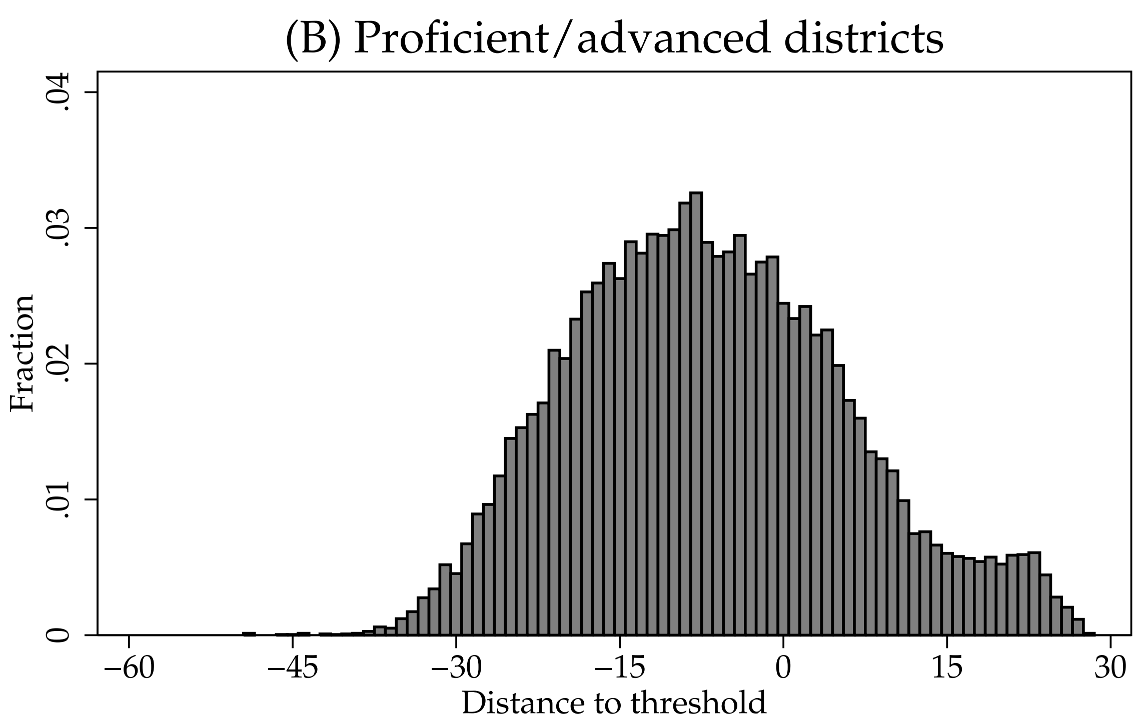
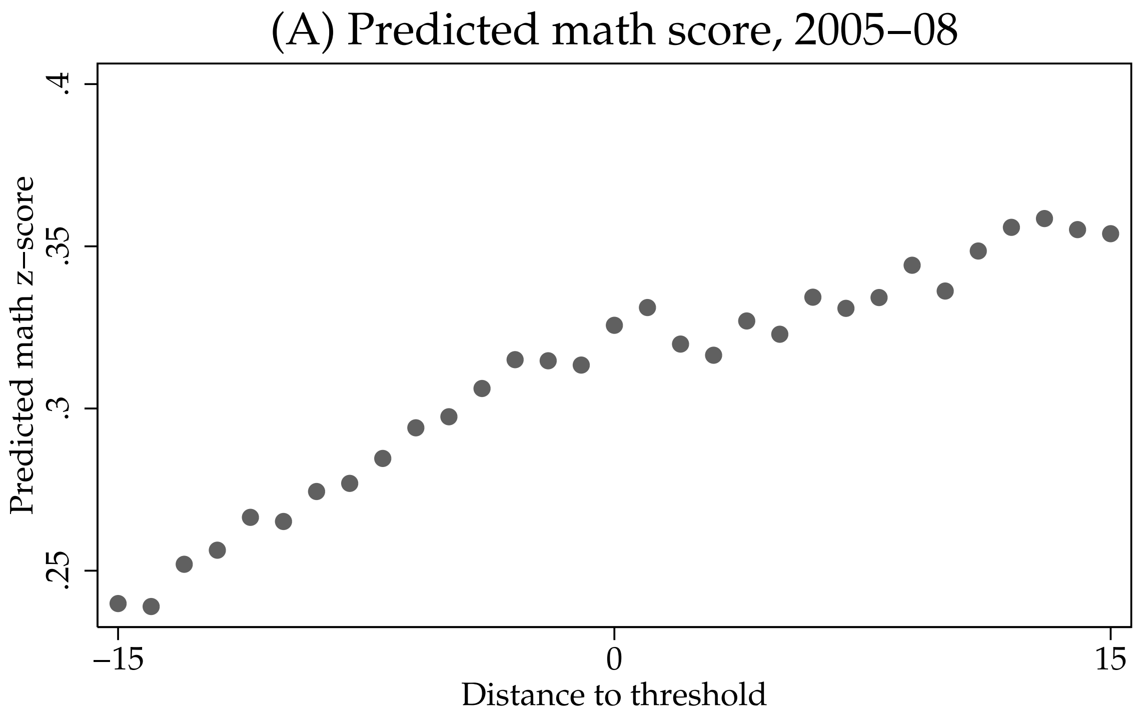


Figure A.7: Smoothness of Covariates, Classes of 2005-08



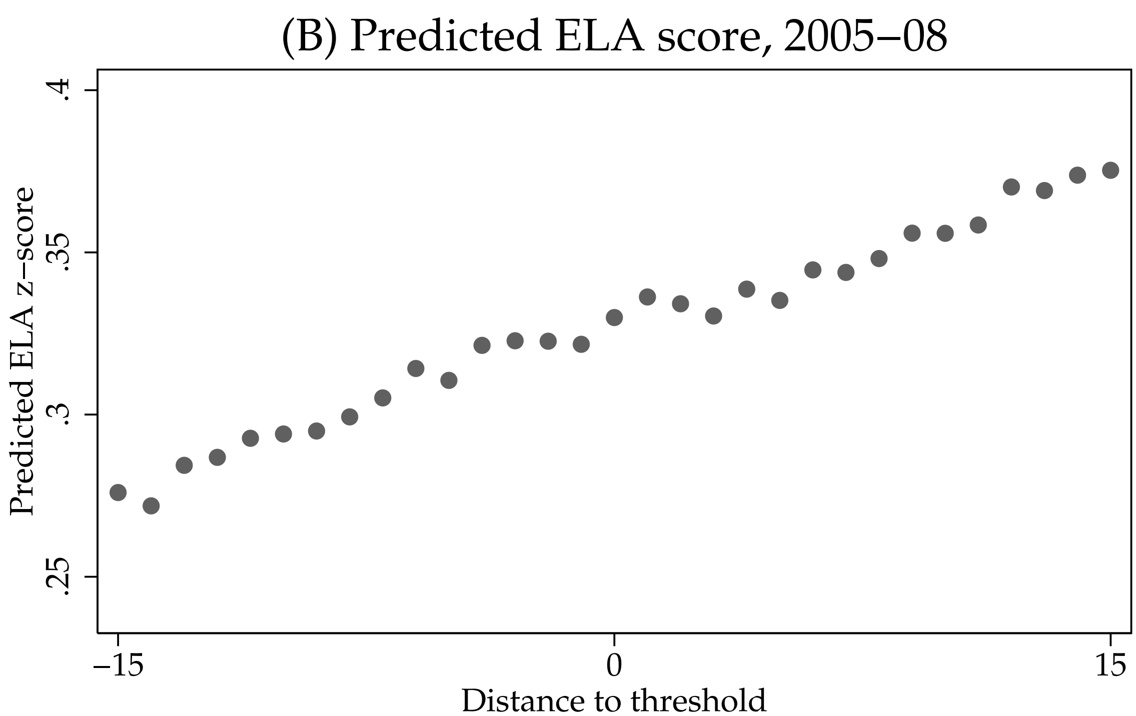


Figure A.8: Enrollment at Four-Year Colleges, Classes of 2005-08

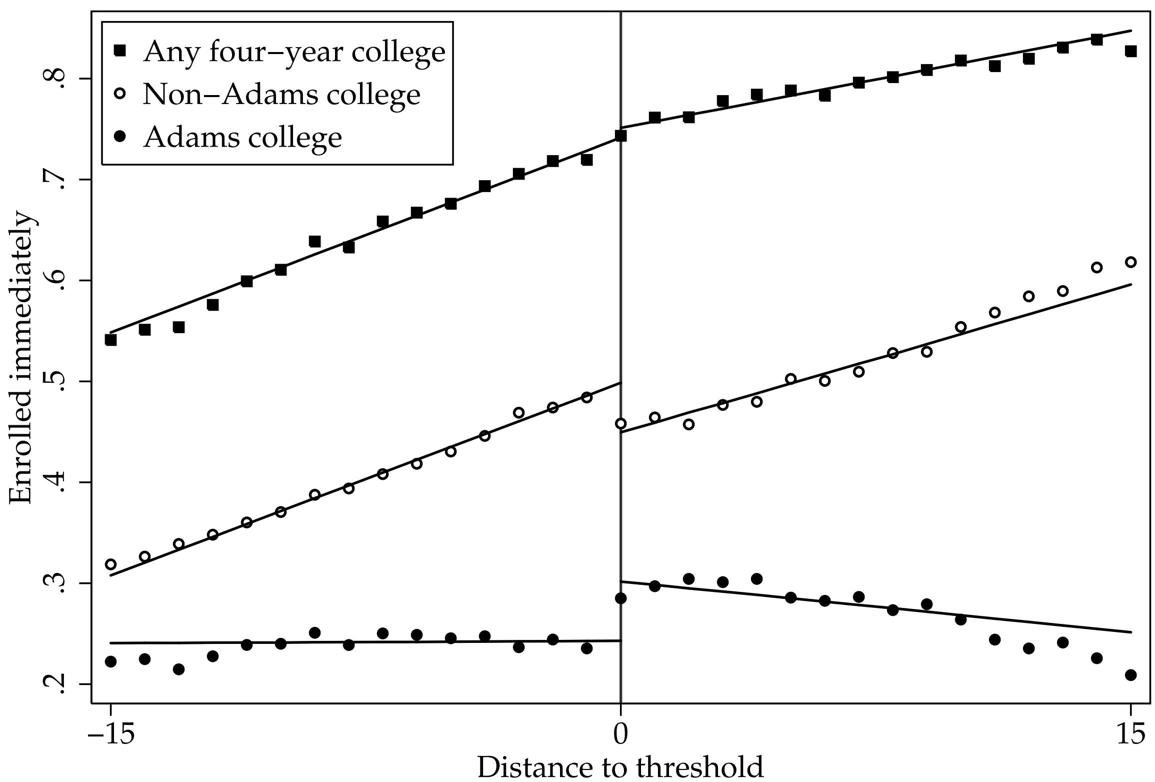


Figure A.9: Graduation from Four-Year Colleges, Classes of 2005-08

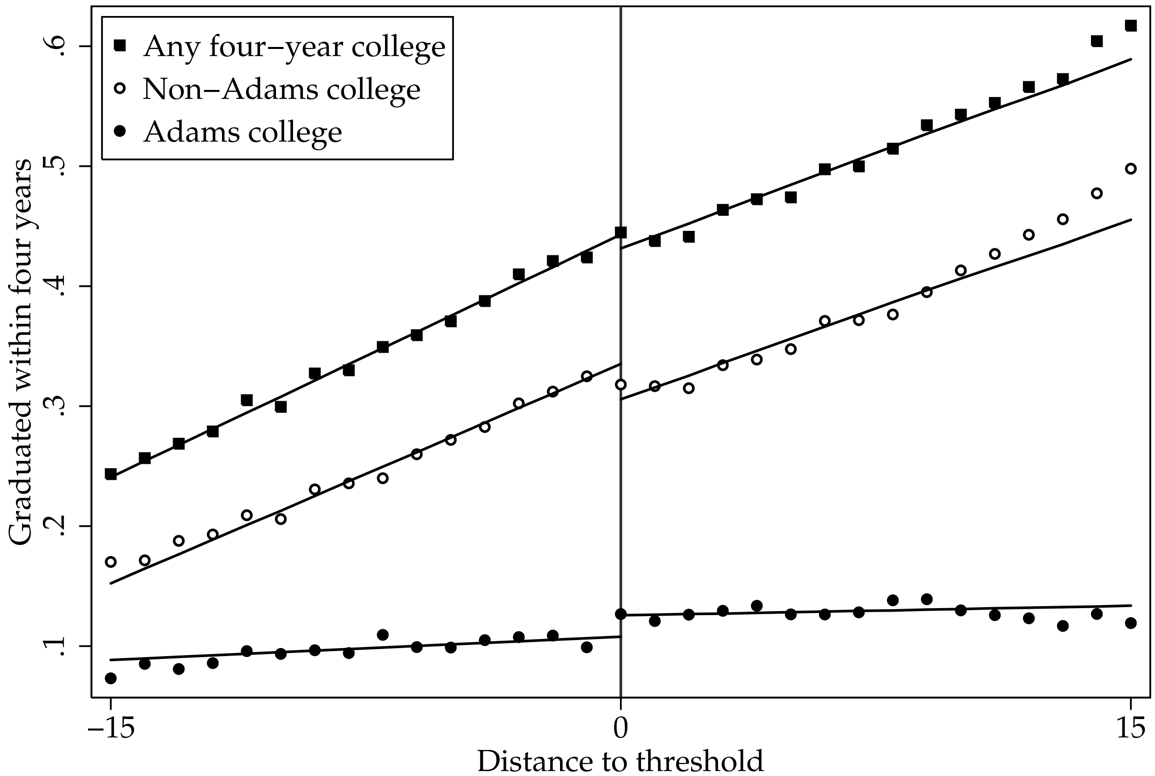


Table A.1: College Quality Measures, Selected Institutions

	2004 MA freshmen (1)	Four-year grad. rate (2)	SAT math score, p75 (3)	Instr. spending (4)	College quality (5)	Net price (6)
(A) Adams colleges						
U. Mass. Amherst	2608	.43	630	9.9	.02	8.6
U. Mass. Dartmouth	1078	.26	580	5.3	-.72	10.7
U. Mass. Lowell	791	.24	610	6.4	-.58	7.6
U. Mass. Boston	349	.12	560	8.8	-1.03	8.3
Bridgewater State	960	.23	560	3.7	-.93	7.7
(B) Other colleges						
Suffolk Univ.	419	.35	550	12.2	-.53	23.3
Univ. of Rhode Island	288	.35	600	7.3	-.38	19.4
Johnson and Wales Univ.	436	.42	590	7.2	-.32	16.9
Univ. of Connecticut	275	.45	650	13.2	.26	18.3
Merrimack College	231	.45	590	7.5	-.22	15.6
Univ. of Vermont	229	.5	630	10.8	.18	18.1
Univ. of New Hampshire	502	.54	620	8.9	.17	19.7
Syracuse Univ.	216	.66	670	16.8	.88	17.7
Boston Univ.	586	.62	690	32.5	1.33	17.2
Tufts Univ.	186	.84	740	29.1	1.96	15.1
Harvard Univ.	124	.86	790	107.8	4.35	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. College quality is the standardized first principal component of each institution's four-year graduation rate, the 75th percentile SAT math score, and instructional expenditures per student, measured as of 2004.

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

	Adams college (1)	Any U. Mass. (2)	U. Mass. Amherst (3)	U. Mass. Dartmouth (4)	U. Mass. Lowell (5)	U. Mass. Boston (6)	Any state college (7)	Bridgewater State Coll. (8)
(A) Classes of 2005-06								
Enrolled immediately	0.066***	0.040***	0.030***	0.009***	-0.000	0.002	0.026***	0.008***
	(0.009)	(0.007)	(0.005)	(0.003)	(0.003)	(0.002)	(0.006)	(0.003)
$\bar{Y}$	0.239	0.151	0.073	0.034	0.031	0.013	0.087	0.024
Graduated within 6 years	0.027***	0.018***	0.015***	0.005*	-0.003	0.001	0.009**	0.000
	(0.007)	(0.006)	(0.005)	(0.003)	(0.002)	(0.002)	(0.004)	(0.002)
$\bar{Y}$	0.184	0.119	0.064	0.019	0.023	0.012	0.065	0.026
N	49,424	49,424	49,424	49,424	49,424	49,424	49,424	49,424
(B) Classes of 2005-08								
Enrolled immediately	0.059***	0.035***	0.019***	0.008***	0.003	0.006***	0.023***	0.008***
	(0.006)	(0.005)	(0.004)	(0.002)	(0.002)	(0.002)	(0.004)	(0.002)
$\bar{Y}$	0.235	0.146	0.074	0.034	0.027	0.011	0.090	0.023
Graduated within 4 years	0.018***	0.010***	0.007**	0.002	0.001	0.000	0.008***	0.002*
	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
$\bar{Y}$	0.099	0.067	0.045	0.013	0.007	0.002	0.032	0.009
N	105,736	105,736	105,736	105,736	105,736	105,736	105,736	105,736

Notes: Heteroskedasticity robust standard errors clustered by 12th grade school district are in parentheses (* p<.10 ** p<.05 *** p<.01). Outcomes are enrollment in or graduation from the specific college or set of colleges listed at the top of each column. Each coefficient on aid eligibility is generated by local linear regression with an edge kernel of bandwidth 15 points, with controls for high school class, gender, race, low-income status, limited English proficiency and special education status. In panel (A), the sample consists of the high school classes of 2005-06. In panel (B), the sample consists of the high school classes of 2005-08. Listed below each coefficient is the mean of the outcome for students just below the eligibility threshold.