Reducing Frictions in College Admissions: Evidence from the Common Application*

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Abstract

College admissions in the U.S. is decentralized, creating frictions that limit student choice. We study the Common Application (CA) platform, under which students submit a single application to member schools, potentially reducing frictions and increasing student choice. The CA increases the number of applications received by schools, reflecting a reduction in frictions, and reduces the yield on accepted students, reflecting increased choice. The CA increases out-of-state enrollment, especially from other CA states, consistent with network effects. CA entry changes the composition of students, with evidence of more racial diversity, more high-income students, and imprecise evidence of increases in SAT scores.

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1 Introduction

There are a variety of mechanisms for matching students to schools. Under centralized systems, students submit a single application and are then matched to schools. In Chile, for example, students applying to college take an entrance exam and then submit a single application that includes a ranked list of eight programs. Students are then offered admission to their highest ranked program for which their exam score exceeds the program-specific cutoff (Hastings et al. (2013)). Starting with students entering high school in the fall of 2004, New York City adopted the deferred acceptance algorithm for matching students to high schools (Abdulkadriglu et al. (2005)). Under this system, both students and schools submit ranked lists, both with incentives to truthfully report their preferences, and an algorithm then matches students to schools.

College admissions in the United States, by contrast, has traditionally followed a decentralized process. In particular, students first choose the set of schools to which to apply. Schools then independently decide whether or not to make admissions offers to these applicants. Finally, students select a school from their choice set, the institutions to which they were offered admissions. Historically, students have completed separate applications for each school, entailing substantial time costs, or frictions.[1]

These frictions in U.S. college admissions might limit the number of schools to which students apply. By limiting the number of applications submitted, substantial frictions might reduce the number of schools to which students are accepted, thus ultimately limiting the degree of student choice. Further, since students tend to apply to colleges close to home, these frictions might also lead to a less integrated market from a geographic perspective. By reducing frictions, students might apply more nationally and ultimately attend a school further from home. At the same time, substantial frictions, by reducing student choice sets, might also lead to changes in how different types of students sort across colleges. For example, there could be less sorting across schools according to ability, with schools less stratified than under a more centralized college admissions process. By reducing frictions, high ability students might be disproportionately induced to apply to selective out of state colleges, leading to more stratification.

In this paper, we investigate these issues in the context of the Common Application (CA), a

[1] These time-based frictions are in addition to any information frictions facing students as a result of decentralized college admissions.

private initiative designed to address the lack of a centralized government system. In particular, the CA platform allows students to complete one application for all member institutions, with membership increasing from roughly 100 colleges in 1980 to 700 colleges by 2016. The CA, by allowing students to submit a single application to multiple institutions, may simplify and significantly reduce time costs associated with college admissions. Given this reduction in frictions, the CA might increase student choice, in turn leading to increased geographic integration but also increased stratification according to ability across institutions. Colleges might also use the larger applicant pool under the CA to increase their racial diversity. Of course, different types of applicants might be differentially impacted by the CA. For example, since the CA reduces time costs but not financial costs of applying to multiple colleges, low-income students, for whom financial costs are more salient, might be less responsive to the CA than high-income students. This could lead to an increase in high-income students enrolling at CA colleges.

Given this motivation, we ask a series of research questions in this paper. Has the CA reduced frictions, resulting in more college applications at member institutions and increased student choice? Has the CA led to a more geographically integrated market, with more students attending CA institutions far from home? If so, by increasing student choice and integrating the market geographically, has the CA contributed to stratification, a widening of the selectivity gap between more selective and less selective institutions? Has the CA altered racial and socioeconomic diversity in higher education?

To answer these questions, we first present a simple model of the college admissions process that includes student application decisions, university admissions offers, and student acceptances of these offers. We then consider the impact of the CA, modeled as a reduction in the costs of applying to a second CA school. The model predicts that joining the CA leads to an increase in applications due to a reduction in frictions. Likewise, schools joining the CA experience a reduction in their yield–the fraction of students accepting an admissions offer–and admit more applicants in order to meet their capacity. Thus, in the model, the CA increases student choice. The CA also contributes towards geographic integration, with an increase in out-of-state students from other states with CA institutions. In our model, the introduction of the CA increases stratification according to ability, with high ability students disproportionately sorting into CA schools but reduces stratification according to race as colleges use the larger applicant pool to diversity their student body. Finally, in our model, high-income students, for whom time costs are more salient, disproportionately use the CA, leading to an increase in enrollment of high income students at CA colleges.

We then test these predictions using panel data from the College Board covering the years 1990 to 2016. We estimate fixed effects regression models, comparing outcomes for schools before and after joining the CA, and also provide event studies, investigating the timing of any effects associated with entry into the CA. Overall, we find that the CA increases applications, consistent with a reduction in frictions, and reduces yield, consistent with enhanced student choice. Schools respond to this reduced yield by admitting more students. Turning to the composition of students, we find that the CA has accelerated geographic integration. In particular, there is strong evidence that entry into the CA is associated with an increase in the fraction of out-of-state students, especially from other states with significant CA penetration, consistent with network effects. Finally, we investigate three measures of student heterogeneity. Consistent with our model predictions, we provide some evidence that entry into the CA is associated with an increase in SAT scores. While these results are imprecise, we provide stronger evidence that CA adoption increases the fraction of non-white students and reduces the fraction of low-income students. Given that, prior to joining, CA colleges tend to have fewer non-white students, fewer low-income students, and higher test scores, the CA has increased stratification according to income and tests scores but has reduced stratification according to race.

The paper proceeds as follows. Following some background information on the CA, we provide a discussion of the relevant academic literature. This is followed by the presentation of the theoretical model of the college admissions process. We then describe the data, empirical approach, and our key empirical results. The final section concludes.

2 Background

As noted above, college admissions has historically been decentralized in the U.S. As a private effort towards greater centralization, the CA began as a consortium of 15 colleges in 1975. It grew rapidly thereafter, with increases in membership in every year since 1975 and a significant acceleration of membership starting around 2000 (Figure 1). As of 2016, the end of our sample period, there were roughly 700 institutions. Taken together, the CA currently receives approximately 4 million applications from 1 million students annually.[2]

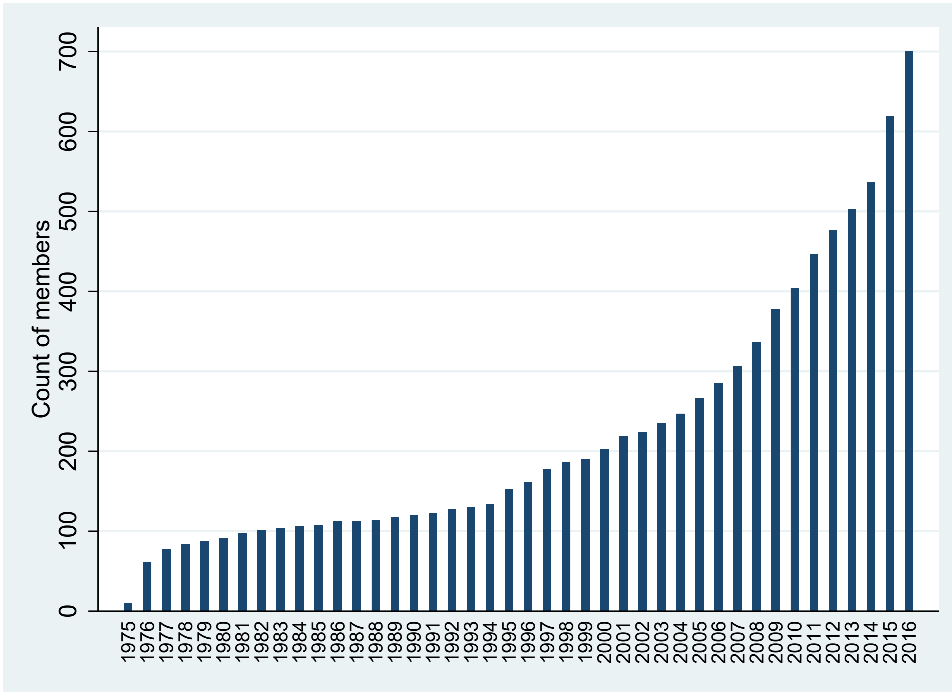


Figure 1: Common Application Membership by Year

The CA was founded by a small set of liberal arts colleges but has since expanded to a wide range of public and private institutions, especially more selective institutions. In particular, as shown in Figure 2, membership among the top 50 liberal arts colleges was already very high, over 80 percent, in 1990, the beginning of our analysis, and was universal in this group by the late 1990s. During our sample period, membership among top 50 private institutions increased rapidly, from under 40 percent in 1990 to roughly 90 percent by 2016. Membership among less selective liberal arts colleges and other private institutions also increased during our sample period but remained below 50 percent in 2016. The CA was originally closed to public institutions but that ban was lifted in 2002, leading to a rapid increase in membership among the top 50 public institutions. Less selective public institutions, by contrast, joined at a slower rate, with membership rates still below 20 percent by the end of our sample period.

In addition to this rapid entry overall, the CA has also become more diverse from a geographic perspective. That is, the CA started in the Northeast but is now accepted by colleges in many

[2]From https://www.commonapp.org/about-us, accessed April 2018.

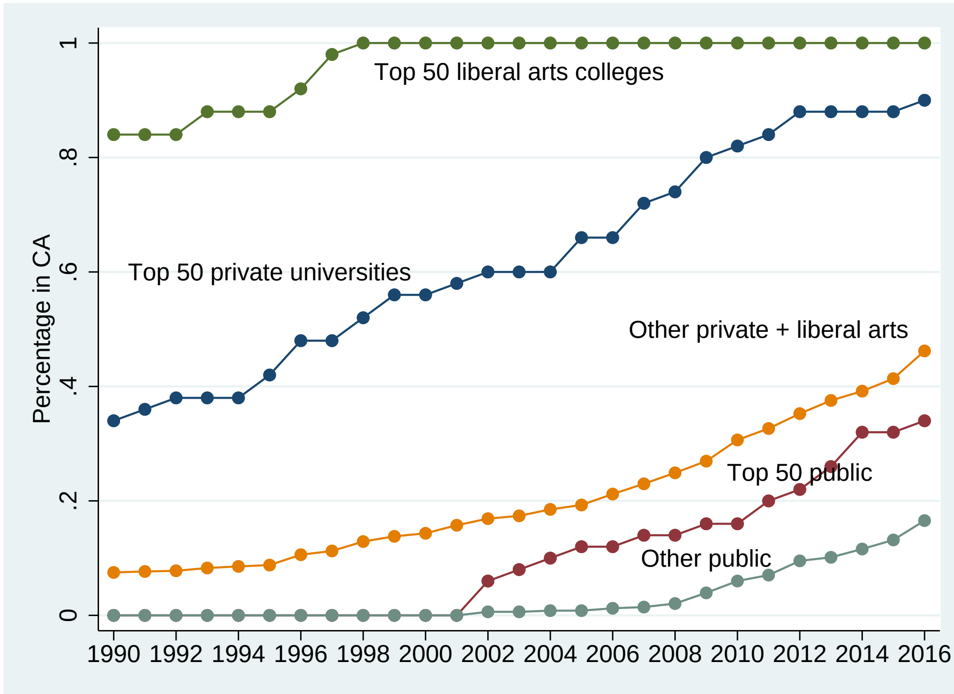
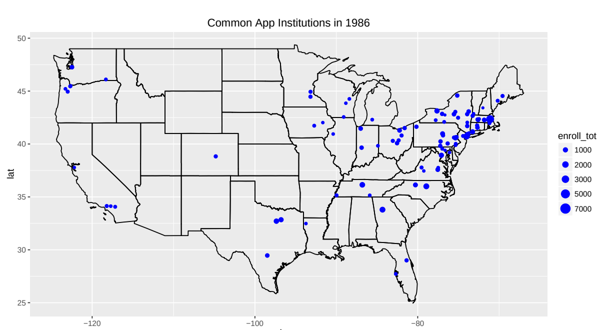


Figure 2: Common Application Membership Rates by Year and Type

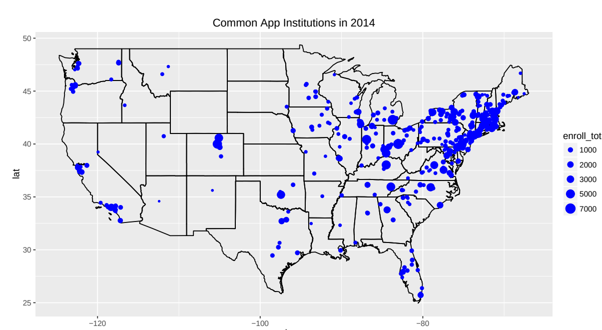
different states. In particular, Figure 3 plots the locations of CA members in 1986 and 2014, documenting a much wider geographic distribution in the latter year, with significant new penetration in states such as California, Oregon, Colorado, Indiana, and Florida. Given this substantial adoption over time and a diverse set of members at current, it is natural that the CA may have led to significant changes in college admissions.

Figure 3: Common Application Membership by State

(a) CA in 1986



(b) CA in 2014



3 Related Literature

Several existing studies have examined the impact of the CA on the higher education sector. Smith (2013) studies the effect of the number of applications on enrollment probabilities using variation induced by adoption of the CA by nearby colleges. He finds that increasing the number of applications, when induced by the CA, significantly increases enrollment probabilities. Smith et al. (2015) analyze various frictions in the application process, finding some evidence that the CA increases applications. Fees and essay requirements, by contrast, decrease applications.

Perhaps the paper most closely related to this one is Liu et al. (2007), who also use panel data from the College Board to study how CA membership affects admissions outcomes and the composition of enrollees. Regarding admissions outcomes, their key findings are that joining the CA increased the number of applications received by colleges, increased the number of acceptances, and reduced yield. Regarding the composition of enrollees, they find that the CA reduced SAT scores, increased non-white attendance, and increased low-income representation.

While the focus on admissions outcomes and the composition of students is similar, our paper is different on at least four dimensions. First, we study a more recent time period, 1990-2016, compared to the period 1975-2005 in their study. The CA has grown dramatically since the end of their sample period, as noted above, from under 300 members in 2005 to roughly 700 in 2016. In addition, while their study focuses exclusively on private institutions, public institutions began joining in 2002, and we study both types of institutions. Moreover, the CA also moved from a paper-based application system to a fully online platform beginning in 1998. Second, perhaps due to these changes in the CA over time, our effects regarding admissions outcomes tend to be larger in magnitude. In particular, we find that applications rise 12 percent and that yield falls 8-9 percent, whereas Liu et al. (2007) find that applications rise 6 percent and that yield falls by 3 percent. We also find different results for some outcomes related to student composition, with some evidence of increases in SAT scores and reductions in the fraction of low-income students. Third, given our focus on geographic integration, we provide novel findings documenting robust increases in out-of-state enrollment, and we also examine the role of network effects in terms of out-of-state enrollment increases being driven by students from source states with significant CA penetration. This contributes to a literature on trends in geographic integration in higher education, as described below. Finally, in terms of methodology, we provide event study figures, allowing readers to see the dynamic effects of CA adoption, and also provide results from an identification strategy that compares outcomes for new CA members to outcomes for schools that will join the CA in the next few years. We argue that joiners are more comparable to this control group than to broader control groups that include never joiners and schools that join in the more distant future.

More broadly, our paper is related to studies examining policies that make it easier to apply to college.[3] In the context of financial aid policy, Bettinger et al. (2012), for example, show that assistance filling out the FAFSA, a complex financial aid application, increases aid receipt, college attendance, and persistence. Pallais (2015) examines an increase in 1997 in the number of free ACT score reports, from three to four, previously costing $6 for the fourth report. She finds that this led to a large increase in scores sent by ACT takers, relative to SAT takers, and low-income ACT takers subsequently attended more selective colleges. Bond et al. (2018) documents that the opening or closing of nearby SAT testing centers changes college attendance and college graduation outcomes. Goodman et al. (2018) documents that many low-income students do not re-take the SAT, even though retakes are both free and associated with substantial increases in test scores. In this paper, we focus on a different change in the college admissions process, namely a reduction in the complexity and time associated with applying to multiple colleges.

Another literature has examined how college admissions, and in particular the recent increase in the number of applications per student, has changed both university and student strategic behavior. Bound et al. (2009) document increases over time in the number of students applying to college, increases over time in applications per student, and reductions in acceptance rates at selective institutions. Blair and Smetters (2019) investigate why colleges, especially elite ones, haven't responded to this increase in applications by expanding capacity. They argue that colleges compete

[3]Given that the CA reduces the time cost associated with submitting applications to multiple CA schools, we interpret the CA as reducing time-based frictions associated with applications. Yet it is also possible that the CA provides information to applicants through the platform. In this sense, our paper is related to a literature on information frictions in college admissions. Hoxby and Avery (2013) document substantial information frictions in the US, with many low-income but high-ability students not applying to selective colleges, despite generous financial aid at these institutions. In a randomized control trial, Hoxby and Turner (2014) and Hoxby and Turner (2015) provide these high-ability but low-income students with information about college admissions and financial aid. This intervention increases applications to, and ultimately attendance at, selective institutions. Gurantz et al. (2019) provided information about selective colleges to 785,000 low-income and middle-income students but find little evidence of changes in college attendance patterns. Bird et al. (2019) conduct a large-scale field experiment using the CA platform and document that providing information about financial aid does not increase college attendance patterns, and similar results are found using a state-sponsored application portal.

on prestige, providing incentives for each institution to reduce admissions rates. Avery and Levin (2010) document that early applicants are more likely to be admitted when compared to the regular applicant pool, and argue that this finding is consistent with an early application serving as a signal of student enthusiasm for attending the institution. Avery et al. (2013) argue that standard methods of ranking colleges, such as the U.S. News and World Report Best Colleges Ranking, provide incentives for institutions to manipulate admissions decisions to reduce acceptance rates and to increase yield.

This paper is also related to a literature on geographic integration in higher education. Historically, the US market for higher education was highly localized, with most students attending universities close to their residence.[4] In 1949, over 90 percent of students attended in-state universities (Hoxby, 2000). During the subsequent decades, the market for higher education became more national, leading to both higher tuition and greater student sorting (Hoxby, 1997, 2000, 2009). Despite this shift, the US market may still be considered local in nature, with roughly 80 percent of first-time students enrolled in a college in their home state.[5] Knight and Schiff (2019) and Cohodes and Goodman (2014) argue that financial incentives, in the form of in-state tuition discounts and financial aid for in-state institutions, have contributed to this high rate of attendance at in-state public institutions. New technologies, such as the CA, may disrupt these patterns. Deming, Lovenheim, and Patterson (2016), for example, argue that less-selective colleges are particularly localized and study the effects of competition from online degree programs in these markets, finding that online competition reduces enrollment at private non-selective institutions.

4 Theoretical Model

In this section we develop a simple model of college admissions. We use the model to consider how the adoption of the CA, which reduces the cost to applying to multiple colleges, alters admissions outcomes in terms of the number of applications, selectivity, and yield. We also use the model to make predictions regarding how the CA might alter the composition of students who ultimately

[4]Outside of the US, Gibbons and Vignoles (2012) study student attendance college decisions in England and find that conditional on going to college, distance is the most important factor in explaining choice of college.

[5]As of Fall 2014. See Table 309.20 of the "Digest of Education Statistics," National Center for Education Statistics (NCES), https://nces.ed.gov/programs/digest/d16/tables/dt16_309.20.asp.

enroll in terms of ability, race, and income.

Following the decentralized process of applying to college in the U.S., our model of college admissions has three distinct stages. First, students decide which colleges to apply to. Second, colleges make admissions offers. Finally, given these offers, students decide which college to attend. In the context of this model, we consider the CA, which reduces the costs of applying to a second CA institution.

4.1 Setup

There are two colleges: $c = 1$ and $c = 2$. Students receive a payoff $V_c = U_c + \varepsilon_c$ from attending college c. The first term U_c is known prior to applying and may include residency status, reflecting a preference for in-state colleges.[6] The second term, which we assume is distributed type-1 extreme value, is revealed after applying but before choosing a college. This second term could be interpreted in a variety of ways, including scholarships and financial aid offered by colleges or impressions from campus visits by students. Not attending college is also an option, with a payoff normalized to zero. There are two types of students, each representing one-half of the population. The first type prefers college 1 over college 2, the second prefers college 2 over college 1, and we assume symmetry in the expected utility gains from attending the first choice college.[7] When applying, students pay an application fee of F to the first college and a potentially lower fee ($f \leq F$) when applying to a second college. The CA can be interpreted as a reduction in f since the application developed for the first choice college can also be used for the second college.

On the supply side, colleges have a fixed capacity and can serve a fraction $0 < \kappa < 1$ of first-choice students; thus, 2κ represents overall capacity across the two institutions. These capacities, along with student applications, determine admissions rates Q_c.

4.2 Equilibrium

In the third stage, following student application decisions and university admissions offers, there are four possible student choice sets: choosing between both colleges, college 1 or 2 only, or only the outside option. The value of being accepted to both colleges equals $C_{12} = ln[exp(U_1) +$

[6] This could be due to either a preference for proximity or lower in-state tuition at public institutions

[7] That is, $U_1 - U_2 = \delta > 0$ for the first type and $U_2 - U_1 = \delta > 0$ for the second type.

$exp(U_2)+1]$.[8] Likewise, we denote $Y_{12} = exp(U_1)/[1+exp(U_1)+exp(U_2)]$ as the yield for the first-choice college and y_{12} as the yield for the second-choice college for students accepted to both. The value of being accepted to only the first choice equals $C_1 = ln[exp(U_1)+1]$, and the corresponding yield is $Y_1 = exp(U_1)/[1+exp(U_1)]$. Similar expressions apply to the value of being accepted to only the second choice (C_2) and the corresponding yield is denoted by Y_2, with $Y_1 > Y_2$.

In the second stage, taking yield as given, schools set their admission rates in order to satisfy capacity. We focus on an equilibrium in which all students apply to their first choice and a fraction b of students also apply to their second-choice college. Then, admissions rates are set in order to equate the number of student acceptances of university admissions offers to university capacity. For college 1, for example, total students acceptances equal the yield on first-choice students who are admitted to college 1 plus the yield on second-choice students who both apply to and are admitted to college 1. This must then equal the overall university capacity, as expressed below:

$$Q_1 \underbrace{[(1-b)Y_1 + bQ_2Y_{12} + b(1-Q_2)Y_1]}_{\text{yield on first-choice students}} + \underbrace{Q_1 b\,[Q_2 y_{12} + (1-Q_2)Y_2]}_{\text{yield on second-choice students}} = \kappa \tag{1}$$

Among first-choice students, a fraction $1-b$ apply to only their first choice, with yield of Y_1, and a fraction b also apply to their second choice. In the latter case, a fraction Q_2 are also admitted to their second choice, with yield of Y_{12}, and a fraction $1-Q_2$ are denied admission to their second choice, with yield for college 1 thus equal to Y_1. The second term represents yield on second-choice students, with a fraction b applying to both colleges. Among these, a fraction Q_2 are also admitted to their first choice and yield thus equals y_{12}. The remaining fraction $(1-Q_2)$ are not admitted to their first choice and yield on these students equals Y_2.

Then, working backwards to the first stage, applying to both colleges yields a value of $A_{12} = Q_1Q_2C_{12} + Q_1(1-Q_2)C_1 + (1-Q_1)Q_2C_2 - F - f$ for type 1 students. That is, students are accepted to both colleges with probability Q_1Q_2, college 1 only with probability $Q_1(1-Q_2)$, college 2 only with probability $(1-Q_1)Q_2$ and face application costs of $F+f$. For type 1 students applying to only college 1, the value equals $A_1 = Q_1C_1 - F$. In equilibrium, the fraction of students

[8] This follow the standard formula for consumer surplus in a logit model. Similar derivations apply for type 2 students, given the symmetry of the model.

applying to both colleges increases until the value from a second application equals the value of a single application ($A_{12} = A_1$). This can be written as:

$$Q_2[\underbrace{Q_1(C_{12}-C_1)}_{\text{option-value}}+\underbrace{(1-Q_1)C_2}_{\text{safety-value}}] = f \tag{2}$$

The option value from a second application represents the benefit of being able to attend college 2 when the student has been accepted to both colleges, which occurs with probability Q_2Q_1. This captures the idea that students may learn that college 2 is actually preferred to college 1 throughout the admissions process, following the realization of ε_1 and ε_2. The safety value from a second application represents the benefit of being able to choose college 2 if not admitted to college 1, and this event occurs with probability $Q_2(1-Q_1)$.

In a symmetric equilibrium, equations 1 and 2 represent two equations with two unknowns: the fraction of students applying to both colleges (b) and the university admissions rate (Q). For simplicity, we assume here a solution that is unique and interior in both b and Q, and the Appendix details the associated assumptions.[9] We provide a graphical interpretation of this equilibrium in Figure 4 and provide closed form solutions for b and Q in the Appendix. The student indifference constraint is the admissions rate at which students are indifferent between applying to only one college and applying to both colleges, as determined by equation 2. The college feasibility constraint is determined by equation 1 and requires, given capacity, a reduction in admissions rates given an increase in the number of applications received. As shown, the initial equilibrium, in admissions rate Q^* and applications rate b^* , occurs at the intersection between the student indifference condition and the college feasibility constraint.

4.3 Effect of the Common Application

We next consider a comparative static based upon a reduction in the cost of applying to a second college.

Proposition: Consider the introduction of the Common Application, with a marginal reduction in f from f=F. There are four effects: 1) application activity (the fraction b) increases,

[9] These require that application costs are small, relative to the benefits of a larger choice set and that college capacity is neither too small nor too large

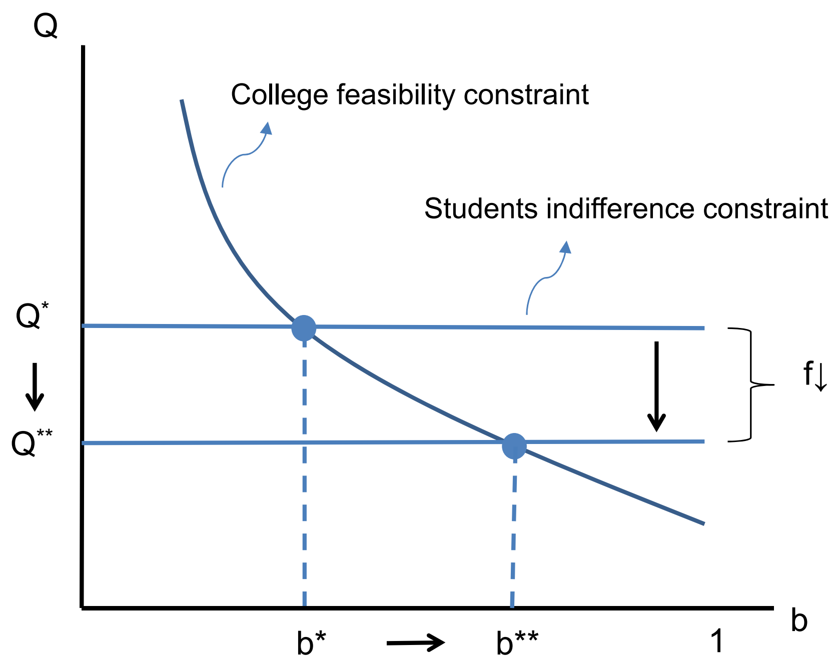


Figure 4: Theoretical Effects of Common Application

2) colleges become more selective (a reduction in Q), 3) yield falls and, despite increasing selectivity, universities accept a larger number of applications, 4) students are more likely to attend out-of-state institutions.

We provide graphical interpretation of these results in the context of Figure 4 and refer readers to the Appendix for a Proof. As shown, given a reduction in F, students are no longer indifferent between applying to one institution and applying to both institutions at the initial admissions rate.[10] Given this, admissions rates fall from Q^* to Q^{**} in order to restore student indifference, and the fraction of students applying to both colleges increases accordingly, from b^* to b^{**}. Despite the reduction in admissions rates, universities make more admissions offers in total. This results from the reduction in yield on admitted students, who tend to have larger choice sets. Finally, interpreting first-choice colleges as in-state and second-choice colleges as out-of-state, the CA leads to geographic integration, resulting from more students applying to out-of-state institutions.

[10] In the absence of any adjustment in admissions rates (Q), the CA in fact drives student application behavior to a corner solution, with all students applying to both colleges.

4.4 Extensions

We consider three extensions of the model, with details in the Appendix. The first has three colleges, two in the CA and one outside of the CA, allowing for consideration of network effects. There is now also a third state, and college 3 is located in state 3. Relative to a baseline without the CA, the introduction of the CA (with colleges 1 and 2 as members) leads to an increase in students applying to both colleges 1 and 2 but a reduction in second application activity for students whose ex-ante first choice is college 3, which is outside of the CA. Given this, there are more students from state 1 attending college 2 and, likewise, more students from state 2 attending college 1. Correspondingly, there is a reduction in students from state 3 attending colleges 1 or 2. Thus, the CA leads to network effects, with more student migration between states connected by the CA.

While we have not formally extended the model beyond three colleges, it is natural to conjecture that network effects might intensify as the size of the network grows beyond two. Suppose that the CA consists of colleges 1, 2, and 3, but not college 4.[11] In this case, the marginal value of applying to all three CA colleges, relative to the value of applying to only 1 and 2, $(A_{123} - A_{12})$ equals:

$$Q_3[\underbrace{Q_1Q_2(C_{123} - C_{12}) + Q_1(1-Q_2)(C_{13} - C_1) + (1-Q_1)Q_2(C_{23} - C_2)}_{\text{option-value}} + \underbrace{(1-Q_1)(1-Q_2)C_3}_{\text{safety-value}}] - f$$

The option value now consists of three separate cases: the student is admitted to all three colleges, only colleges 1 and 3, and only colleges 2 and 3. The safety value is comparable to before. Given this, if the costs of an additional application (f) are low, students might find it optimal to apply to all three schools in the CA instead of applying to only two. Indeed, as f, the cost of applying to an additional CA college conditional on applying to at least one CA college, goes to zero, students will either apply to all CA colleges or no CA colleges, and this logic extends beyond three colleges. Thus, the value of the CA might grow along with the number of members, leading to stronger effects of membership.

The second extension also has three colleges, two in the CA and one outside of the CA, but

[11] In this case, the value of applying to all three CA colleges (A_{123}) equals $Q_1Q_2Q_3C_{123} + Q_1Q_2(1-Q_3)C_{12} + Q_1(1-Q_2)Q_3C_{13} + (1-Q_1)Q_2Q_3C_{23} + Q_1(1-Q_2)(1-Q_3)C_1 + (1-Q_1)Q_2(1-Q_3)C_2 + (1-Q_1)(1-Q_2)Q_3C_3 - F - 2f$.

also considers heterogeneous students. We label them low-ability and high-ability here, but a race-based interpretation is also provided below. Colleges want to attract as many high-ability students as possible and admit them with probability one. Low-ability students are then admitted at an endogenous admissions rate to fill remaining capacity. In equilibrium, high ability students disproportionately attend CA schools and low-ability students disproportionately attend schools outside of the CA, resulting from increased application activity among high ability students at CA schools.[12] Thus, the CA increases stratification, with high ability students disproportionately attending CA schools. While this second extension focuses on student ability, colleges might also value other student attributes, and the extension can naturally handle any such attribute. Colleges valuing racial diversity, for example, might be able to enroll a higher fraction of non-white students via an increase in the size of this applicant pool via the CA. Given these predictions, our empirical analysis investigates the effect of joining the CA on both test scores and the racial composition of the student body.

The third extension also has three colleges, two in the CA and one outside of the CA, but considers a different source of student heterogeneity, namely applicant income. In particular, we consider an extended model with two types of application costs, financial and time. The financial cost, which includes the application fee, is unchanged under the CA. The time cost, by contrast, of applying to a second CA college falls when the CA is adopted. We also consider two types of students. For high-income students, time costs are more salient; for low-income students, financial costs are more salient. Given this, high-income students are more responsive, in terms of applying to multiple colleges, under the CA, given the reduction in time costs but not financial costs. Thus, schools joining the CA are predicted to disproportionately attract high-income applicants, and to ultimately enroll more high-income students, relative to schools not in the CA.[13] We investigate this prediction below with data on Pell grants.

[12] Although there is no safety value motivation, given that these high ability students are admitted to their first choice with certainty, there remains an option value from additional applications.

[13] Colleges might also have preferences over diversity in terms of student income. It is less clear, however, whether colleges would have a preference for high-income students, who could benefit the school financially by paying full tuition, or low-income students, who could increase socioeconomic diversity.

4.5 Welfare

As noted in the introduction, many countries use more centralized systems for college admissions. Given this, it is natural to ask whether the CA increases student welfare in the context of our model. While the CA does reduce frictions and thus tends to increase student choice, it does not necessarily increase student welfare. In fact, the CA strictly reduces ex-ante welfare in our baseline model. Recall that, in equilibrium, students are indifferent between applying to both colleges and applying to only one college, which equals $A_1 = Q_1 C_1 - F$. Importantly, this value A_1 declines under the CA. This is due to the fact that the value of admission (C_1) and the cost of applying to a single college (F) are both unchanged and the probability of admission (Q_1) falls. This knock-on effect associated with reduced acceptance rates leads to increased competition for a fixed number of slots. Since all students are indifferent between submitting one application and submitting two, it follows that all students are worse off ex-ante.

In our two extensions with heterogeneous students, there are winners and losers under the CA. Students with high test scores are strictly better off since they are guaranteed admission and have a larger choice set under the CA. Students with lower test scores and whose first choice is a CA member, by contrast, are worse off due to CA colleges becoming more selective. Likewise, in our extension to income, low-income students are strictly worse off while high-income students might be better off. An additional issue is that our model does not incorporate other possible benefits of the CA, such as a reduction in information frictions and an increase in overall college attendance. Both of these features might lead the CA to increase overall welfare.

In summary, it is not obvious that the CA increases welfare. In fact, the CA strictly reduces welfare in our baseline model. Under less stylized models, there are likely to be both costs and benefits associated with expanding the size of the consortium. Finally, our model does not incorporate several possible benefits of the CA, such as a reduction in information frictions and an increase in overall college attendance.

4.6 Summary

Our model suggests that the introduction of the CA increases applications and reduces admissions rates. Likewise, the CA reduces yield and increases the number of admitted students. There is an increase in out-of-state attendance, especially from other CA states. Finally, the CA can lead to a change in the composition of students. If schools have preferences for high ability students and diversity, then schools joining the CA will have more enrollees with high test scores, and more non-white enrollees. The reduction in time costs could also increase enrollment from high-income students. The CA strictly reduces ex-ante welfare in our baseline model but can lead to winners and losers under the model extensions.

5 Empirical Analysis

To test the model predictions, we next consider how admissions outcomes and student demographics change when an institution joins the CA. We first describe the data and our empirical approach. We then present the key empirical results with respect to aggregate admissions outcomes, including applications, yield, admits, and selectivity. After addressing issues of geographic integration, we then turn to the question of whether and how the CA might change the composition of students.

5.1 Data

Our primary data source is the College Board's Annual Survey of Colleges, covering the years 1990-2016. These data include information on both admissions outcomes (the number of applications, admits, and subsequent freshman enrollment) and demographics of the entering student body (fraction out-of-state, SAT scores at the 25th and 75th percent level, and percent non-white). We focus on four-year institutions, both public and private, and the unit of observation is an institution-year pair. Summary statistics are provided in Appendix Table A1. As shown, institutions receive 4,462 applications on average, admit 2672 students, and enroll 931 students. Acceptance rates average 70 percent across institutions and years, and yield, the fraction of admissions offers accepted by students, averages 41 percent. The fraction of out-of-state enrollment averages 31 percent, and the fraction of non-white students in the freshmen class averages 32 percent. The College Board panel is unbalanced since institutions do not respond to the survey every year. The median institution is included in 24 out of 27 surveys, and two-thirds of institutions are included in at least 21 surveys.

To examine the effects of the CA on admissions and enrollment outcomes, these data are combined with the year in which each university became a member of the CA.[14] Finally, we also use two other data sources. First, we downloaded data on the number of students receiving Pell grants by institution and year from the Department of Education.[15] Second, the Integrated Postsecondary Education Data System (IPEDS) has information on state-to-state student migration conducted biennially from 1986 to 2014, and we use these data to study network effects. In this case, the unit of observation is an institution by source state by year.

5.2 Identification Strategy

We use two estimating equations in most of our analysis: a regression model with a constant coefficient and an event study specification. The regression model relates an outcome y_{ct} (e.g., applications) to an indicator for CA membership in year t (CA_t) as follows:

$$ln(y_{ct}) = \beta CA_{ct} + \mu_c + \mu_t + \varepsilon_{ct} \tag{3}$$

where c indexes colleges, μ_c is a college fixed effect, and μ_t is a year fixed effect. Then, given the log specification, the parameter β captures the percent change in outcomes when joining the CA, after controlling for time effects and university effects.

Our event study specification is designed to measure the timing of any effects of entry and is given by:

$$ln(y_{ct}) = \underbrace{\sum_{k=-K}^{k=-1} \beta_{t+k} 1(t - J_c = k)}_{\text{pre-entry}} + \underbrace{\sum_{k=0}^{k=K} \beta_{t+k} 1(t - J_c = k)}_{\text{post-entry}} + \mu_c + \mu_t + \varepsilon_{ct} \tag{4}$$

where J_c is the year college c joined the Common App and $1(t - J_c = k)$ indicates that college c joined the CA k years ago (or will join in the future when k is negative). We normalize β_{t-1} to

[14] The entry year for current CA members was provided to us by The Common Application organization. The organization could not provide us with entry information for previous members and also only provided us with the most recent entry year for schools that left and then re-joined. They noted to us that it is uncommon for schools to leave the CA and even more rare for schools to then re-join at a later time.

[15] These data were downloaded from https://www2.ed.gov/finaid/prof/resources/data/pell-institution.html (accessed March 1, 2020).

zero and hence the key parameter β_{t+k} captures the effect of joining the CA at time t on outcomes at time $t+k$, relative to outcomes at time $t-1$.

A key threat to identification in our analysis is that joiners might have different pre-trends relative to the comparison group, which includes both schools that never join during our sample period and schools that will join in the future but before the end of our sample period. To address this concern, we also implement an alternative identification strategy in which, similarly to Deshpande and Li (2019), we compare outcomes for joiners to outcomes for colleges that will join the CA in the near future.[16] The key idea behind this approach is that schools that join in the near future are more comparable than schools joining in the more distant future and schools that never join the CA during our sample period. More specifically, for each school that joins, we construct a control group that includes colleges that will join three to five years into the future. To ensure that the control group does not join during the relevant window, we analyze outcomes over a six-year window, including the three years before joining, the join year, and the two years after joining. For example, for a school joining in 2000, the comparison group includes colleges that join in 2003, 2004, and 2005, and we analyze outcomes over the 1997-2002 period. We present both regression estimates with a single coefficient as well as event studies based upon this restricted control group of schools that will join in the near future. More details are provided in the Online Appendix Section A.10.

Comparing the two approaches, our baseline approach has two key advantages. First, it is based upon a larger sample size, both in terms of the number of institutions and the time span analyzed per institution. Second, our baseline strategy is better able to detect any long-run effects of joining the CA given that the analysis focuses on a longer time span. The key advantage of the alternative strategy, based upon a control group of future joiners, is that the control group is arguably more comparable since it is based upon colleges that will join in the near future. In addition, the control group is fixed, whereas the comparison group in our baseline analysis changes over time for each school that joins during our sample period.

[16] Deshpande and Li (2019) estimate the effects of Social Security Administration field office closings on local disability recipients by comparing areas where a field office closed to areas where an office closed several years later.

5.3 Admissions Outcomes

We begin our investigation of the effect of joining the CA by examining the number of applications using the College Board data.[17] As shown in the first column of Table 1, we find that applications are 12 percent higher after a college joins the CA, relative to the period before they joined the CA. This economically and statistically significant result is consistent with the CA reducing frictions in college admissions via a reduction in the cost of applying to multiple universities that use the CA. Results are similar when restricting the control group to future joiners, as shown in the first column of Table 2.

To investigate the role of pre-trends and to consider any dynamic effects of joining the CA, we next present results from the corresponding event study specification.[18] As shown in the left panel of Figure 5, which includes 95 percent confidence interval bars, there is a slight downward trend in applications just before a school joins the CA. After joining the CA, by contrast, there is a discontinuous 10 percent increase in the number of applications received. Moreover, the effect grows over time, rising to roughly 25 percent after one decade in the CA. There are at least two possible reasons why the effects might increase over time. First, the effect could be increasing over time due to the design of the platform, with, for example, the internet playing a large role in the success of the CA today, relative to the early days of the CA, when applications were still submitted on paper. Second, there could be network effects, with larger effects associated with joining the CA as the number of other CA members increases over time. We investigate this possibility of network effects in more detail below. When restricting the control group to future joiners, as shown in the right panel of Figure 5, there are no pre-trends in the number of applications received. Applications again spike by 10 percent in the join year, with some evidence again that the effect of joining the CA grows over time, reaching 15 percent just two years after schools join the CA.

We next investigate whether entry into the CA has led to a decrease in yield, defined as the fraction of admissions offers accepted by students. As shown in column 2 of Table 1, there is a 9 percent reduction in yield after a college joins the CA, relative to the period before they joined the CA, and this effect is statistically significant at conventional levels. In the context of our model, this finding is consistent with the CA increasing student choice via a reduction in frictions as-

[17] Standard errors are clustered at the institution level.

[18] As noted above, we normalize the coefficient one year before joining to zero ($\beta_{t-1} = 0$).

sociated with submitting college applications to multiple CA schools. Results are similar when restricting the control group to future joiners, as shown in column 2 of Table 2. Figure 6 shows the event study specifications for yield. As shown in the left panel of Figure 6, there is an immediate and discontinuous drop after a college joins the CA, with yield falling by roughly 7 percent. This effect again becomes more pronounced over time, with a 15 percent reduction in yield one decade after joining the CA. This dynamic effect could again be driven by either the CA becoming more powerful over time or by network effects associated with an increase in the number of CA members. Finally, as shown in the right panel of Figure 6, results are similar when restricting the control group to future joiners, with an immediate 7 percent reduction in the join year and a 10 percent reduction just two years after joining.

Given this reduction in yield, colleges might need to increase the number of admitted students in order to satisfy their capacity, as discussed in the theoretical model. As shown in column 3 of Table 1, we indeed find a large 11 percent increase in the number of admitted students in our baseline regression. When restricting the control group to future joiners, as shown in column 3 of Table 2, we document a somewhat smaller effect. But this 9 percent increase remains economically and statistically significant. As shown in the event study for the full sample (left panel of Figure 7), there is a discontinuous 10 percent increase in admits upon joining, and the effect again increases over time, rising to 20 percent after 10 years. When restricting the control group to future joiners, as shown in the right panel, we again document a discontinuous increase, with further evidence of an increasing effect after just two years, from roughly 8 percent to 12 percent.

Finally, we investigate whether selectivity has changed, as measured via acceptance rates. Here the results are more mixed. When analyzing the full sample via a regression, we find no evidence of a change in selectivity, as shown in column 4 of Table 1. When restricting the control group to future joiners, by contrast, we document a 3 percent reduction in acceptance rates (column 4 of Table 2), and this difference is statistically significant at conventional levels. The event study for the full sample, in the left panel of Figure 8, documents a small drop in the acceptance rate after joining and larger effects in the years following CA adoption, with a 5 percent reduction in acceptance rates 10 years after joining the CA. When restricting the control group to future joiners, as shown in the right panel of Figure 8, we document a sharp 2 percent reduction in acceptance rates upon joining, and the effect is stable over time in this case.

To summarize, we find strong evidence that CA entry increased the number of applications, consistent with reduced frictions, and reduced yield, consistent with large student choice sets. We find mixed evidence regarding a hypothesized fall in acceptance rates but strong evidence that the number of admitted students increased.

Table 1: CA Entry and Admissions Outcomes

	(1) Log Applications	(2) Log Yield	(3) Log Admits	(4) Log Selectivity
CA member	0.1204***	-0.0868***	0.1138***	-0.0067
	(0.0201)	(0.0130)	(0.0204)	(0.0110)
Observations	34519	34360	34556	34468
Clusters	1632	1631	1632	1632

All specifications include institution and year FE.
Standard errors clustered by institution (unitid).

Table 2: CA Entry and Admissions Outcomes: Future Joiners Control

	(1) Log Applications	(2) Log Yield	(3) Log Admits	(4) Log Selectivity
CA member	0.1183***	-0.0805***	0.0909***	-0.0277***
	(0.0142)	(0.0115)	(0.0125)	(0.0078)
Observations	9678	9652	9678	9672
Clusters	496	496	496	496

All specifications include institution FE, year FE, and a joiner indicator.
Standard errors clustered by institution (unitid).

Figure 5: CA Entry and Applications

(a) Full Sample

(b) Future Joiners Control

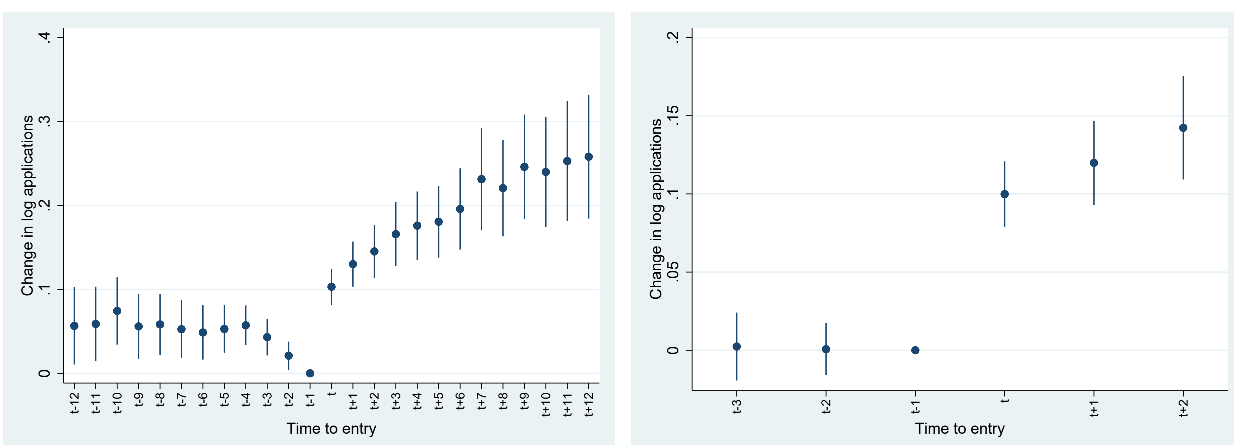
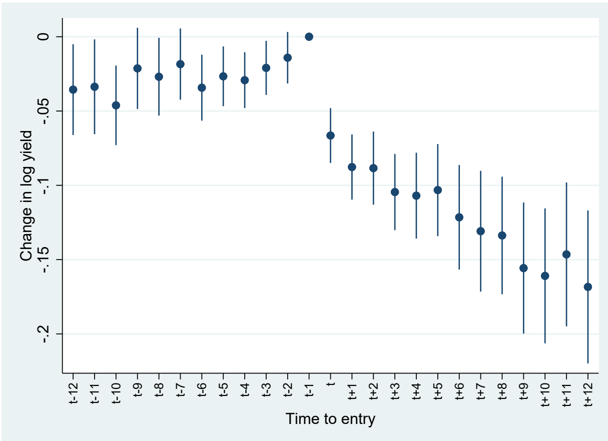


Figure 6: CA Entry and Yield

(a) Full Sample



(b) Future Joiners Control

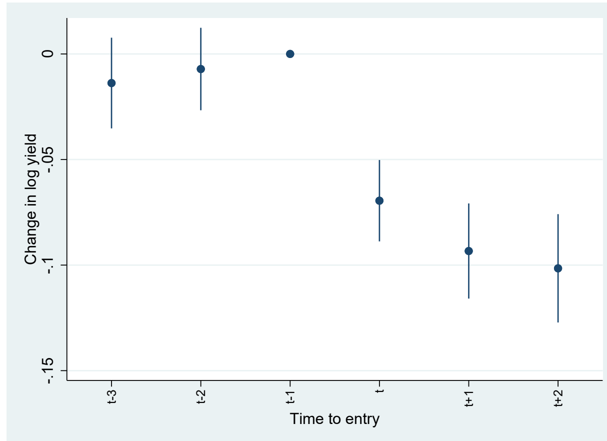
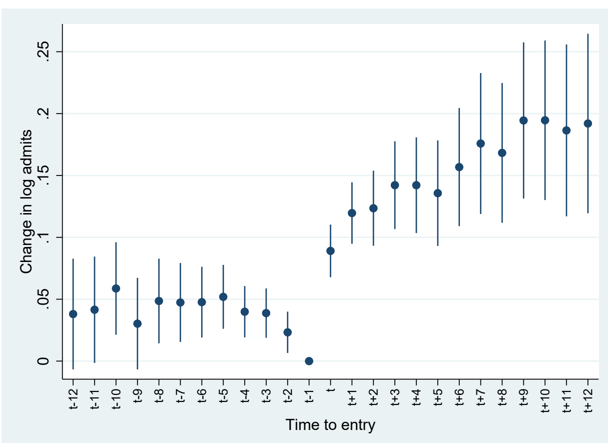


Figure 7: CA Entry and the Number of Admits

(a) Full Sample



(b) Future Joiners Control

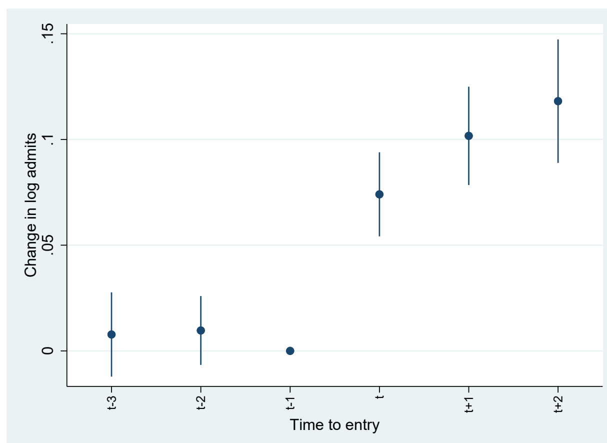
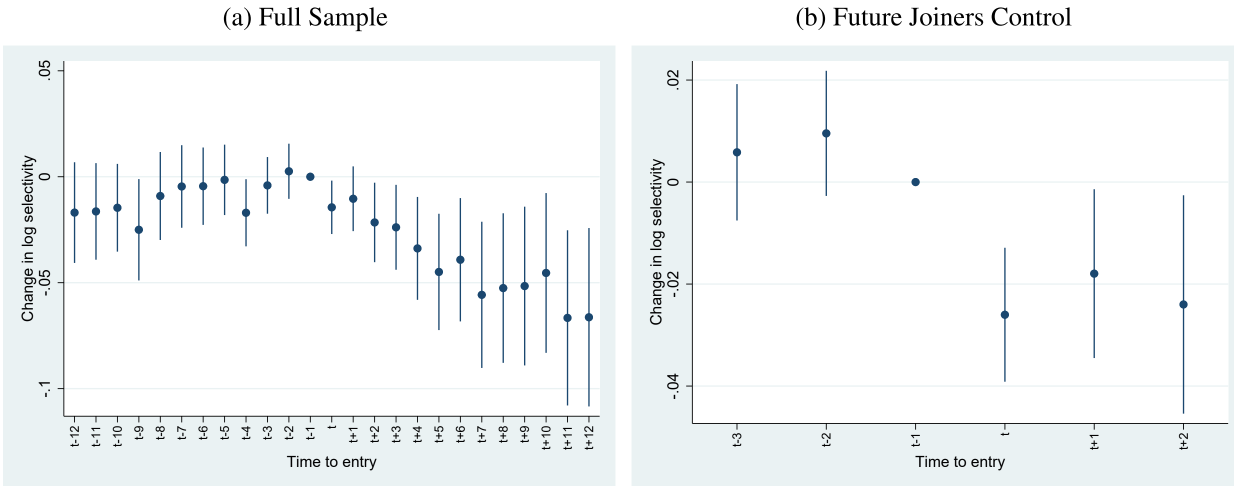


Figure 8: CA Entry and Selectivity



5.4 Geographic Integration

Given the documented reduction in frictions and increased student choice sets, we next examine the role of the CA in contributing towards recent trends in geographic integration. In the Appendix, we first provide evidence that the geographic integration documented by Hoxby (2000), covering the period 1949-1994, has continued into our sample period. In particular, we find an increase over time in the average distance traveled by students and an increase in the fraction of out-of-state students.

Using College Board data, we measure the extent to which the CA has contributed towards these trends in geographic integration. As shown in column 1 of Table 3, the fraction of out-of-state students rises by 1.4 percentage points in the years after joining, a roughly 5 percent increase relative to the sample average of 30 percent out-of-state. When restricting the control group to future joiners, we document an increase of roughly 0.8 percentage points, as shown in column 1 of Table 4. The corresponding event study for the full sample, as reported in the left panel of Figure 9, documents an immediate increase in the fraction of out-of-state enrollment of roughly 1 percentage point following a school joining the CA, and this effect roughly doubles, to 2 percentage points, 10 years after joining the CA. When restricting the control group to future joiners, we find smaller increases of roughly 0.5 percentage points, and these estimates are less precise due to the smaller sample size.

In the Appendix, we document similar results using our data on student migration from IPEDS. In particular, CA entry leads to an increase in out-of-state students. In addition, IPEDS includes information on state-to-state migration of college students, and we use this information to measure the average distance that students travel to attend college. We find that entry into CA does increase distance traveled, and this effect largely comes from an increase in attendance from nearby states.

To summarize, we find, that the CA has contributed towards geographic integration, with an increase in the fraction of out-of-state students when a school joins the CA. This is consistent with the predictions of our theoretical model, under which the CA induces more students to apply to and ultimately attend out-of-state institutions following a reduction in the costs of applying to multiple institutions. Below we consider the source of these out-of-state students via an investigation of network effects associated with the CA.

Table 3: CA Entry and Student Profiles

	(1) Out-of-State%	(2) SAT 25th Pctile	(3) SAT 75th Pctile	(4) Enroll % non-White	(5) Ugrad Enroll % Pell
CA member	0.0136***	4.4189	9.8235***	0.0082**	-0.0242***
	(0.0045)	(2.7833)	(2.5404)	(0.0039)	(0.0048)
Observations	37621	28504	28510	27494	26782
Clusters	1597	1428	1428	1567	1762

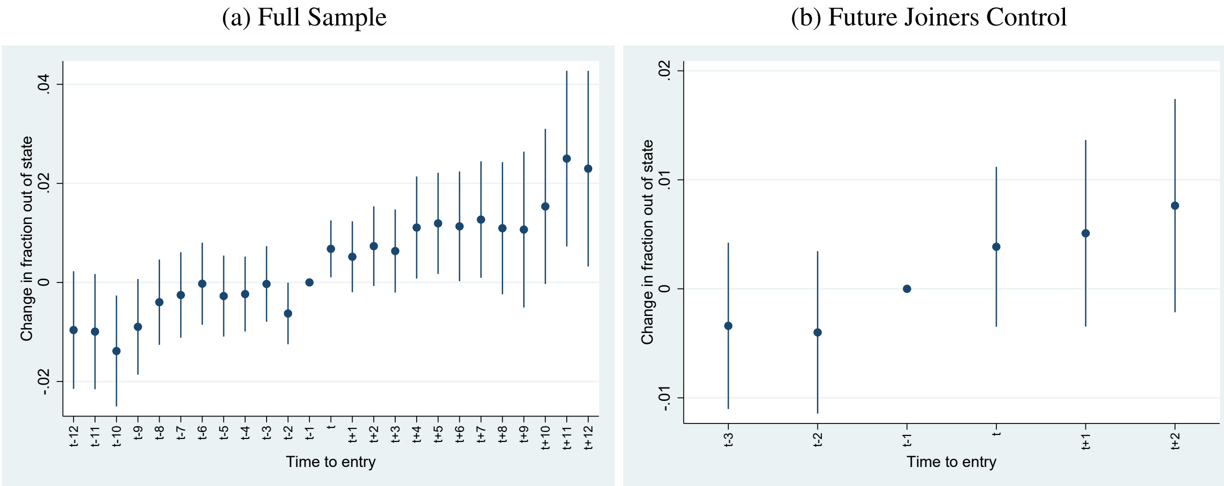
Cols 1-4 use CB data; Col 5 uses separate Pell and IPEDS data.
All specifications include institution and year FE.
Standard errors clustered by institution (unitid).

Table 4: CA Entry and Student Profiles: Future Joiners Control

	(1) Out-of-State%	(2) SAT 25th Pctile	(3) SAT 75th Pctile	(4) Enroll % non-White	(5) Ugrad Enroll % Pell
CA member	0.0077**	1.2630	1.3616	0.0163***	-0.0073*
	(0.0034)	(1.8955)	(1.8921)	(0.0049)	(0.0044)
Observations	9752	9081	9081	8237	8229
Clusters	492	480	480	487	468

Cols 1-4 use CB data; Col 5 uses separate Pell and IPEDS data.
All specifications include institution FE, year FE, and a joiner indicator.
Standard errors clustered by institution (unitid).

Figure 9: CA Entry and Out-of-State Enrollment



5.5 Network Effects

Given the network effects predicted by an extension of the theoretical model, we hypothesize that the effects of the CA should be increasing in the size of the network.[19] We investigate these issues by examining the outcomes described above but by also including in our regressions an interaction term between CA membership and network size, defined as the number of CA members in year t.

As shown in the first column of Table 5, we find that increasing the size of the network by 100 members increases the effect of CA membership on applications by 1.3 percent. For example, joining the CA at the beginning of our sample period, with roughly 100 members, increases applications by 8.5 percent. By the end of our sample period, by contrast, when the CA had 700 members, joining the CA increases applications by over 16 percent. We do not find any evidence of network effects when studying yield, as shown in column 2 of Table 5, and we find some evidence of reverse network effects when examining the number of admits, as shown in column 3 of Table 5. When measuring selectivity, by contrast, we find strong evidence of network effects, as shown in the final column of Table 5, with larger reductions in acceptance rates as the number of CA members grows.

We next study network effects in the context of geographic integration. As shown in column 1 of Table 6, we find that the effect of CA membership is increasing in network size. For example,

[19] For an overview of network effects in two-sided markets, see Rysman (2009).

joining the CA at the beginning of our sample period, with roughly 100 members, increases the fraction of out-of-state students by only 0.5 percentage points. By the end of our sample period, by contrast, when the CA had 700 members, joining the CA increases out-of-state enrollment by approximately 2.5 percentage points.

Table 5: CA Entry, Network Size, and Admissions Outcomes

	(1) Log Applications	(2) Log Yield	(3) Log Admits	(4) Log Selectivity
CA member	0.0726**	-0.1155***	0.1933***	0.1220***
	(0.0304)	(0.0262)	(0.0342)	(0.0240)
CA X network	0.0131*	0.0079	-0.0217**	-0.0352***
	(0.0077)	(0.0067)	(0.0086)	(0.0058)
Observations	34519	34360	34556	34468
Clusters	1632	1631	1632	1632

All specifications include institution and year FE.
Standard errors clustered by institution (unitid).
Network size measured in 00's; average is 325 schools.

Table 6: CA Entry, Network Size, and Student Profiles

	(1) Out-of-State%	(2) SAT 25th Pctile	(3) SAT 75th Pctile	(4) Enroll % non-White	(5) Ugrad Enroll % Pell
CA member	0.0015	-6.0308	-21.7286***	0.0044	0.0480***
	(0.0074)	(5.2642)	(4.8148)	(0.0065)	(0.0075)
CA X network	0.0033*	2.9767**	8.9885***	0.0010	-0.0184***
	(0.0019)	(1.2973)	(1.2274)	(0.0016)	(0.0018)
Observations	37621	28504	28510	27494	26782
Clusters	1597	1428	1428	1567	1762

All specifications include institution and year FE.
Standard errors clustered by institution (unitid).
Cols 1-4 use CB data; Col 5 uses separate Pell and IPEDS data.
Network size measured in 00's; average in CB data is about 325 schools.
IPEDS starts in 1999, average network size is 350 schools.

We further examine the role of network effects in geographic integration using data on the source state of enrollment. Recall that the extension of our theoretical model to three colleges predicts that institutions joining the CA are likely to see a greater increase in applications from students in states that already have a significant number of CA colleges. For example, if New York has high CA penetration (i.e., many New York schools in the CA), then we might expect that UW-Madison will attract more New York students after joining the CA since these New York students are already using the platform to apply to CA colleges in New York.

To examine these issues around the CA and student migration from source to destination states, we use IPEDS biennial migration data. We provide two measures of CA penetration (P_{st}), one based upon the fraction of colleges in source state s at time t that are members of the CA and one that is similar but weighted by college enrollment, recognizing that large colleges naturally receive more applications and are thus more salient to applicants from source state s. We then add this penetration measure and an interaction with the CA entry indicator to our two-way fixed effects specification, where the dependent variable is the number of freshmen (N_{sct}) from source state s attending college c at time t. This interaction term provides a test of whether enrollment from high CA penetration states increases when college c joins the CA. In our specification, the unit of observation is now a college by source state by year, and we thus include college by source state fixed effects and source state by time fixed effects:

$$ln(N_{sct}) = \beta_1 CA_{ct} + \beta_2 P_{st} + \beta_3 CA_{ct} \times P_{st} + \mu_{sc} + \mu_{st} + \varepsilon_{sct} \quad (5)$$

The key parameter of interest, β_3, captures the increase in enrollment from states with high CA penetration when a college joins the CA, after controlling for differences across states according to CA penetration and overall differences across colleges in CA membership.

As shown in column 1 of Table 7, the coefficient on the interaction between CA membership and CA penetration is positive and statistically significant, suggesting that the increase in applications upon joining the CA is derived from students applying to other CA schools. In terms of the magnitude of the effect, schools joining the CA enroll 3 percent more students from source states with no CA penetration but over 20 percent more students from source states with complete CA penetration (i.e., $P_{st} = 1$). This positive interaction effect is robust to restricting the control group to future joiners (column 2), using the full sample but weighting CA penetration by enrollment (column 3), and both restricting the control group to future joiners and using the weighted penetration measure (column 4).

Table 7: CA Entry, Network Size, and Source States

	(1) Log Enrollment	(2) Log Enrollment	(3) Log Enrollment	(4) Log Enrollment
CA member	0.0338***	0.0026	0.0371***	0.0088
	(0.0102)	(0.0094)	(0.0101)	(0.0089)
CA member x CA penetration	0.1767***	0.1648**		
	(0.0419)	(0.0635)		
CA member x CA penetration wtd			0.1138***	0.0824*
			(0.0223)	(0.0330)
Observations	1052079	447984	1052079	447984
Clusters	1652	498	1652	498

Cols 1+3 use full IPEDS sample; Cols 2+4 use joiners only.
All specifications include institution-source and year-source FE; Cols 2+4 also include joiner indicator.
Standard errors clustered by institution.

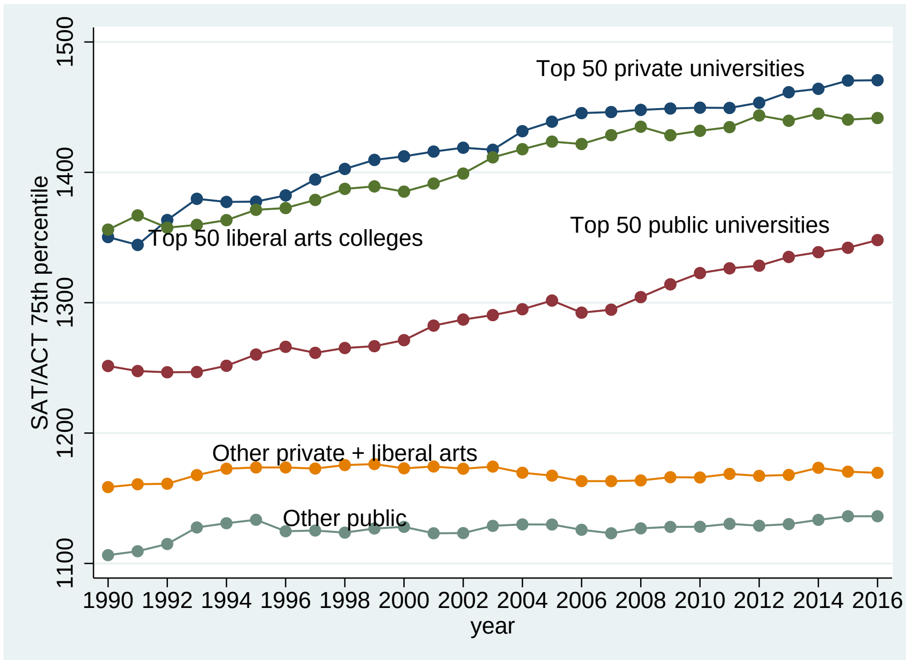
5.6 Stratification

Our final research question involves whether the CA changed the types of students enrolling at institutions. We investigate heterogeneity along three dimensions: test scores, race, and income. First, given the reduction in frictions, the increased student choice sets, and geographic integration, we investigate whether the CA has contributed towards a widening of the gap between more selective and less selective institutions. Second, to the extent that colleges value racial diversity, they might be able to re-shape the racial composition of their student body due to the larger applicant pool after joining the CA. Third, motivated by our theoretical extension that considers income, we investigate whether joining the CA increases the fraction of high-income students enrolling at the university.

5.6.1 SAT scores

We begin by documenting general trends in SAT scores at different types of institutions. To do so, and in parallel with Figure 2, we classify schools into five categories: top 50 liberal arts, top 50 private, top 50 public, other private and liberal arts, and other public. As shown in Figure 10, there is a large and increasing gap in SAT/ACT scores at the 75th percentile between selective schools (top 50 liberal arts, top 50 private, and top 50 public), and less selective institutions over our sample period. Thus, there is evidence of increasing stratification in general during our sample period.

Figure 10: Stratification in Higher Education



Given that the CA is disproportionately used by selective institutions, as documented above, we next investigate the degree to which the CA has contributed to this widening of the gap between more selective and less selective institutions. As shown in columns 2 and 3 of Table 3, there is a general increase in SAT scores of enrolled freshman following entry into the CA. In particular, SAT scores at the 25th percentile increase by 4.4 points and SAT scores at the 75th percentile increase by 9.8 points, although only the latter effect is statistically significant.[20] When restricting the control group to future joiners, the results remain positive but are now statistically insignificant, as shown in columns 2 and 3 of Table 4. Figure 11 (both panels) suggests that SAT scores do not increase at the 25th percent level. Figure 12, by contrast, documents increases in SAT scores at the 75th percentile upon CA entry, although there is evidence of pre-trends when using the full sample (left panel) and the results lack precision when restricting the control group to future joiners (right panel).

[20]One interpretation of the difference in effects between the 25th and 75th percentile, in the context of our theoretical extension to heterogeneous student ability, is that the fraction of high ability students is small. In this case, only the top of the distribution of SAT scores would change following entry into the CA, and the bottom of the distribution would be unaffected since it is composed of low-ability students regardless of CA membership.

Figure 11: CA Entry and SAT 25

(a) Full Sample (b) Future Joiners Control

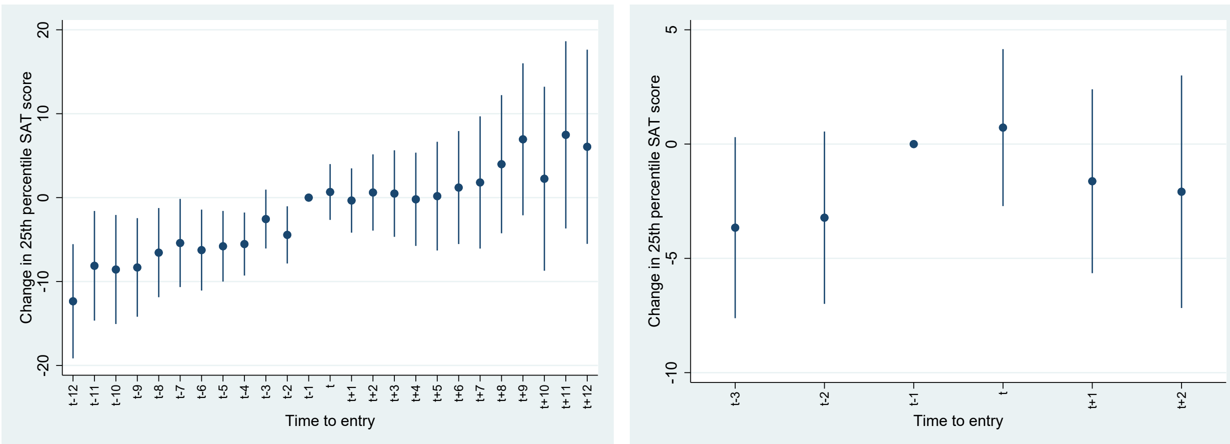
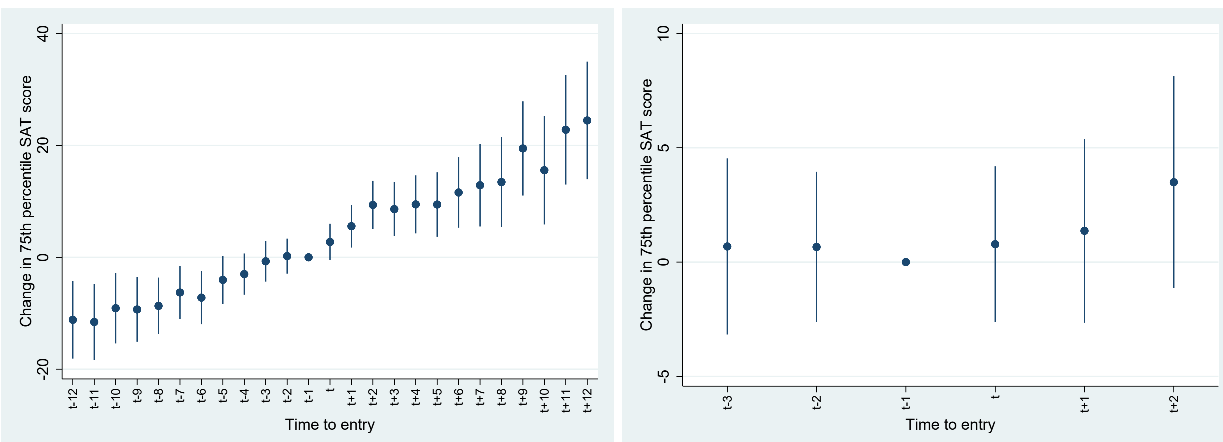


Figure 12: CA Entry and SAT 75

(a) Full Sample (b) Future Joiners Control



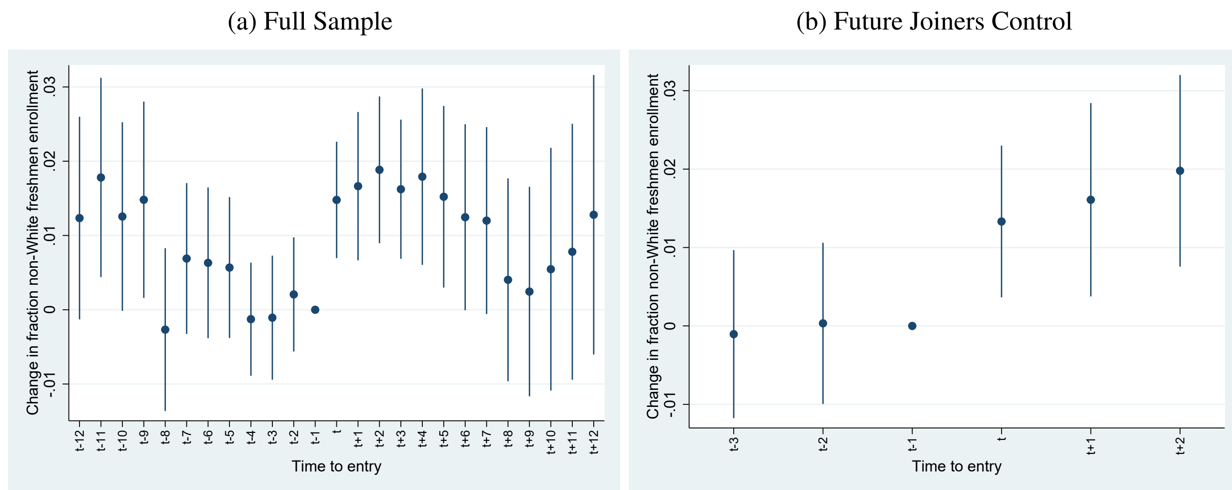
5.6.2 Racial composition

Given that universities tend to value racial diversity, they might be able to use the larger applicant pool after joining the CA to increase the fraction of non-white students.[21] While we do not have any data on the racial composition of the applicant pool, we can examine the racial composition of the entering class. As shown in column 4 of Table 3, we document an increase of nearly 1

[21] Arcidiacono and Lovenheim (2016) review the literature measuring the degree of racial preferences in admissions and note that less selective institutions have less scope for such preferences given that they tend to admit a large fraction of applicants.

percentage point in the fraction of non-white students following CA entry, relative to the sample average of 32 percent. Restricting the control group to future joiners, we document a 1.6 percent increase in the fraction non-white in the entering class, as shown in column 4 of Table 4. The full sample event study, as shown in the left panel of Figure 13, documents a discontinuous increase in the fraction non-white in the year of entry. The results are generally noisy, however, and statistically insignificant starting eight years after CA entry. When restricting the control group to future joiners (right panel of Figure 13), the results are cleaner, with no pre-trends, a discontinuous increase of over 1 percentage point at time of entry, and stable effects thereafter.

Figure 13: CA Entry and Fraction Non-White

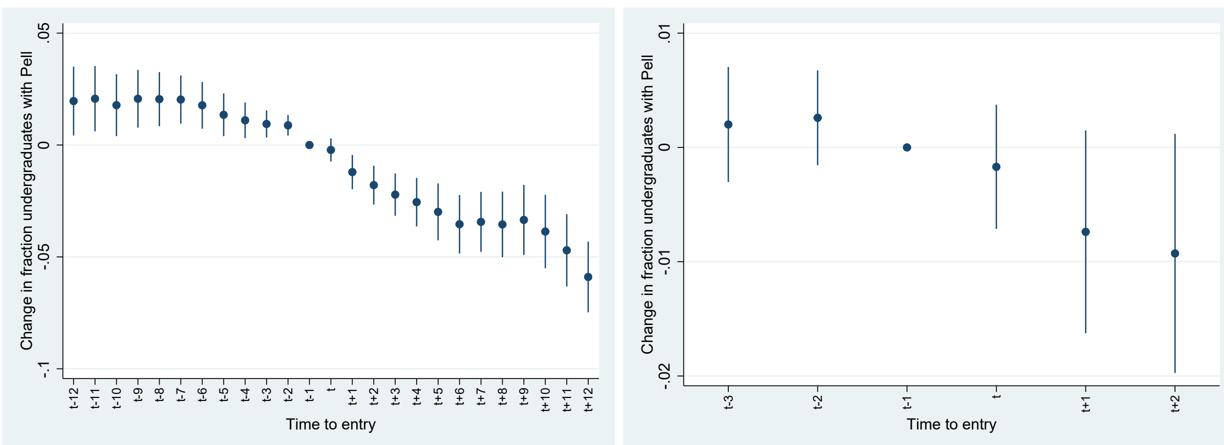


5.6.3 Income distribution

As predicted by our theoretical extension to income, higher-income students might be more responsive to the CA, relative to low-income students, for whom financial costs associated with applying are more salient. To measure the fraction of low-income students, we use data on the fraction of students with Pell grants. Importantly, while our previous measures are based upon the entering freshman class, these measures of Pell grants are based upon the entire student body. Given this, we do not expect to see discontinuous changes upon entry and instead expect to see more gradual changes in outcomes following CA entry. As shown in column 5 of Table 3, we find a reduction in percent Pell of 2.4 percentage points, a large effect relative to the baseline of 43 percent. When restricting the control group to future joiners, we find smaller effects, a 0.7 percentage point reduction, and these effects are statistically significant at the 90 percent level. Event studies using the full sample, as shown in the left panel Figure 14, document gradual declines in percent Pell, with a reduction of roughly 5 percentage points one decade after joining the CA. Likewise, when restricting the control group to future joiners, we document a gradual decline, with a reduction of one percentage point two years after joining the CA. As noted above, gradual, rather than discontinuous, declines are consistent with the fact that the Pell data cover all enrollees and not just first-year students.

Figure 14: CA Entry and Fraction Receiving Pell Grants

(a) Full Sample (b) Future Joiners Control



5.6.4 Summary

We find that the CA leads to changes in the degree of diversity on campus. Regarding SAT scores, CA colleges tend to be more selective with higher test scores at baseline. We find some evidence that SAT scores increase when joining the CA but those results are imprecise; if there is an effect of the CA on stratification by test scores, it is an increase. We find stronger evidence that the CA increases racial diversity, with a robust increase in the fraction of non-white students. Given that CA members tend to have fewer non-white students prior to joining the CA, as shown in Table 9, the CA has reduced racial stratification. Finally, we also find evidence that the CA reduces income diversity, with a documented reduction in the fraction of students receiving Pell grants. Given that CA members tend to have higher income students prior to joining the CA, as shown in Table 8, the CA has increased stratification according to income.

Table 8: CA Membership, Race, and Income

	Never joiners	Current CA members	Future CA members
Percent non-white (1990)	25.0	17.7	21.5
Percent Pell (1999)	44.1	19.3	33.2

5.7 Other Outcomes

While we have attributed our results to the Common Application, it remains possible that the CA was adopted as part of a larger institutional strategy to increase applications and to change the composition of the student body. Thus, the effects that we have attributed to joining the CA might instead reflect other changes in institutional strategy adopted at the same time as CA entry.

To address this issue, we next explore changes in other university policies and outcomes. While we lack data on university recruiting and outreach, we do attempt to examine three other potential aspects of larger institutional strategy. First, it could be the case that universities want to expand their size and adopt the CA at the same time in order to increase the size of their applicant pool. Second, universities might have attempted to increase the quality of instruction at the same time as CA adoption. Finally, in an effort to increase the number of applications, admissions offices might have both joined the CA and reduced application fees.

As shown in column 1 of Table 9, we find some evidence of universities increasing their size when joining the CA, with an 3.7 percent increase in enrollment, when analyzing the full sample.[22] When restricting the control group to future joiners in column 4, however, we do not find any increases in the size of universities. Likewise, the event study documents an increase when using the full sample (left panel of Figure 15) but a small increase or no increase when restricting the control group to future joiners.

To investigate the quality of instruction, we use data on the number of PhD faculty. As shown in columns 2 of Table 9, we do not find any changes in the log number of PhD faculty upon CA entry, and results are similar when restricting the control group to future joiners (column 5). Event studies, as shown in Figure 16, also do not document any changes in the number of PhD faculty when a school joins the CA.

Finally, we investigate whether the application fee changes upon CA entry. As shown in column

[22] It is also possible that this result reflects university size being below capacity prior to joining the CA.

3 of Table 9, application fees, if anything, tend to increase upon CA entry, with a statistically significant increase in application fees of $1.64 when examining the full sample and a statistically insignificant increase of $0.69 when restricting the control group to future joiners. Event studies, as shown in Figure 17, are inconclusive in this case.

Taken together, we find little evidence that joining the CA is part of a larger institutional strategy to increase the number of applications. We do find some evidence that enrollment grows upon CA entry but no evidence of changes in instructional quality or application fees, which, if anything, tend to increase.

Table 9: CA Entry and Other Outcomes

	(1) Log Enrollment	(2) Log PhD Faculty	(3) Application Fee	(4) Log Enrollment	(5) Log PhD Faculty	(6) Application Fee
CA member	0.0372**	0.0055	1.6358**	0.0111	0.0175	0.6878
	(0.0147)	(0.0161)	(0.6834)	(0.0094)	(0.0156)	(0.4762)
Observations	38359	33882	40881	9856	8621	10063
Clusters	1632	1602	1632	496	477	496

Cols 1-3 use full sample; Cols 4-6 use joiners-only.
All specifications include institution and year FE; Cols 4-6 also include joiner indicator.
Standard errors clustered by institution.

Figure 15: CA Entry and Enrollment

(a) Full Sample

(b) Future Joiners Control

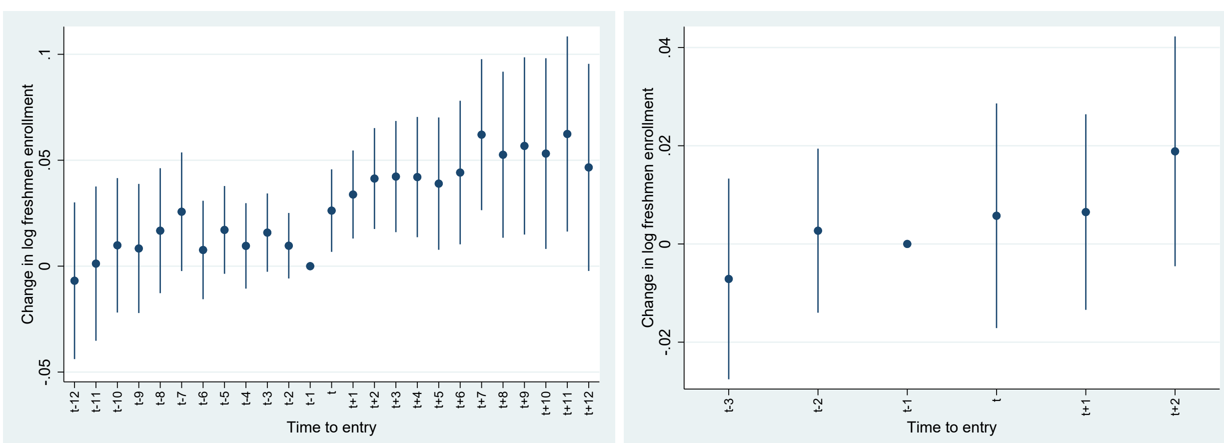


Figure 16: CA Entry and PhD Faculty Count

(a) Full Sample (b) Future Joiners Control

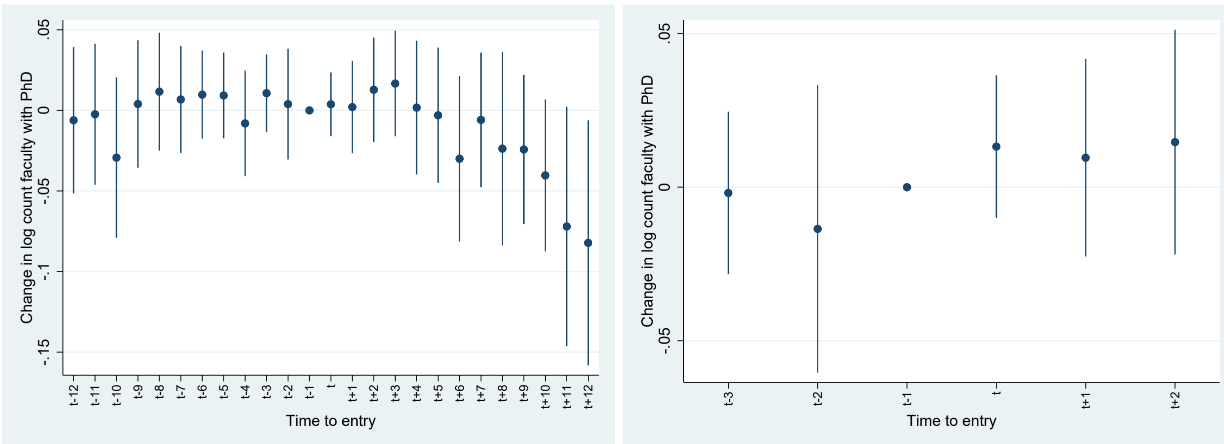
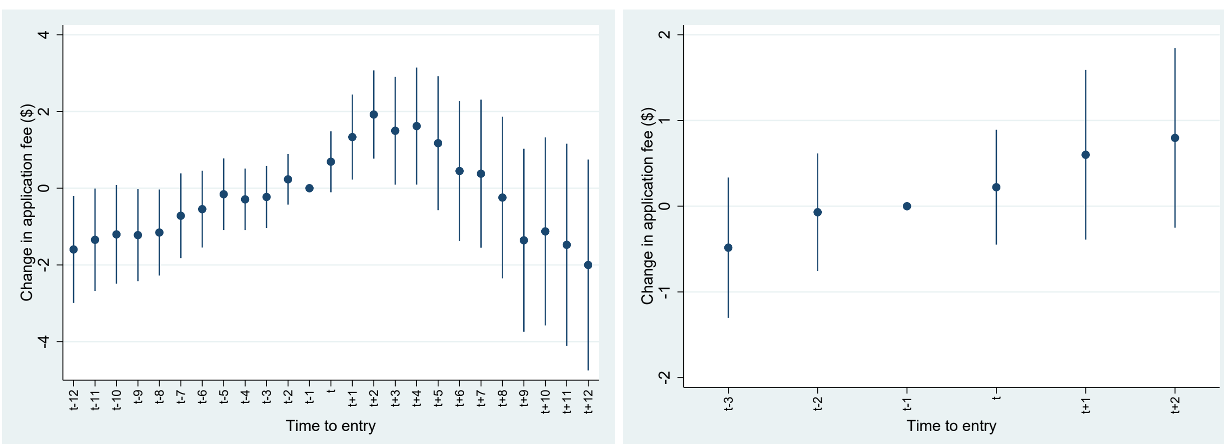


Figure 17: CA Entry and Application Fee

(a) Full Sample (b) Future Joiners Control



6 Conclusion

Consistent with model predictions, we find that the CA has significantly altered college admissions. In particular, after joining the CA, institutions experience an increase in the number of applications, consistent with a reduction in frictions. There is also a significant reduction in yield, consistent with increased student choice due to the CA. We also provide evidence that the CA has accelerated geographic integration, with more out-of-state students. Moreover, these out-of-state students tend to come from other states with significant CA penetration, patterns consistent with network effects in the CA. Taken together, these results suggest that the CA, by reducing application costs, has reduced frictions and increased student choice sets in college admissions, resulting in a more integrated market. Finally, we provide some evidence that CA entry is associated with changes in the composition of students, with increases in racial diversity, fewer low-income students, and weaker evidence of increases in SAT scores.

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A Appendix (For Online Publication)

A.1 Conditions for an Interior Solution

Regarding equation 2, the key condition for a unique solution is that the upper solution to the quadratic equation implies an admissions rate in excess of one. To ensure that only the lower solution is feasible requires that application costs be small, relative to the benefits of a larger choice set:

$$F < C_{12} - C_1 \tag{6}$$

That is, the cost of a second application must be less than the option value of also being admitted to one's second choice. The requirement that F is small also guarantees that a solution exists, in the sense that the discriminant is positive.

Regarding equation 1, we require the following condition for an interior solution:

$$QY_1 < \kappa < Q^2(Y_{12} + y_{12}) + Q(1-Q)(Y_1 + Y_2) \tag{7}$$

where Q is set at its equilibrium value and is thus a function of model parameters. The left hand side of the inequality requires that college capacity is more than sufficient to accommodate accepted students when all students apply to only their first choice, given equilibrium admissions rates. The right hand side requires that the college capacity is not sufficient to accommodate the situation when all students apply to both colleges, given equilibrium admissions rates. Thus, capacity can be neither too small nor too large.

A.2 Equilibrium Solution

We first solve equation 2 for the equilibrium admissions rate. While this equation is quadratic in Q and thus has two solutions in principle, the upper solution implies an admissions rate in excess of 1, under the assumptions outlined in the Appendix above, and we thus focus on the lower solution:

$$Q^* = \frac{C_2 - \sqrt{C_2^2 - 4f(C_1 + C_2 - C_{12})}}{2(C_1 + C_2 - C_{12})} \tag{8}$$

Given this equilibrium admissions rate, one can then calculate the equilibrium fraction of students applying to both colleges via equation 1, yielding:

$$b^* = \frac{\kappa - QY_1}{Q^2[Y_{12} + y_{12} - Y_1] + Q(1-Q)Y_2} \tag{9}$$

where Q is set at equilibrium levels.

A.3 Proof of Proposition 1

Parts 1) and 2): In Equation 8, it is clear that equilibrium admissions rates are increasing in F. Thus, a marginal reduction in F leads to a reduction in equilibrium admissions rates. This effect is illustrated in Figure A1 below.

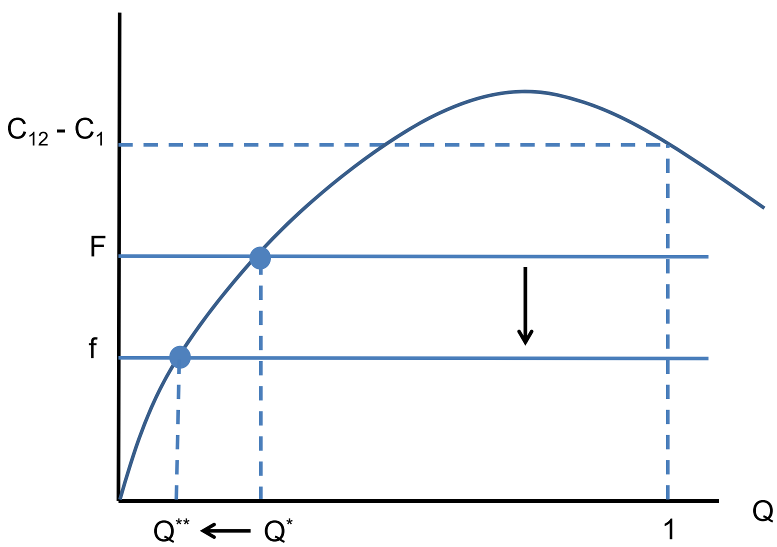


Figure A1: Effects on admissions rates

Given that Q declines under the CA, we must next show that b is decreasing in Q. Taking the derivative of equation 9 with respect to Q, we have:

$$\frac{db}{dQ} = \frac{-Y_1}{D} - \frac{(\kappa - QY_1)[2Q(Y_{12} + y_{12} - Y_1 - Y_2) + Y_2]}{D^2} \tag{10}$$

where the denominator equals $D = Q^2[Y_{12} + y_{12} - Y_1] + Q(1-Q)Y_2$. This denominator is positive since $Y_{12} + y_{12} > Y_1$.

Substituting back in the definition of b, we have that:

$$\frac{db}{dQ} = \frac{-Y_1 - b[2Q(Y_{12} + y_{12} - Y_1 - Y_2) + Y_2]}{D} \tag{11}$$

Re-arranging the numerator, this relationship can be written as follows:

$$\frac{db}{dQ} = \frac{-2bQ(Y_{12} + y_{12} - Y_1) + (bQY_2 - Y_1) - bY_2(1-Q)}{D} \tag{12}$$

Each of these three terms in the numerator are negative. In particular, the first term is negative since $Y_{12} + y_{12} > Y_1$. The second term is negative since $Y_2 < Y_1$, $b < 1$, and Q<1. Finally, the third term is negative since $Q < 1$ in equilibrium. Since the denominator must be positive for b to be positive, the slope is negative. This change in application rates is illustrated in Figure A2 below.

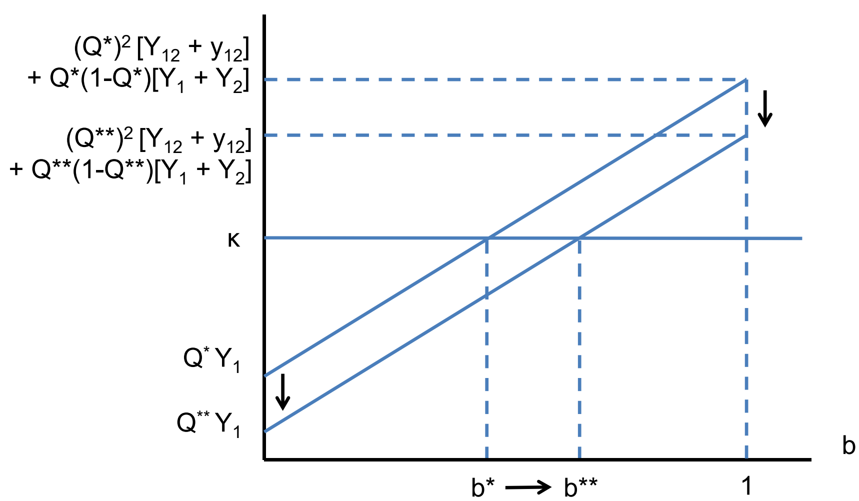


Figure A2: Effects on applications

Part 3): Note that the number of admitted students is equal to $Q(1+b)$, the product of the admissions rate and the number of applications received. Using the closed form solution for b, This can be written as:

$$Q(1+b) = Q + Qb = Q + \frac{\kappa - QY_1}{Q[Y_{12} + y_{12} - Y_1] + (1-Q)Y_2} \tag{13}$$

Taking the derivative, we have that:

$$\frac{dQ(1+b)}{dQ} = 1 - \frac{Y_1}{D} - \frac{\kappa - QY_1}{D^2}[Y_{12} + y_{12} - Y_1 - Y_2] \tag{14}$$

where the denominator equals $D = Q[Y_{12} + y_{12} - Y_1] + (1-Q)Y_2$.

Using the fact that $Qb = [\kappa - QY_1]/D$, the slope can be re-written as:

$$\frac{dQ(1+b)}{dQ} = 1 - \frac{Y_1}{D} - \frac{Qb}{D}[Y_{12} + y_{12} - Y_1 - Y_2] \tag{15}$$

This can be re-written as:

$$\frac{dQ(1+b)}{dQ} = \frac{D - Y_1 - Qb[Y_{12} + y_{12} - Y_1 - Y_2]}{D} \tag{16}$$

Since D is positive, we simply need to show that the numerator is negative. Since the term $Y_{12} + y_{12} - Y_1 - Y_2$ is negative, the numerator is increasing in b. Thus, to show that it is negative for all b between 0 and 1, we simply need to show that it is negative when $b = 1$. In this case, and canceling terms, the numerator can be written as $Y_2 - Y_1$, which is negative.

Part 4): The increase in out-of-state students follows directly from the increase in b resulting from the reduction in F.

A.4 Extension to 3 Colleges

We next consider the case in which two colleges ($c = 1$ and $c = 2$) join the CA but a third college ($c = 3$) does not join. In this case, there are three types of students, corresponding to the ex-ante ranking of the third college. Type 1 students have ex-ante preferences that rank college 3 last (there are two sub-types: either $U_1 > U_2 > U_3$ or $U_2 > U_1 > U_3$). Type 2 students have ex-ante preferences that rank college 3 in the middle (either $U_1 > U_3 > U_2$ or $U_2 > U_3 > U_1$). Type 3 students have ex-ante preferences that rank college 3 first (either $U_3 > U_1 > U_2$ or $U_3 > U_2 > U_1$). Given all of this, we can write the ex-ante preferences of the three different types (six different sub-types) of students as follows:

$$U_1 > U_2 > U_3, 1.1$$

$$U_2 > U_1 > U_3, 1.2$$

$$U_1 > U_3 > U_2, 2.1$$

$$U_2 > U_3 > U_1, 2.2$$

$$U_3 > U_1 > U_2, 3.1$$

$$U_3 > U_2 > U_1, 3.2$$

Let Q_{CA} and Q_N denote admissions rates at the CA colleges and the non-CA college, respectively. Capacities are symmetric and equal κ.

We focus here on the case in which students do not apply to all three colleges.[23] Let $b_1$be the fraction of type 1 students applying to their first and second choice and likewise for b_2 and b_3. The feasibility constraint for college 1 (college 2 is analogous) is now given by:

$$Q_{CA}[\underbrace{(1-b_1)Y_1}_{type\,1.1} + \underbrace{(1-b_2)Y_1}_{type\,2.1} +$$

$$\underbrace{b_1 Q_{CA} Y_{12} + b_1(1-Q_{CA})Y_1}_{type\,1.1} + \underbrace{b_2 Q_N Y_{12} + b_2(1-Q_N)Y_1}_{type\,2.1}] + \tag{17}$$

$$Q_{CA}[\underbrace{b_1 Q_{CA} y_{12} + b_1(1-Q_{CA})Y_2}_{type\,1.2} + \underbrace{b_3 Q_N y_{12} + b_3(1-Q_N)Y_2}_{type\,3.1}] = \kappa \tag{18}$$

And for college 3 it is:

[23] This could formalized by having a large difference in preferences between the second and third choice. For type 1.1 students, for example, $U_2 - U_3$ would be large.

$$2Q_N[\underbrace{(1-b_3)Y_1 + b_3 Q_{CA} Y_{12} + b_3(1-Q_{CA})Y_1}_{types\,3}] +$$
$$2Q_N[\underbrace{b_2 Q_{CA} y_{12} + b_2(1-Q_{CA})Y_2}_{types\,2}] = \kappa \tag{19}$$

Prior to the CA, the three relevant indifference conditions are given, similarly to before, by:

$$Q^2(C_{12} - C_1) + (1-Q)QC_2 = F \tag{20}$$

With the introduction of the CA, the conditions become as follows for type 1 students:

$$Q_{CA}^2(C_{12} - C_1) + (1-Q_{CA})Q_{CA}C_2 = f \tag{21}$$

However, for types 2 and 3, now they incorporate the two different admission rates. For type 2 students, taking the case of 2.1, we have that:

$$Q_{CA}Q_N(C_{12} - C_1) + (1-Q_{CA})Q_N C_2 = F \tag{22}$$

For type 3 students, taking the case of 3.1, we have that:

$$Q_N Q_{CA}(C_{12} - C_1) + (1-Q_N)Q_{CA}C_1 = F \tag{23}$$

Claim: these three indifference conditions cannot be simultaneously satisfied

Proof: The introduction of the CA causes the right hand side in equation 20 to fall from F to f. This implies that, given the admissions rate at CA schools, more type 1 individuals find it profitable to apply to a second school, increasing b_{CA}. However, under a higher b_{CA}, CA colleges will have excess demand, violating their feasibility constraint (equation 18). Thus, Q_{CA} must decrease until type 1 students are indifferent between applying to a second school or not.[24]

Now, note that the fall in Q_{CA} causes the left hand side in equation 22 to increase, implying that more type 2 students want to apply to a second college. However, the opposite happens with type

[24]Note that an increase in b_{CA} must accompany the fall in Q_{CA}. Else, if only Q_{CA} were to fall, colleges would not meet the feasibility constraint, as they would have open vacancies given the smaller admission rate.

3 applicants. The fall in Q_{CA} pushes down the left hand side in equation 23, implying that fewer type 3 students want to apply to a second college.

Due to these opposing effects of a decrease in Q_{CA} for type 2 and type 3 students, both conditions cannot be simultaneously satisfied, meaning that either b_2 or b_3 must be at a corner solution. More formally, comparing the conditions for type 2 and type 3, we have that:

$$Q_{CA}Q_N(C_{1,2}-C_1)+(1-Q_{CA})Q_NC_2 = Q_NQ_{CA}(C_{1,2}-C_1)+(1-Q_N)Q_{CA}C_2$$

This is only satisfied when $Q_{CA} = Q_N$. However, under this condition, the left hand side of the three conditions are equal. But this is a contradiction with the fact that the first equation equals f, the second and third equations equal F, with $f < F$.

Claim: There is no equilibrium with $b_2 = 1$ and b_3 interior.

Proof: Assuming that b_1 is interior, and imposing symmetry, this would require the following:

$$Q_{CA}^2(C_{1,2}-C_1)+(1-Q_{CA})Q_{CA}C_2 = f$$

$$Q_{CA}Q_N(C_{1,2}-C_1)+(1-Q_{CA})Q_NC_2 > F$$

$$Q_NQ_{CA}(C_{1,2}-C_1)+(1-Q_N)Q_{CA}C_2 = F$$

Comparing the conditions for type 1 and type 3 and using the fact that $f < F$, we have that:

$$Q_{CA}^2(C_{1,2}-C_1)+(1-Q_{CA})Q_{CA}C_2 < Q_NQ_{CA}(C_{1,2}-C_1)+(1-Q_N)Q_{CA}C_2$$

Re-arranging, this can be written as:

$$Q_{CA}(Q_{CA}-Q_N)(C_{1,2}-C_1-C_2) < 0$$

Since $C_{1,2}-C_1-C_2 < 0$, this requires $Q_{CA} > Q_N$.

Comparing types 2 and 3, we have that:

$$Q_{CA}Q_N(C_{1,2}-C_1)+(1-Q_{CA})Q_NC_2 > Q_NQ_{CA}(C_{1,2}-C_1)+(1-Q_N)Q_{CA}C_2$$

Re-arranging, this can be written as:

$$(1-Q_{CA})Q_N > (1-Q_N)Q_{CA} \tag{24}$$

This requires that $Q_N > Q_{CA}$. This contradicts that earlier requirement that $Q_{CA} > Q_N$.

Summary: The introduction of the CA leads to an increase in b_1, the fraction applying to both CA schools and a reduction in Q_{CA}. Given this, it must be case that b_2 increases to 1 or that b_3 decreases to zero since both cannot be interior. However, we have shown that b_2 cannot equal 1, meaning that $b_3 = 0$. Thus, there is a reduction, all the way to zero, in the fraction applying to a school outside of the CA and a school inside the CA. Given this, there are network effects with more type 1.1 students attending college 2 and more type 1.2 students attending college 1. Likewise, there are fewer type 3.1 students attending college 1 and fewer type 3.2 students attending college 2.

Quantitative analysis: To provide further evidence on the three college case, we choose parameters that guarantee interior solutions before the policy change. In particular, we set $U_1 = 2$, $U_2 = 1$, $\kappa = 0.55$, and $F = 0.3$. Prior to the CA, colleges and students are symmetric, with $Q = 0.2985$ and $b = 0.0776$. Introduction of the CA lowers F to $f = 0.29$. Under the CA, imposing that $b_3 = 0$ in the new equilibrium, the admission rate of the CA schools falls from $Q = 0.2985$ to $Q'_{CA} = 0.2844$, while the admission rate of the non-CA school also falls, but by a smaller degree, to $Q'_N = 0.2942$. These changes reflect the direct and indirect effects of the decrease in F on the different types of students. Type 1 students are the only ones that benefit directly by the policy and strongly increase their applications to a second school from $b = 0.0776$ to $b'_1 = 0.3346$. On the other hand, type 2 students see their application rate grow only marginally, to $b'_2 = 0.0908$. The reason is that type 2 students have as first choice a CA college followed by the non-CA college, so they do not enjoy the lower application fee but do face the lower admission rate from the CA school, providing them with incentives to apply to their second choice.

A.5 Extension to Ability Types

We consider three colleges (c) and two ability types: low-ability and high-ability. We assume that colleges want to attract as many high ability students as possible and thus admit them with probability one. Low ability students are then admitted at a lower rate in order to fill any remaining capacity. Given our interest in stratification, we can then simply study the behavior of high ability students. Given that high ability students are admitted with certainty, the model plays out differently in this case. In particular, students will not be indifferent when choosing their application sets, and corner solutions are now relevant for these high ability students. Given these corner solutions, we focus on non-marginal changes in application costs.

We focus here on two cases. In the first case, application costs are sufficiently high that high ability students only apply to their first choice in the absence of the CA. For students with the preference order $U_1 > U_2 > U_3$, this requires:

$$C_{12} - C_1 < F \tag{25}$$

Suppose now that colleges 1 and 2, but not college 3, join the CA. Further, suppose that application costs fall sufficiently such that $C_{12} - C_1 > f$, and likewise for students with preference ordering $U_2 > U_1 > U_3$. Then, these two sets of students will apply to both colleges, and students with other preference orderings are unaffected. Since these two sets of students are now more likely to attend college (recall that $Y_{12} + y_{12} > Y_1$), the fraction of high ability students at CA colleges increases. The fraction of high ability students at colleges outside of the CA is unchanged.

In the second case, suppose that application costs are sufficiently low that high ability students apply to their top two choices, but not their third choice, in the absence of the CA. For students with the preference order $U_1 > U_3 > U_2$, not applying to the third college requires:

$$C_{123} - C_{13} < F \tag{26}$$

where C_{123} represents the value from having a full choice set of all three colleges. Suppose now that colleges 1 and 2, but not college 3, join the CA, and application costs fall sufficiently such that $C_{123} - C_{13} > f$, and likewise for all students that have college 1 or 2 as their third choice. Then, all students except those with preference orderings $U_1 > U_2 > U_3$ and $U_2 > U_1 > U_3$ will apply to all three colleges. Thus, there is an increase in applications for colleges 1 and 2 and no increase in applications for college 3. Given that the yield on students accepted to college 3 now falls (resulting from more college 3 applicants also applying to colleges 1 and 2), this implies that colleges 1 and 2 will now draw some high ability students who would have attended college 3 in the absence of the CA. Thus, as in the first case, the fraction of high ability students at CA colleges increases. The new effect here is that the fraction of high ability students falls at schools outside of the CA.

A.6 Extension to Student Income

We consider three colleges (c) and two income types: low-income and high-income. There are two types of application costs. As before, the time cost of applying to a first CA college equals F and the time cost of applying to a second CA college equals $f \leq F$. The financial costs of applying to a first CA colleges equals ϕ and the cost of applying to a second CA college also equals ϕ. We simplify the model by assuming that low-income students can only apply to one college, perhaps due to credit constraints. We also assume that colleges do not distinguish between low-income and high-income students in terms of admissions probabilities. Given all of this, only high-income students decide whether or not to apply to a second college. Thus, all of the results from the first extension apply to high-income students but not low-income students. In particular, colleges 1 and 2, which are members of the CA, experience an increase in applications from high-income students, relative to college 3, which is not a member of the CA. Given this, colleges 1 and 2 ultimately enroll more high-income students, relative to college 3, which ends up attracting more low-income students.

A.7 Summary Statistics for Main Variables

Table A1: Summary Statistics

	mean	sd	min	max	count
Applications	4462.01	6469.93	29.00	97121.00	34519
Yield	0.41	0.17	0.03	1.00	34361
Admits	2672.44	3380.56	25.00	36088.00	34556
Freshmen Enrollment	931.38	1130.04	25.00	11807.00	38359
Selectivity	0.70	0.18	0.04	1.00	34468
Fraction Out of State	0.31	0.25	0.00	1.00	37628
SAT 25th pctile	967.22	136.67	410.00	1510.00	28534
SAT 75th pctile	1184.60	130.36	720.00	1600.00	28540
Non-White Enroll %	0.32	0.23	0.00	1.00	27517
PhD Faculty	222.80	348.97	0.00	3792.00	33893
Application Fee	29.82	16.84	0.00	150.00	40881
Ugrad Enroll % Pell	0.43	0.22	0.00	1.00	26821

All variables from College Board data except Ugrad Enroll % Pell;
this variable uses separate IPEDS and Dept. of Ed. data.

A.8 Trends in Geographic Integration

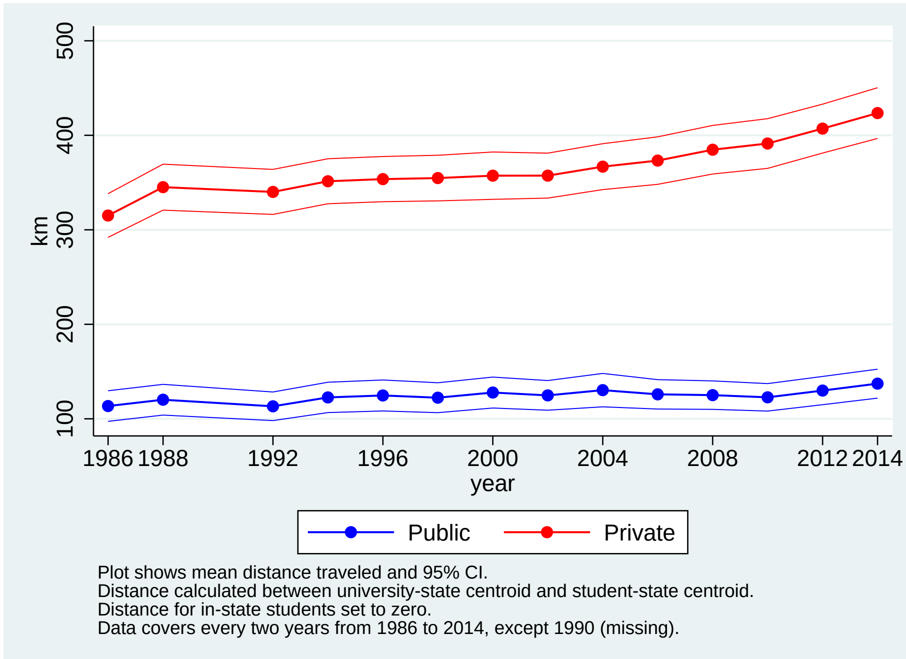
Hoxby (2000) documents that the percentage of students attending in-state institutions fell consistently from 1949 to 1994 and that the role of distance in explaining college choice decreased as well. We extend this study of geographic integration into our sample period by measuring trends in distance traveled from a student's home state to the state of their university using IPEDS data over the period from 1986 to 2014.[25] In Figure A3 we plot the mean distance traveled in each year, along with 95 percent confidence intervals.[26] As shown, there is a clear increase in distance traveled over this time period, with the average distance traveled increasing by over 100 kilometers for private universities and roughly 40 kilometers for public universities. Thus, the trends towards greater geographic integration documented by Hoxby between 1949 and 1994 also appear over our

[25] In particular, we measure the great circle distance in kilometers between state centroids, defining the distance for all in-state students as zero

[26] Letting the subscript s denote a student's state, we define the mean distance traveled by all students from US states at college c in year t as $avdist_{c,t} = (1/nat\_enroll_{c,t})\sum_{s\in S} enroll_{c,s,t} * dist_{c,s}$. The variable nat_enroll is total enrollment from the 50 US states and D.C. The home location of foreign students and students from US territories is usually not available, and therefore we excluded these groups from the total. However, students from these groups are counted in total enrollment when calculating percentage of students attending in-state.

sample period 1986-2014.

Figure A3: Distance Traveled per Student



In Table A2 we calculate the average increase in geographic integration over time for public and private institutions, using the specification $y_{ct} = \beta_1 years_t + \beta_2 years_t \times public_c + \mu_c + \varepsilon_{ct}$. In column 1 we find that distance traveled increases by about 3 kilometers per year for private institutions and 1 kilometer per for public institutions, while column 2 specifies average distance in logs and shows that both types of institutions have roughly the same percentage increase over time of 1.4 percent. In columns 3 and 4 we examine the average distance traveled by out-of-state students only, which allows us to distinguish the effect of a change in the percentage of out-of-state students from a change in the geographic composition of the out-of-state students. Interestingly, the results show that while out-of-state students at private institutions are traveling further each year, there is essentially no increase in distance for out-of-state students at public institutions (the interaction effect is the same magnitude as the main effect). This implies that the increasing distance traveled by public university students comes entirely from an increase in the out-of-state percentage, which increases at about 0.14 percentage points each year for both types of institutions.

Table A2: Geographic Integration by Institution Type

	(1) Distance	(2) Log Distance	(3) Distance	(4) Log Distance	(5) Out-of-state %
years	3.1867***	0.0136***	5.1360***	0.0070***	0.0014***
	(0.2797)	(0.0010)	(0.3278)	(0.0004)	(0.0002)
years X public	-1.9582***	0.0001	-5.5110***	-0.0056***	-0.0001
	(0.3571)	(0.0018)	(0.6052)	(0.0007)	(0.0003)
Constant	236.9366***	4.6789***	876.4421***	6.5852***	0.2941***
	(2.9090)	(0.0127)	(4.2712)	(0.0048)	(0.0022)
Observations	20685	20236	20236	20236	20685
Clusters	1708	1688	1688	1688	1708

Dependent variable in cols 1 and 2 is distance per student.

Dependent variable in cols 3 and 4 is distance per out-of-state student.

Distance is measured in kilometers.

All specifications include institution FE; std errors clustered by institution.

A.9 CA and Geographic Integration (IPEDS data)

As shown in Table A3, universities, after joining the CA, experience a significant increase in the average distance students travel to attend, with column 1 documenting an increase of 30 kilometers, a roughly 10 percent increase (column 2). Restricting to only out-of-state students, the distance increases by 55 kilometers (column 3), an increase of 7 percent for this population (column 4). In addition to out-of-state students traveling further, joining the CA also decreases the fraction of in-state students by about 2.3 percentage points (column 5). Generally, the magnitudes of the effects in Table A3 are large. Comparing each coefficient in Table A3 to its counterpart in Appendix Table A2, the effect of joining is about 10 times larger than the yearly trend for distance measures and about 15 times larger for in-state percentage.

Table A3: CA Entry and Geographic Integration

	(1) Distance	(2) Log Distance	(3) Distance	(4) Log Distance	(5) Out-of-state %
CA member	30.1654***	0.1044***	55.1233***	0.0700***	0.0233***
	(6.1947)	(0.0255)	(8.5535)	(0.0105)	(0.0048)
Observations	20629	20176	20176	20176	20629
Clusters	1652	1628	1628	1628	1652

Dependent variable in cols 1 and 2 is distance per student.

Dependent variable in cols 3 and 4 is distance per out-of-state student.

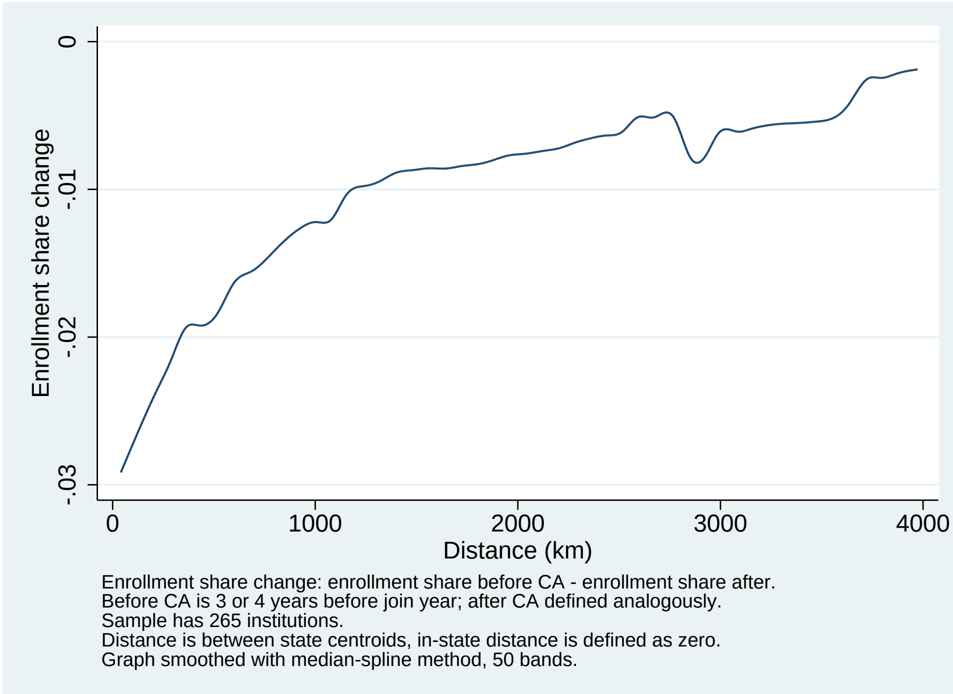
Distance is measured in kilometers.

All specifications include institution FE and year FE; std errors clustered by institution.

As a further analysis of the effect of joining CA on distance traveled, we now consider the change in the entire distribution of a college's enrollees over distance. To do so, we restrict our sample to only those institutions which joined the CA and which have migration data both three or fours years before and three or four years after joining, depending on whether the institution joined in an odd or even year. We then sum the enrollees across all universities in each period (pre, post) and calculate the percentage coming from each state-to-state distance. This allows us to calculate two cumulative distribution functions (CDF), where each bin of the CDF represents a given state-to-state distance and we are calculating the percentage of students traveling that distance to all universities in a period. We then plot the difference between the before and after CDF in Figure A4.[27] The largest difference occurs at zero, indicating that most of the effect comes from a 3 percentage point decrease in the in-state percentage. The slope of this differenced CDF increases sharply and approaches zero, so that a distance of 1200 kilometers the change is less than 1 percent, and then flattens. This shape suggests that CA entry increases the distance traveled by enrollees by mostly increasing the number of enrollees from nearby states.

[27] We truncate the graph at 4000km since the share of students coming from a greater distance is very small in both periods.

Figure A4: Effect of CA Entry on Enrollment Share Change by Distance



A.10 Future Joiners Control: Methodology and Data Preparation

As described earlier, a key threat to identification in our analysis is that joiners might have different pre-trends relative to the comparison group, which includes both schools that never join during our sample period and schools that will join in the future but before the end of our sample period. We address this concern with an additional specification in which we compare outcomes for joiners to outcomes for colleges that will join the CA in the near future. Specifically, we compare schools that joined in year j to schools that will join in years $[j+w, j+2w-1]$, over a pre-join period $[j-w, j-1]$ and a post-join period $[j, j+w-1]$. We chose a window of three years, $w=3$, a duration we thought was sufficient to make joiners and future joiners quite comparable, but still long enough to estimate a post-join effect. For example, for a school joining in 2000, the comparison group includes colleges that join in 2003, 2004, and 2005, and we analyze outcomes over the 1997-2002 period.

This empirical strategy is similar, although not identical, to that used by Deshpande and Li (2019) and we constructed our dataset in a similar way. We first assembled separate datasets of joiners and future joiners for every join year j, and then appended each join year's data into a single dataset. The resulting dataset has some duplicate observations since the same school-year may serve as a control observation for multiple join-years. For example, a school joining in 2004 is a control observation for schools joining from 1999-2001. In all specifications we cluster standard errors at the school level and therefore these duplicates do not affect inference. Additionally, since we compare joiners to future joiners, most schools serve as both treated and control observations, over different join years j. Therefore, following Deshpande and Li (2019), we also include an additional indicator for whether a school is a joiner for a specific join year j as a control. The regression model using this strategy is:

$$ln(y_{jct}) = \beta * (CA_{cjt}) + \mu_c + \mu_t + \alpha * 1(J_c = j) + \varepsilon_{jct} \tag{27}$$

The corresponding event-study specification is:

$$ln(y_{jct}) = \sum_{k=-w}^{w-1} \beta_k [1(J_c = j) \times 1(t - J_c = k)] + \mu_c + \mu_t + \alpha * 1(J_c = j) + \varepsilon_{jct} \tag{28}$$