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The Algorithm Advantage: Ranked Application Systems Outperform Decentralized and Common Applications in Boston and Beyond

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The Algorithm Advantage: Ranked Application Systems Outperform Decentralized and Common Applications in Boston and Beyond*

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Abstract

School choice systems increasingly use common applications, where students can apply to multiple schools on a single form, though schools make admission decisions independently. We model three application systems: a common application, a decentralized system with costly separate applications, and a ranked-choice system using a matching algorithm. Our model shows that while a common application may expand access, it increases competition and may produce worse matches than a decentralized system where application costs encourage more selective applications. Ranked-choice systems combine reduced application costs with preference-based matching that reduce mismatches. We examine these predictions by analyzing how Boston's charter school sector was affected when it adopted an online common application. Counterfactual simulations suggest the common application performs no better than alternatives on several metrics and did little to increase access for disadvantaged groups. A ranked system consistently outperforms a common application across various levels of competition and assumptions on preference stability between application and enrollment stages.

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1 Introduction

Recent efforts to expand access to educational opportunities attempt to reduce barriers to exercising choice, often by adopting common application where students can apply to multiple schools using a single form. Advocates of common applications emphasize three main benefits by comparison to decentralized systems, where students must submit separate applications to each school. First, they lower application costs and reduce logistical barriers for applicants. For example, Oakland, CA administrators stated their common application eliminated the need for families to "drive all over town" to apply to different schools. Second, they increase access to information about schools, as Buffalo, NY officials noted when highlighting how their platform improved knowledge about local charter school options. Third, they aim to equalize opportunities for all families to exercise school choice, with Los Angeles, CA staff emphasizing how common enrollment systems level the playing field.[1]

Table 1 lists twelve large US cities that have adopted common application systems for K-12 school choice since 2017, primarily in their charter school sectors. Several of these cities also explored a ranked-choice system where students submit a single form and rank schools in order of preference, then the schools use a matching algorithm in tandem with these rankings to generate at most one placement offer per student. For example, when Boston's charter schools considered alternatives to the existing decentralized system, stakeholders advocated for a ranked system that would unify applications across all school sectors, following examples set by Denver and New Orleans (Fox, 2016). While a mayoral working group considered this option and it received strong support from several groups, Boston ultimately did not adopt a ranked system and the charter schools switched to a common application (the "Boston Public Charter School Application").

This paper develops a model to analyze how a common application affects student access to schools compared to decentralized and ranked systems. We focus on a fundamental trade-off: a common application system lowers application barriers but also intensifies competition for school spots. The effectiveness of these systems depends largely on how well they connect student preferences to school assignments. In decentralized systems, student preferences are incorporated because students avoid applying to schools they do not want to attend. Ranked systems incorporate student preferences by giving each student a choice among all remaining schools with openings. By contrast, with a common application, students only have choices among schools if admitted to them independently, which happens with a lower probability than in a ranked application system.

Our model provides a frictionless comparison of these three assignment systems, allowing us to

[1] Appendix C provides summaries of statements from officials from these cities.

analytically isolate trade-offs between them. However, even in this simplified environment, we cannot make definitive statements about the comparison of ranked and decentralized systems without strong assumptions about the distribution of application costs or student preferences, as we illustrate by means of a series of examples.

For this reason, we rely on empirical analysis to study the properties of charter school applications and outcomes in Boston before and after the adoption of the Boston Public School Charter Application. The link from theory to practice highlights the need to extend the baseline theoretical model to allow student preferences to change between application and enrollment, a phenomenon that has been illustrated as important in previous studies (e.g., Walters (2018), Kapor, Neilson, and Zimmerman (2020), and Grenet, He, and Kubler (2022)). The common application seems well-suited to accommodate evolving student preferences because it enables applications to both highly attractive schools and those that seem less appealing initially, but may gain appeal over time.

Our empirical analysis reveals several key findings about the performance of different application systems. First, the implied rankings of choices between the application stage and the enrollment stage are not perfectly persistent. A school ranked first at the time of application remains the top choice only 72% of time when students make enrollment decisions. A school ranked second only has a 53% chance of being ranked second at enrollment, and is roughly equally likely to be the top choice or third choice. Second, after accounting for changes in preference, both the common application and decentralized systems result in 36% of students receiving their first-choice school, while the ranked system would have placed 39% of students in their top choice. Third, contrary to one of its main policy goals, Boston's charter common application did not improve school access for disadvantaged student groups. Fourth, our demand model estimates show that the common application system produces no significant improvements in overall student welfare compared to either the ranked or decentralized systems and, in fact, the ranked system outperforms the other two in realized utility according to our estimates.

We also consider the possibility that the Boston context may produce idiosyncratic results given its pattern of school admission rates and applicant demand. To address this possibility, we use our empirical model to simulate different market conditions, varying both the intensity of competition for limited school seats and the extent to which student preferences shift between application and enrollment periods. Intuitively, we might expect that more competitive environments favor the ranked or decentralized systems since they facilitate matches of students to their first-choice schools, whereas greater changes in preferences provide support for a common application. Our findings are consistent with these intuitions, though the ranked system always outperforms the common application system in overall utility and in first-choice assignments in these simulations.

This paper connects to several research areas. First, it relates to studies examining the *Common App* system used by US colleges and universities. Knight and Schiff (2022) found that expansion of the *Common App* increased application volumes while reducing yield rates for accepted students, a pattern we also observe in Boston's charter system.[2] Other *Common App* studies include Liu, Ehrenberg, and Mrdjenovic (2007), Smith (2013), and Klasik (2012). This work does not consider the potential effects of a ranked system or develop structural equilibrium models of application and admissions to compare three systems. Additionally, higher education involves considerations like financial aid competition and private universities objectives that don't apply to K-12 charter schools. Second, our research connects to literature on preference signaling and matching market frictions, including Avery and Levin (2010) on early admissions, Chade, Lewis, and Smith (2014) on frictional matching, and Che and Koh (2016) on strategic college admissions. Our findings about preference discovery align with Grenet, He, and Kubler (2022)'s evidence that applicants often lack full information about their own preferences. Related behavioral aspects of education market design are surveyed in Rees-Jones and Shorrer (2023), and Kapor, Karnani, and Neilson (2024) examine relevant aftermarket frictions. Third, our work contributes to research on student assignment and market design, such as Abdulkadiroğlu and Sönmez (2003), Abdulkadiroğlu, Agarwal, and Pathak (2017), Kapor, Neilson, and Zimmerman (2020), and Chen and He (2021). Fourth, since common applications reduce application barriers, our research connects to studies of access barriers in both college admissions (e.g., Hoxby and Avery (2013), Hoxby and Turner (2015), and Pallais (2015)) and social programs (e.g., Deshpande and Li (2019)). Finally, our work relates to equilibrium models of colleges and schools by Fu (2014) and Singleton (2019).

This paper is structured as follows. Section 2 presents the model and compares the common application separately to the decentralized application system and the ranked application system. Section 3 provides details on the Boston charter common application. Section 4 describes the structural model. Section 5 reports estimates and the counterfactual simulations. Section 6 uses the empirical model to examine situations other than Boston. The last section concludes.

[2] Knight and Schiff (2022) also develop a theoretical model of a common application, in which a common application reduces application fees. In their baseline model, the common application strictly reduces student welfare, but generates winners and losers under their model extensions. Our theoretical findings also show ambiguous welfare comparisons, which motivates our structural equilibrium model of application and admissions.

2 Model and Basic Properties

Suppose there are S schools, each with capacity K, and N students who wish to enroll in one of those schools, where $N > SK$. Student i has utility values $(u_{i1}, u_{i2}, \ldots, u_{iS})$ where $u_{ij} > 0$ represents student i's utility for attending school j relative to an outside option, which is normalized to 0.

We consider three application systems and will add assumptions for formal analysis of them.[3]

- **Decentralized Application**: Each application to a single school has known cost $c > 0$. Each student chooses to apply to any number of schools from 0 to S. The schools conduct independent admissions lotteries and set equilibrium admission rates (i.e. probabilities that individual applicants are admitted) to meet their capacities of K students per school.

- **Common Application**: A student's first application has cost $c > 0$, but all subsequent applications are costless.[4] This structure means that each student applies either to no schools or to all S schools.

- **Ranked Application**: Each student who participates pays a cost c and submits a list of schools ranked in order of their preference. The schools submit identical randomly generated ordinal rankings for the students, then students are assigned to schools with the student-proposing deferred acceptance (DA) algorithm.

For our theoretical comparisons across systems, we assume the cost c is the same. The application costs in this model capture both physical costs of application such as time spent filling out application forms as well as psychological and informational costs.[5] Whether these costs should be included in measuring overall utility depends on whether or not costs are seen to affect welfare. Since our the empirical model in Section 4 does not distinguish between sources of these costs, we report utility estimates both incorporating and ignoring these costs.[6] For our theoretical comparisons between systems, we assume a constant c across cases, but relax this assumption in the empirical section.

The three systems elicit and use student preferences differently. In the Ranked system, students directly state their preferences in order, which the matching algorithm then uses for assignments. In

[3]Our convention in this paper is use capitalized letters for Decentralized Application, Common Application, and Ranked Application when referring to these specific models, and lowercase otherwise.

[4]We relax the assumption of costless secondary applications in our empirical application.

[5]In a related higher-education context, Fu (2014) emphasizes costs of application include actual physical as well as psychic costs. Specifically, Fu (2014) states: "Besides application fees, a student has to spend time and effort gathering and processing information and preparing application materials. Moreover, she also incurs nontrivial psychic costs such as the anxiety felt while waiting for admissions results."

[6]This approach follows the practice in health economics of presenting welfare results under various assumptions about which costs should be included in the welfare calculations. For example, Handel (2013)'s study of consumer inertia reports welfare estimates both excluding inertia costs and fully incorporating them.

the Decentralized system, students reveal preferences through application decisions – applying to a school signals interest while not applying suggests disinterest. In contrast, the Common Application system allows students to express preferences after receiving admissions decisions, when they choose their most preferred option among schools that accepted them. Example 1 illustrates how these different systems affect assignments.

Example 1. *Suppose that there are* $2N$ *students and two schools, each with capacity* $0.75N$*. Half of the students have utility values (8, 4) and the other half have utility values (4, 8).*

In a pure-strategy Common Application equilibrium, each student submits an application to both schools and the schools choose admission probability $p = \frac{1}{2}$ to fill their entering classes.[7] The incentive condition for equilibrium is that students gain from participation at cost c, i.e. $\frac{1}{2} * 8 + \frac{1}{4} 4 \geq c$ or $c \leq 5$.

In a pure-strategy Ranked Application equilibrium, students at the top of the ranking list submitted by schools receive offers from both schools in the course of the deferred acceptance algorithm and are thus assigned to their first choice. Since the schools have identical capacities and half of the students prefer each to the other, the schools reach capacity at approximately the same time. As a result, three-quarters of students are matched to a school with (approximately) all of them assigned to a first-choice school. The incentive condition for universal participation in equilibrium is $\frac{3}{4} * 8 \geq c$ or $c \leq 6$.

There are two possible pure-strategy equilibria in the Decentralized system. As in the case of the Common Application, if students apply to both schools with the Decentralized system, an admission rate of $p = \frac{1}{2}$ fills the classes at each school, but in this case, the students have to pay $2c$ for those applications instead of just c with the Common Application. It is cost-effective to apply to a first-choice school if $8p \geq c$ or $c \leq 4$ and separately to apply to one's second-choice school if $4p(1 - p) \geq c$ or $c \leq 1$. By contrast, if each student submits a single application to their first-choice school, then an admission rate of $p' = \frac{3}{4}$ fills the classes at each school. This is an equilibrium if it is cost-effective to apply to the first school, i.e. $\frac{3}{4} * 8 \leq c$, or $c < 6$ but not to the second school, i.e. $\frac{3}{4} * \frac{1}{4} * 4 \leq c$ or $c \geq \frac{3}{4}$. In sum, there is an equilibrium where students apply to both schools if $c \leq 1$ and there is an equilibrium where students apply only to first-choices schools if $\frac{3}{4} \leq c \leq 6$.

One reason for the existence of multiple equilibria with the Decentralized system and $\frac{3}{4} \leq c \leq 1$ is that an increase in admission rate p increases the expected value of an application to one's first-choice

[7] With independent admission decisions and probability p of admission at each school, proportion $(1 - p)^2$ of students are not admitted to either school, so the market clearing condition is $1 - (1 - p)^2 = \frac{3}{4}$. This yields a quadratic equation $2p - p^2 = \frac{3}{4}$, which has relevant solution $p = \frac{1}{2}$.

school, but may either increase or reduce the expected value of a subsequent application to a second-choice school. (The change in expected value of the second application depends on whether $p(1-p)$ increases or decreases.) Thus, it is possible that an increase in p at all schools has the counterintuitive effect of reducing total applications and enrollment in the Decentralized system.

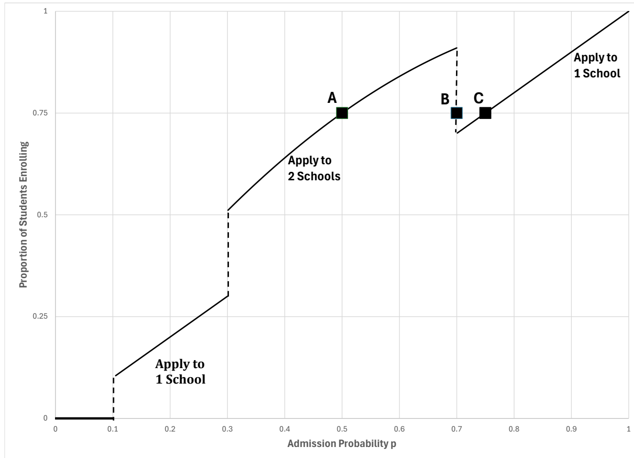
Cost (c)	Common Application	Ranked	Decentralized
$c \leq \frac{3}{4}$	2 apps per student	Universal Participation	2 apps per student
$\frac{3}{4} \leq c \leq 1$	2 apps per student	Universal Participation	Multiple Equilibria
$1 \leq c \leq 5$	2 apps per student	Universal Participation	1 app per student
$5 \leq c \leq 6$	Non-universal participation	Universal Participation	1 app per student

Comparison of Equilibria in Example 1

The table summarizes the equilibrium analysis above. With lowest costs $c < \frac{3}{4}$, the Common Application and Decentralized systems yield identical distributions of assignments with half of the students assigned to their first-choice and one-quarter of them assigned to a second-choice school, though the application costs are higher with the Decentralized system. With highest costs, students are only matched to first-choice schools with the Decentralized or Ranked systems but that is not the case in a Common Application system. This comparison highlights the relatively inefficiency of revealed preference as a sorting mechanism in the Common Application, because in this example, some students who prefer school 1 are only admitted to school 2 and some students who prefer school 2 are only admitted to school 1.

The next figure illustrates why there are multiple equilibria for the Decentralized system, in the case of $c = 0.84$. It is cost-effective to apply to a first-choice school with utility 8 at admission probability p if $8p \geq c$ or $p \geq 0.105$. It is cost-effective to submit a second application to a second-choice school with utility 4 if $4p(1-p) \geq c$ or $0.3 \leq p \leq 0.7$. Point A corresponds to the equilibrium with $p = \frac{1}{2}$ and two applications per student. Point C corresponds to a second pure strategy equilibrium with $p = \frac{3}{4}$ and one applications per student. Point B corresponds to a third equilibrium with $p = 0.7$ and mixed strategies for the students.[8]

[8] In this case with $c = 0.84$ and $p = 0.7$, each student applies to at least one school and some students apply to both schools. Since 70% of those applying to a single school are admitted and $.7 + .3 * .7 = .91 = 91\%$ of those applying to both schools are admitted to at least one of them, there is a mixed strategy equilibrium where each student applies to both schools with probability $\frac{5}{21}$ so that 75% of students are admitted to at least one school.



Decentralized Application in Example 1

We can rank the welfare results of the three equilibria of the Decentralized Application in the figure in terms of admission probability p. First, the pure strategy equilibrium (point C) with one application per student yields higher expected utility per student than the mixed strategy equilibrium (point B) because some students apply to one school in each equilibrium and those students achieve higher expected utility in the first case with $p = \frac{3}{4}$ than in the second with $p = 0.7$. Second, by similar reasoning, the mixed strategy equilibrium (point B) yields higher expected utility per student than the pure strategy equilibrium (point A) with two applications per person because some students apply to both schools in each equilibrium and those students get higher expected utility with $p = 0.7$ in the mixed strategy case than with $p = 0.5$ in the second pure strategy equilibrium. Intuitively, each increase in the proportion of students submitting a second application causes congestion and reduces expected utility as well as the probability of mismatches with assignments to second-choice schools, thereby suggesting an underlying advantage for the Decentralized System by comparison to the Common Application.

Knight and Schiff (2022) use related logic to show that a decentralized system dominates a common application in a 2x2 symmetric model with two types of students and two schools where the common application reduces but does not eliminate the cost of a second application.[9] In equilibrium of that model, all students are indifferent between submitting one and two applications with common application equilibrium. Students prefer the decentralized system over this common application equilibrium because the decentralized system leads to a higher admission rate at each school.

[9] In their model, students also experience preference shocks after submitting their applications.

Example 1 suggests that school assignments in both the Ranked and Decentralized systems have more desirable properties than the Common Application, and further that the results of the Ranked system are more robust than those of the Decentralized system. We formalize these intuitions in our theoretical analysis below. Some comparisons of the Decentralized system and Common Application only hold for the symmetric case in terms of preferences and school capacities while comparisons of the Ranked and Common Application hold more generally.

2.1 Common vs. Decentralized Applications

We assume the symmetric case for comparison of Decentralized and Common Application. Each student's utility values $(u_{i1}, \ldots, u_{iS})$ are independent and identically distributed draws from a symmetric joint distribution F, so that all rank orders of preferences are equally likely for students. We assume that both N and K are large, so that schools can accurately anticipate the relationship between admission rates and enrollment and that c is small enough that allow schools to reach capacity.

We show in Appendix A.1 that, as in Example 1, there exists a unique pure strategy equilibrium for the Common Application and it yields the same admission probability at each school and also that there exists a symmetric equilibrium with the Decentralized Application, but it is not necessarily unique. When there are multiple equilibria for the Decentralized Application, we use the symmetric equilibrium with fewest applications and highest admission rate per school for welfare comparisons.

Propositions 1a and 1b below verify that the intuitions suggested by Example 1 hold for general symmetric distributions of utility values for students and for more than two schools.

Proposition 1. *a) Comparing the Common Application and (any) symmetric equilibrium of Decentralized Application, the Common Application equilibrium yields more applications to each school and each school admits a lower percentage of applicants.*

b) With independent symmetric preferences, the distribution of ordinal ranks for enrolled students under the Decentralized Application system stochastically dominates the distribution of ordinal ranks for enrolled students under the Common Application system.

Proof. See Appendix A.2. ■

Intuitively, there are two distinct forces that drive this result. First, the Common Application induces students to apply to a larger set of schools, thereby increasing the proportion of admissions to less preferred schools in student rankings. Second, since the Common Application equilibrium has a lower probability of admission than a Decentralized Application equilibrium, a student who is admitted to a less preferred school is relatively unlikely to also be admitted to a more preferred school in the Common Application system. Yet, this result need not hold beyond the case of symmetric preferences, as shown by the following example.

Example 2. *Suppose 80 students have values (10, 0), 72 students have values (9.9, 9), 53 have values (8, 8.1) with 40 spots per school with application cost 4.5.*

With the Decentralized Application system, the first two types apply to school 1 (80 people) and school 2 (72 people) with admission rates of 0.5 and $\frac{5}{9}$ respectively and expected utility 5 each. With the Common Application system, the other two types (125 people total) apply to both schools and the admission rate is 40% for each school, so there is a 64% chance of being admitted to at least one school. With the Decentralized Application, half of the students enroll at a first choice school, but with the Common Application a higher proportion $\frac{40}{64} = \frac{5}{8}$ of students enroll at a first choice school.

The extreme nature of preferences in Example 2 highlights the intuition for Proposition 1b. Since the Decentralized Application system discourages secondary applications, it tends to promote assignments to schools with higher (more preferred) ordinal rankings. In the example, however, there is perfect correlation between strength and order of preference as the students with utility values greater than 9 for the first-choice schools all prefer school 1. With the given level of cost per application, students who prefer school 2 only apply under the Common Application and as a result, the Common Application does well in matching students to most preferred schools. In general, short of some systemic reason to find a correlation between strength and order of preferences, it is natural to expect the logic of Proposition 1b and the sorting advantage of the Decentralized Application over the Common Application to carry over to practice.

2.1.1 Heterogeneous Application Costs

One motivation for common application systems is to enhance opportunities for low-income students and others who have limited access to skilled guidance about the application process. To allow for this possibility, we expand the model to allow for differential application costs for two types of students, where applicants of type 1 ("Advantaged") have cost per application c_1 and applicants of type 2 ("Disadvantaged") have cost per application $c_2 > c_1$. Under the Common Application system, we assume that type 1 students can apply to all schools at cost c_1 and that type 2 students can apply to all schools at cost c_2. We continue to assume that both types of students have identical and symmetric distributions of utility values for the schools.

Proposition 2. *With differential costs, if* $c_1 = 0, c_2 > 0$*, and type 2 students do not all apply to both schools in the Decentralized Application equilibrium, then the Common Application unambiguously increases the number of type 2 students who are assigned to a school.*

Proof. If $c_1 = 0$, then all type 1 students apply to all schools under any admissions system. As in Proposition 2, the admission probability at each school in the Common Application system must be lower than the admission probability at each school for the Decentralized Application system. Otherwise, more students will apply and more students will be admitted to at least one school using the Common Application system, thereby causing over-enrollment. But since all type 1 students apply exhaustively in each system, they have a lower probability of admission to at least one school in the Common Application system equilibrium. Thus, to make up the deficit in enrollment and maintain the market-clearing condition, a larger number of type 2 students must enroll in the Common Application equilibrium than in the Decentralized Application equilibrium. ■

Proposition 2 is limited in two important ways. First, it does not consider application costs. Even if the assignments to type 2's improve with the Common Application, there might be an even larger increase in costs for this group. Second, Proposition 2 pertains specifically to the number of seats assigned to type 2 students and not the expected utility of type 2 student school assignments. As a result, it is possible that type 2 students could gain seats but lose expected utility from school assignments with the Common Application, as is the case for type 1 students in Example 3 below.

Despite the natural intuition that the Common Application should level the playing field and thus be beneficial to type 2 students, it could have the opposite effect, as shown by Example 3.

Example 3. *Adjust Example 1 as follows. Suppose that there are* $2.5N$ *students and two schools, each with capacity* $0.75N$*. There are* $2N$ *students of type 1 with application cost* $c_1 > 0$*. Of these students, half (*N *students) have utility values (8, 2) and the other half (*N *students) have utility values (2, 8). There are* $0.5N$ *students of type 2 with application cost* $c_2 > c_1$*. Of these students, half (0.25N students) have utility values (8, 2) and the other half (0.25N students) have utility values (2, 8).*

Note that since $c_1 > 0$, the conditions for Proposition 2 do not hold in this example. Under the Decentralized Application system, if all students submit a single application to their most preferred school, then each school receives $1.25N$ applications and each school can fill its class by choosing an admission probability of 0.6. Under the Common Application system, if only type 1 students apply, $2N$ students apply to each school and, after accounting for the students who are admitted to both schools, each school would fill its class by choosing an admission probability of 1/2.

Given these admission probabilities, students attain expected utility from school assignments of $0.6 * 8 = 4.8$ in the Decentralized Application system and expected utility from school assignments of $0.5 * 8 + 0.25 * 2 = 4.5$ with the Common Application system. Thus, for any pair of values c_1 and c_2 satisfying $0.5 < c_1 < 4.5 < c_2 < 4.8$, these are the unique equilibrium outcomes for the two application systems.

In this example, the Common Application system induces students of type 1 to apply to both schools rather than to a single school, and that choice in turn reduces the equilibrium admission probability and discourages type 2 students from participating. Therefore, we have to add a caveat to the earlier intuition: the Common Application system will be beneficial to disadvantaged types if advantaged types are already applying extensively.

2.2 Ranked Application

The advantage of the Ranked Application over the Common Application is relatively robust, so we now extend the model to allow for different capacities by school and asymmetric distribution of student preferences and utility values across schools. To facilitate the comparison between Ranked and Common Application, we assume a sufficiently low cost c for participants so that all participating students either rank or apply to all schools; this choice enables us to focus on a comparison of the resulting assignments of students to schools.

A key feature of our description of the Ranked Application system is that the schools submit identical rank-ordered preference lists of students drawn by lottery. This is equivalent to assuming that the student-proposing deferred acceptance algorithm begins by generating a single rank-ordered list at random for the schools. The resulting mechanism is equivalent to a serial dictatorship, whereby students ranked highest by schools act in turn as quasi-dictator, with each choosing their most preferred among schools with available seats.[10]

The design choice for schools to submit identical rank orderings of students accentuates the misfortune of students who are unlucky enough to get a poor ranking at school 1, for now those students necessarily get poor rankings at every school. Yet, the use of common rankings across schools has the advantage of encouraging self-selection in the choices of students. Students with best lottery numbers receive offers and are ensured of enrolling at their most preferred schools. As a result, the first school to reach capacity in Ranked Application only enrolls students who prefer it to all other schools. By contrast, under Common Application, every school enrolls some students who were admitted only to

[10]Studies of the serial dictatorship mechanism include Satterthwaite and Sonnenschein (1981), Abdulkadiroğlu and Sönmez (1998), and Svensson (1999).

that school and had no other options.

We document the advantage of self-selection from a single lottery in the Ranked Application system by comparison to a Common Application in terms of admission rates, probability of admission to one's first-choice school, and the existence of unstable matches.

Proposition 3. *Each school offers admission to a smaller proportion of students with the Common Application system than it does with the Ranked Application system.*

Proof. See Appendix A.3. ■

Corollary 4. *A higher proportion of students are assigned to first-choice schools with the Ranked Application system than with the Common Application system.*

Corollary 4 follows immediately from Proposition 3 because the probability of admission to any particular (first-choice) school is higher with the Ranked Application system than with the Common Application system. However, as shown in Example 4 in the Appendix, the ordinal distribution of assignment probabilities with the Ranked Application does not necessarily stochastically dominate the ordinal distribution of assignment probabilities with the Common Application system in general.

Corollary 4 connects our model to research that compares the properties of the student-proposing deferred acceptance algorithm with a single tie-breaker compared to the student-proposing deferred acceptance algorithm with school specific tie-breaking (Abdulkadiroğlu, Pathak, and Roth, 2009; Ashlagi and Nikzad, 2020; Allman, Ashlagi, and Nikzad, 2023). For instance, Allman, Ashlagi, and Nikzad (2023) provide conditions under which all agents prefer a common lottery to independent lotteries in a continuum matching model when applicant preferences are generated according to a multinomial distribution with common quality ranking.

Proposition 5. *Given a set of applicants who do not all have the same set of preference orderings over schools, the Ranked Application guarantees a pairwise stable assignment of students to schools, while there is positive probability that the Common Application implements an assignment of students to schools that is not pairwise stable.*

Proof. Comparing any two applicants with distinct set of preference orderings, suppose without loss of generality that student 1 is assigned to school A and student 2 is assigned to school $B \neq A$ with the Ranked Application. If student 1 prefers B to A, then by revealed preference that student never received an offer from school B. By contrast, student 2 received an offer from B, so must lie ahead of student 1 on the rank order list. Since student 1 received an offer from A, student 2 must also have received an offer from A and then chose B, so by revealed preference, student 2 prefers B to A. Since both students prefer B to A, they cannot gain from pairwise trade.

By contrast, with the Common Application, some proportion of students who strictly prefer A to B are only admitted to B and some proportion of students who strictly prefer B to A are only admitted to B. Thus, in a large population, there are pairs of students where one is admitted only to A, the other is admitted only to B, and they can gain from pairwise trade. ■

3 Boston's Online Common Charter Application

Our theoretical model reveals key tradeoffs between assignment systems. Under a decentralized system, application costs direct students to apply only where they most want to go, leading to lower overall demand and relatively high admission rates. A common application reduces costs for applicants who would be happy at multiple schools rather than their outside option, yet thereby increases competition and reduces admission rates overall. This can result in poor matches between schools and students by comparison to either the decentralized or ranked systems. Similarly, the decentralized system offers more possibilities for miscoordinated assignments (e.g., when a student who prefers school 1 is assigned to school 2 while a different student who prefers school 2 is assigned to school 1) that are not possible with a ranked system. At the same time, the decentralized system puts more weight on strength of preference than does the common application, as students with lower cardinal utility values for a particular school may choose not to apply under the decentralized system; the resulting advantage for the decentralized system is that expected utility for students enrolling in an n^{th} choice school will tend to be higher than a decentralized system.

Our model has an additional limitation relative to practice: it assumes student preferences remain fixed throughout the process, whereas previous papers have documented that students frequently change their preferences between applying and enrolling as conditions change and they learn more about their options. The advantage of a decentralized system is that it promotes desirable matches by suppressing applications to lower value schools, but that advantage can become a disadvantage relative to the common and ranked systems when the preferences of schools are known to change from the time of application to the time of enrollment decision.

To better understand these competing forces, we build an empirical model that measures the differences between assignment systems. We use data from Boston's charter sector, which switched from a decentralized system to a common application system. The empirical model goes beyond the theoretical framework by incorporating both where students and where they actually enroll. This captures how student preferences may shift between the application stage and final enrollment decisions. We use this model to evaluate Boston's current common application system and compare it to a hypothetical ranked choice system. This empirical approach allows us to extend our theoretical framework with real data, providing concrete evidence for comparing different assignment systems across different settings.

3.1 Background

In 2016, after an unsuccessful attempt to combine charter and district school admissions into one unified system (Vaznis, 2016), Boston's charter schools adopted a common application system known as the Boston Public Charter School Application (BPCSA), with applications due in February 2017. Each school continued to run its own admission lottery in March 2017 using the applicant lists from the common application rather than from individual school applications.

Our sample covers six Boston charter schools that admitted 5th grade students throughout our sample period from 2015 to 2020: Academy of the Pacific Rim, Boston Collegiate, Excel Academy, Match, Neighborhood House, and Roxbury Prep (run by Uncommon Schools).[11]

We focus on 5th grade charter admissions, where students currently in traditional public schools can choose to apply to charter schools or stay where they are.[12] This grade level allows us to study the effect of the common application without complications that arise in later grades, when students face additional choice options such as district-wide school choice in 6th grade or Boston's competitive exam schools in 7th grade.[13]

Appendix Figure G.1 shows where Grade 5 schools were located in Boston in 2017. Charter schools appear as triangles, with six schools in our study shown as shaded triangles. The map reveals that Boston students have many school options available to them. Charter schools are not evenly distributed across the city. They cluster in certain areas, particularly in the East Zone, which includes the neighborhoods of Dorchester, Mattapan, and Hyde Park.[14] This geographic concentration means that charter school access varies depending on where students live in the city.

[11] We exclude two schools that participated in BPCSA – KIPP and Boston Renaissance – because they had incomplete records. The Horace Mann charter schools, which operate under Boston Public Schools oversight and Bridge Boston are also Boston charter schools but they did not participate in BPCSA (Kennedy, 2016).

[12] For more background and related studies on Boston's charters, see Abdulkadiroğlu, Angrist, Dynarski, Kane, and Pathak (2011), Angrist, Cohodes, Dynarski, Pathak, and Walters (2016), Cohodes, Setren, and Walters (2021), and Walters (2018).

[13] For more on these choice options, see Abdulkadiroğlu, Pathak, Roth, and Sönmez (2005) and Abdulkadiroğlu, Angrist, and Pathak (2014).

[14] North, West, and East Zones were designations part of Boston's student assignment system through 2014.

3.2 Sample and Data

Our analysis uses two main data sources: records from the Student Information Management System (SIMS) provided by the Massachusetts Department of Elementary and Secondary Education, and individual charter school admission records. The SIMS data include student demographic information like race, ethnicity and subsidized lunch eligibility. The charter admissions records contain details about applicants and lottery offers. We match charter applicants to the SIMS file using students' name and date of birth, following the procedure described in Abdulkadiroğlu, Angrist, Dynarski, Kane, and Pathak (2011). Since we don't have students' exact addresses, we estimate where they live using using the geocode location of their 4th grade school.[15] We then calculate travel times from these estimated locations to each charter school in our study. More details about data sources and how we calculated travel times are provided in Appendix G.

We construct our sample from Massachusetts public school fourth graders in SIMS data, covering 2014-2019 for time series analysis and focusing on 2016 for our structural analysis. We exclude students missing IDs, those who applied late or were ineligible for charter schools, and students who applied to multiple grade levels in the same year. To identify first-time Boston applicants, we apply three additional filters. First, we include only students who attended non-BPCSA Boston schools in fourth grade during 2016-17, since most students typically stay at their current school. Second, we require valid geographic location data for each student's fourth-grade school, applying this requirement to both BPCSA applicants and non-applicants. Third, we exclude students who have sibling priority at BPCSA schools, as this priority affects their admissions chances independently of other factors. The final sample comprises 3,576 applicants across six years for time series analysis and 5,072 students in 2016 (761 applicants and 4,311 non-applicants) for structural analysis. This means about 15% of eligible students apply for Grade 5 spots through Boston's charter common application.

Table 2 presents summary statistics for our structural analysis sample. Charter applicants concentrate disproportionately in the East Zone, which is where most charter schools are located. Boston's student population reflects the demographics typical of large urban school districts, with high proportions of Black and Hispanic students and students qualifying for subsidized lunch. Within this population, charter applicants are more likely to be Black and less likely to be Hispanic compared to non-applicants. BPCSA applicants and non-applicants have similar baseline Massachusetts Comprehensive Assessment System (MCAS) scores.[16]

[15] Boston is divided into 867 geocodes. For more on geocodes, see Angrist, Gray-Lobe, Pathak, and Idoux (2024). For more on the estimation of student locations, see Appendix G.

[16] This contrasts with the period before the common application, when charter applicants typically had higher baseline

3.3 Descriptive Statistics for the Common Application in Boston

Figure 1 shows that the introduction of the common application coincided with more applications per student and lower admission rates. To isolate differences holding fixed the composition of schools, the analysis in this exhibit restrict attention to schools with complete admissions and enrollment data across all years shown in the figure. Panel A shows a sharp rise from 1.4 to 1.9 applications per applicant in 2017,with these patterns continuing thereafter, consistent with the reduction in marginal cost of applying to additional schools with the adoption of the Common Application. (Appendix Figure D.1 provides a full breakdown of the distribution of applications per applicant and Appendix Table G.3 provides a full distribution of acceptance rates and enrollment counts by school.) While applications per school initially rose following the first year of the common application, the number of applicants and thus the number of applications per school declined after that, as shown in Panel B. Acceptance rates, based on initial offers, dropped sharply between 2016 and 2017, coinciding with the same period when applications per applicant increased, as shown in Panel C. Although acceptance rates gradually recovered after 2017 as the number of applicants per school decreased, they remained below 2016 levels in the following years. These findings support Proposition 1, which predicts that transitioning from Decentralized Application to Common Application would increase applications per applicant while decreasing admission rates.

Subsidized lunch applicants experienced a slightly larger increase in applications per applicant than non-subsidized lunch applicants between 2016 and 2017, a fact shown in Panel D. In addition, subsidized lunch students received a slightly larger share of offers across schools after the introduction of the Common Application. (Appendix Figure D.2 reports these details). Proposition 2 describes conditions under which a common application increases assignments of students who face higher application costs. In Boston, however, the difference between these subsidized and non-subsidized lunch applicants appears modest.

4 Structural Model and Estimation

The changes in application patterns shown in Figure 1 cannot be attributed solely to the introduction of the Common Application. Other factors, such as the November 2016 statewide charter school expansion referendum, may have influenced school preferences in Boston. For this reason, we now turn to structural modeling. This approach allows us to compare three assignment systems within a

test scores than non-applicants (Walters, 2018).

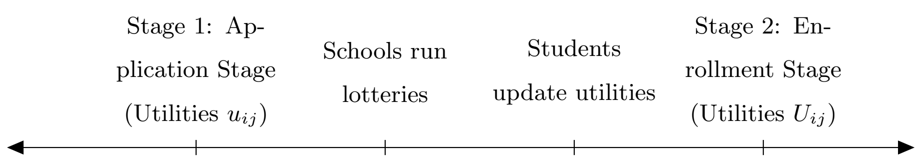
single year by hold demand patterns and time series variation fixed.

4.1 Model Motivation and Setup

We build a structural model of student applications and school choices that allows for those preferences to change between the time of application and enrollment. Since outcomes depend on student preferences and application costs, we use real-world data from both the common and decentralized application systems from our sample to estimate these parameters. We then use that model to compare the actual performance of those two systems to the projected results for the ranked system, which Boston considered but did not adopt.

Sequential Decision-Making Stages

The model spans two periods with sequential decision-making. In Stage 1, potential applicants observe their initial utility values for the schools and choose where to apply. Schools then make admissions decisions between Stages 1 and 2. In Stage 2, students receive updated utility values for each school and make enrollment decisions based on their set of admissions offers. Following Walters (2018) and Kapor, Neilson, and Zimmerman (2020), we incorporate a second-stage shock to utility to explain the empirically-observed pattern of students choosing their outside option despite BPCSA school admission. The timeline is described below:



At the time of the application (Stage 1), the utility for each BPCSA school $j \in \{1, ..., S\}$ for student i is:

$$u_{ij} = \beta_D D_{ij} + \delta_j + \epsilon_{ij}, \tag{1}$$

where D_{ij} is the estimated travel time via public transit and walking measured in minutes between student i and school j, δ_j is a school fixed effect, and ϵ_{ij} is a type-1 extreme value error term with variance normalized to $\frac{\pi^2}{6}$. The outside option has a utility given by another type-1 extreme value error term: $u_{i0} = \epsilon_{i0}$. Each school fixed effect δ_j is relative to the outside option.

After application, a student may be accepted to a subset of the schools where they applied. In Stage 2, the utility for each school (including the outside option) is given by:

$$U_{ij} = u_{ij} + \xi_{ij}, \tag{2}$$

where ξ_{ij} follows a type-1 extreme value distribution but with an estimated variance that differs from the Stage-1 error term. Specifically, ϵ_{ij} has standard deviation $\frac{\pi}{\sqrt{6}}$ while ξ_{ij} has standard deviation $\frac{\kappa\pi}{\sqrt{6}}$. The variable κ governs the extent to which preferences change across stages.

Our emphasis on travel distance for modeling school attendance decisions aligns with prior research on distance influencing choices (see, e.g., Harris and Larsen (2015) and Pathak and Shi (2021).) Appendix Figure D.3 provides supporting evidence, showing that the distance to a school is a strong predictor of both where students apply and where they choose to enroll after being accepted

Enrollment Decision

In Stage 2, students choose from their set of accepted schools by maximizing U_{ij} across their admissions offers, with the outside option always available. Under both common and decentralized application systems, students may receive offers from more than one school, while the ranked system presents students with (at most) a single offer to either accept or reject in favor of the outside option.

Application Decision

In our model, students evaluate their chances of acceptance using the previous year's admission rates rather than forming rational expectations about admissions probabilities. This stands in contrast with our theoretical model where we assume applicants correctly predict their admissions chances. We make this assumption since our data are from the first year of the BPCSA, making it difficult for students to forecast their admissions chances in an entirely new system. It also aligns with data showing little change in the applicant pool after the launch of the BPCSA. Appendix B explores an alternative model where students ignore acceptance probabilities entirely when deciding where to apply, supported by research showing families often misjudge admission chances (see, e.g., Kapor, Neilson, and Zimmerman (2020) and Rees-Jones and Shorrer (2023)).

Let $A_{ij} \in \{0, 1\}$ denote the decision for student i to apply to school j, $Z_{ij} \in \{0, 1\}$ denote acceptance of student i into school j (where $Z_{ij} = 0$ if applicant i does not apply to school j), and S_{ij} denote student i enrolling in school j, which may be a BPCSA charter schools or the outside option. We define A_i and Z_i as vectors containing the complete list of A_{ij} application choices and Z_{ij} admissions outcomes respectively, where there are 2^J possibilities for each of A_i and Z_i.

The expected utility framework requires students to consider the eventual enrollment decisions at the time of application. Assume that student i is faced with a set of charter schools Z_i for which they have received acceptances. Define the set of options for student i as $\mathcal{O}(Z_i) = \{0\} \cup \{j : Z_{ij} = 1\}$. Prior to observing the Stage-2 shock ξ_{ij}, the expected benefit to Stage-2 utility from having an available portfolio of acceptances, relative to only having the outside option available, is given by:

$$\begin{aligned} w(Z_i) &= \mathbb{E}\Big[\max_{j \in \mathcal{O}(Z_i)} U_{ij} - U_{i0}\Big] \\ &= \kappa * \log\Big(1 + \sum_{j=1}^{J} Z_{ij} * \exp\left(\frac{u_{ij} - u_{i0}}{\kappa}\right)\Big). \end{aligned}$$

Finally, assume that each applicant chooses to apply to the portfolio of schools that maximizes Stage-2 expected utility, net of the application costs. We include a single (larger) cost C for the first application and a separate marginal cost c cost for each additional school application in the model to rationalize the fact that most students do not apply to all available schools. This marginal cost of additional observations could represent either the burden of declining unwanted offers or the emotional cost of potential rejection. (See Rees-Jones and Shorrer (2023) for a summary of relevant research on these psychological considerations.) Defining $|a| = \sum_{j=1}^{J} A_{ij}$ as the number of applications submitted by student i, the total cost of those applications with a common application is

$$c(a) = (C - c)\mathbb{1}_{\{|a|>0\}} + c * |a|.$$

Applicant i's optimal set of applications is then

$$A_i = \text{argmax}_{a \in \{0,1\}^J} \sum_{z \in \{0,1\}^J} [\hat{\pi}(Z_i|a) w(Z_i)] - c(a),$$

where $\hat{\pi}(Z_i|A_i)$ is the subjective probability of observing a given realization of acceptances given application decision a.

We model the decentralized application process to be identical to the common application process, with the same fixed cost for the first application but a marginal cost denoted $\tilde{c}$ for subsequent applications that potentially differs from marginal cost c under the common application. The applicant's portfolio choice problem is then

$$A_i^D = \text{argmax}_{a \in \{0,1\}^J} \sum_{z \in \{0,1\}^J} [\hat{\pi}(Z_i|a) \hat{w}(Z_i|\theta, D_i, A_i, S_i)] - \tilde{c}(a)$$

$$\text{where } \tilde{c}(a) = (C - \tilde{c})\mathbb{1}_{\{|a|>0\}} + \tilde{c}|a|.$$

For the ranked application, we assume that students rank exact the same set of schools they would apply to with a common application.

Let $\mu_C^{(s)}$ denote the common application outcome for simulation s. We evaluate common application outcomes based on the average simulated Stage-2 utility as:

$$\bar{W}(\mu_C) = \frac{1}{|\mathcal{I}|} \sum_{i \in \mathcal{I}} E[U_i(\mu_C(i))|\theta, D_i, A_i, S_i]$$
$$\approx \frac{1}{|\mathcal{I}|} \sum_{i \in \mathcal{I}} \left(\frac{1}{100} \sum_{s=1}^{100} U_i^{(s)}(\mu_C(i)^{(s)}) \right).$$

The same steps are used to compute other properties of the common application allocation such as the average share of students who enroll in a school ranked first, second, and so on, based on Stage-2 utilities U_{ij}.

Given parameter estimates $\hat{\theta}$, our goal is to compare the performance of the common application system used in 2017 to decentralized and ranked alternatives. These comparisons require estimating an allocation of students to schools. Let this allocation be denoted by $\mu : \mathcal{I} \rightarrow \mathcal{J}$, where $\mathcal{I}$ is the set of students and $\mathcal{J}$ is the set of BPCSA schools and an outside option. Denote $\mu(i)$ as the enrollment of student i under allocation μ. In an allocation, every student enrolls in either a BPCSA school or the outside option.

4.2 Estimation of the Parameters of the Structural Model

Among the set of applicants and non-applicants, we estimate the parameters of the common application model (school fixed effects, distance coefficients β, the fixed cost C, the marginal cost c, and the variance of the second stage error κ) using simulated maximum likelihood. Define the set of parameters as $\theta = (\delta, \beta, C, c, \kappa)$. Define S_i as the observed school chosen by student i (which may be a BPCSA school or the outside option).

The likelihood can be broken into two separate cases. The first case is when students receive BPCSA school offers. The likelihood computes choice probabilities of application and enrollment:

$$Pr(A_i, S_i|\theta, D_i) = \underbrace{Pr(A_i|\theta, D_i)}_{\text{application}} * \underbrace{Pr(Z_i|A_i)}_{\text{offers}} * \underbrace{Pr(S_i|Z_i, A_i, \theta, D_i)}_{\text{enrollment}}.$$

The second case is when students do not receive a BPCSA offer. Without a BPCSA offer, students do not decide between enrolling in a BPCSA school and outside option because they take the outside option. The corresponding choice probability is therefore only for the application decision $Pr(A_i|\theta, D_i)$. Appendix F writes out the likelihood in these two cases and provides additional details on computation.

4.3 Preference Estimates and Changes between Application and Enrollment

Table 3 reports preference estimates inferred from choices made under the common application. About 15% of eligible students apply for Grade 5 spots through Boston's charter common application, and the rates are similar across subsidized lunch and minority status. The table reports estimates of different cost patterns across student groups, from re-estimating the model allowing costs to differ by demographic group while imposing constant values of other parameters across groups. Subsidized lunch students have higher fixed costs but lower marginal costs than non-subsidized lunch students. This counterintuitive finding stems from two factors: (1) subsidized lunch students live farther from schools and (2) apply to schools with lower average utility (like School 6). The gap in fixed costs between minority and non-minority students is smaller.[17]

Our demand model estimates in Panel B of Table 3 show distance strongly influences application choices. We treat distance as numeraire, so other estimates are normalized by β, representing effects in travel-time minutes. The school fixed effect estimates in Panel B show some schools are more popular than others, conditional on distance. The three least popular schools are School 3, 5 and 6, a fact that is also apparent when looking at the fraction of applicants applying, reported in Panel C. The negative school fixed effects relative to the outside option reflect low overall application rates, since school effects are relative to the outside option.

There are also large differences in application shares to each school by minority status in Panel C. For example, 49% of Black and Hispanic applicants apply to School 1 and 2, while only 29% of non-Black and Hispanic applicants apply to School 1 and 78% apply to School 2. These differences are likely driven by patterns of geographic sorting by race within Boston. While the differences are not as pronounced comparing students across subsidized lunch categories, Panel D of Figure 1 shows that after the common application was adopted, applications per applicant increased more significantly for subsidized lunch students than for non-subsidized students.

The estimate of $\kappa/|\beta| = 9.37$ indicates substantial preference changes between application and enrollment stages. This large preference shock is evidenced by enrollment patterns: 48% of applicants choose the outside option, with 33% doing so despite acceptances. Only 53% of outside option enrollees had no BPCSA acceptance, suggesting students apply for option value but often change preferences before enrollment.

Table 4 shows how school rankings shift between application and enrollment stages. The table

[17] As a comparison, Fu (2014) estimates application costs for college applications, and finds that marginal application costs decrease rapidly in the number of applications, with the estimated practical costs of these applications that are much larger than the submission fees (1900 dollars for the first application and 900 dollars for the second application).

reports seven options corresponding to the six BPCSA charter schools in our data and the outside option. For each applicant, we impute the ranking of the school based on our preference estimates using only information from application (Stage 1) in the rows of the table. The columns report the ranking of the school based on preference estimates that also use information on enrollment decisions (Stage 2). A school ranked first at application has a 72% chance of remaining the top choice at enrollment, reflecting the preference changes captured by our κ estimate. The transition rate for lower ranked choices is higher. For example, a school ranked 3rd during application has a 46% chance of still being ranked third at the enrollment stage. It has a 26% chance of being ranked higher, and a 29% chance of being ranked lower. This table shows that it will be important to consider the fact that preferences may change between application and enrollment stages in our comparison across application systems.

5 Comparisons of Three Admissions Systems in Boston

5.1 Simulation Procedures

We use our model to simulate the three different assignment systems using data from the 2017 common application year. Our simulation must generate utilities, application costs, and produce assignments to clear the market. To generate utilities, we use our estimates of $\hat{\theta}$ and unobserved tastes $(\epsilon_{ij}, \xi_{ij})$ based on student's application and enrollment decisions. Specifically, for each student i, given $\hat{\theta}$ and geographic location D_i, we draw error terms $(\epsilon_{ij}^{(s)}, \xi_{ij}^{(s)})$, where $s = 1, ..., 100$, from the estimated unconditional distributions. We then require that these unobserved components of tastes be consistent with observed application (A_i) and enrollment (S_i) decisions by discarding any draws that are not.[18] This procedure defines a simulated Stage-1 utility $u_i^s(j) \equiv u_{ij}^{(s)}$ and Stage-2 utility $U_i^s(j) \equiv U_{ij}^{(s)}$ for each student-school pair for each simulation s.

Application costs are estimated from demand model for the common and ranked application simulations (shown in Table 3). Applicants submitted fewer applications under the decentralized system compared to the common application. For the decentralized system simulation, we calibrate marginal costs using all simulations and apply it uniformly to ensure the simulated 2017 application behavior aligns with the 2016 decentralized average of 1.60 applications per student based on the simplex Nelder-Mead algorithm.[19] When there are two student groups, we use the same procedure where we

[18] 8.7% of students were found attending BPCSA schools in 2017 without recorded acceptances, possibly due to missing waitlist data. Since we have incomplete information about the choice set which led to their enrollment S_i, we only adjust unobserved tastes for application choices, and not enrollment decisions.

[19] Because we model perceived acceptance probabilities $\hat{\pi}$ as backward-looking and $\tilde{c}$ is only calibrated based on application behavior, the number of applications each applicant submits is weakly monotonically decreasing in $\tilde{c}$. We therefore avoid potential issues of multiple equilibria that would occur if there were feedback between $\tilde{c}$ and $\hat{\pi}$.

match the group-specific number of applications for each group separately.[20]

The approach to clear the market depends on school capacities and the assignment system. We directly observe 2017 school enrollments, so we set school capacity equal to total school enrollment.[21] Within each simulation, this enrollment count is used for school capacities across all application systems.

To clear the market, for the common application system simulation, we directly observe common application enrollment outcomes in 2017, and so do not need to simulate a waitlist. For simulations in different environments, we also do not need a waitlist: schools make offers to applicants in order of random priority, drawn independently across schools, until each reaches capacity.

Market clearing in the decentralized system simulation is similar to the common application. Schools accept applicants one-at-a-time if they have capacity or reach 100% acceptance in order of a random priority order. Students choose their highest-utility school among acceptances, based on Stage-2 utility $U_{ij}^{(s)}$. As with the common application, there is no waitlist in this procedure because it concludes when schools either reach capacity or accept all applicants.[22]

We simulate market-clearing in the ranked application outcome, μ_R, using the student-proposing deferred acceptance (DA) algorithm. Schools use identical random lottery numbers to determine student priorities. Two rounds are needed because some students who receive an initial offer may opt to take their outside option, opening up capacity at schools they were initially assigned. In the first DA round, students apply to the same set of schools that they are observed applying to under the common application in 2017, with school rankings derviced from Stage-1 utilities $u_{ij}^{(s)}$. After the first DA round, students are either assigned to a school or unassigned. Students are then placed on waitlists for any school where they originally applied but did not receive an offer, regardless of their initial ranking for that school. In the second DA round, students whose first choice based on Stage-2 utilities is the same as their Stage-1 assignment (out of all originally ranked schools and the outside option) can choose to enroll in their Stage-1 assignment. Other students submit new rankings of the

[20] Appendix Table G.3 shows that the implied marginal cost for decentralized applications is approximately 1.70, more than twice the cost in the common application system. This implies that a higher marginal cost per application is needed to explain the number of applications under the decentralized system. When costs differ by subsidized lunch status, non-subsidized lunch students encounter higher marginal costs in the decentralized system, consistent with the pattern found in the common application system.

[21] For students attending a BPCSA school where we do not record the student receiving an acceptance, we assign them to the school that would provide them the highest utility, and adjust school capacity as necessary to accommodate them. Because of this approach, school capacities may vary slightly between different simulation scenarios. This is the only reason the common application outcomes are simulated. For all other students, simulated enrollments will be identical to their observed 2017 enrollments.

[22] Note that this procedure is equivalent to the school-proposing deferred acceptance algorithm where school rankings of students are drawn from an independent random distribution.

schools on their original Stage-1 rank order list based on Stage-2 utilities.[23] The procedure terminates after the second round because a student would never reject an acceptable offer they receive in the second round since there are now new taste shocks.

5.2 Ranking and Welfare Comparisons

Table 5 compares how students are distributed across their preferred schools under each application system. The ranked system has the highest share of students obtaining their top-choice school, which aligns with Corollary 4. The decentralized and common application systems lead to fewer students obtaining their first choice, each with roughly similar performance. This similarity reflects a balance of competing factors: while the common application system potentially exposes students to more schools they might prefer, this advantage is counterbalanced by increased competition for those same schools. Although the absolute differences between systems appear small, these absolute levels are largely a consequence of aggregate supply and demand.[24] The differences are significant when measured in percentage terms. For example, approximately 9% more students (0.031/0.356) are offered their top choice under the ranked system compared to the common application system.

Table 5 reveals that while similar percentages of students obtain their first-choice school in both systems, more students secure either their first two or first three choices under the common application system. This finding contrasts with the prediction of Proposition 1, which concluded that rank distribution under the decentralized application system first-order stochastically dominate those under the common application. This discrepancy likely arises because Proposition 1 does not allow for student preference changes between the application and enrollment stages.

We next compare different assignment systems against two benchmarks. The first benchmark is a utility-maximizing "first-best" assignment subject to capacity constraints, computed by solving the Shapley-Shubik assignment problem with the objective of maximizing overall total utility (Shapley and Shubik, 1971). The second benchmark represents a scenario where all students attend their outside option, intended to capture a no-choice "neighborhood" assignment outcome.[25] We present

[23]In this second round, students are not restricted to rank schools that are better than their first round. This is designed to mimic the waitlist structure used in the traditional Boston Public Schools match, in which "students will be on all waitlist for schools they ranked on their choice list until June 15, 2021" (`https://www.bostonpublicschools.org/Page/6487`). BPS has since changed the policy to default students to the waitlist for their highest ranked school unless an applicant indicates otherwise.

[24]Differences between assignment systems are swamped by aggregate supply-and-demand considerations are a phenomenon seen in other work, e.g., Abdulkadiroğlu, Agarwal, and Pathak (2017) and Agarwal and Somaini (2018).

[25]This approach requires us to add up utility across all individuals. Since we use distance as our measuring unit in the choice model (representing "willingness to travel"), the justification for combining utilities this way may be weaker than in cases involving monetary prices. This is because it assumes that traveling one additional mile affects each applicant's utility equally, which may not be true. We include this metric because having a simple, single summary measure for comparison is valuable.

the comparison in two ways: first ignoring marginal costs, then subtracting marginal costs from total utility. We do this because our model does not identify where these costs come from, so we cannot definitively determine whether these costs affect overall welfare. Panel A of Figure 2 shows shows that when ignoring marginal costs, the ranked system captures 64.2% of the potential utility gain between these benchmarks, followed by the decentralized system (62.3%) and the common system (62.0%). Even though fewer students obtain their top two or top three choices under the decentralized system compared to common application as shown in Table 5, the decentralized system has comparable total utility as the common application because it better matches preference intensity as students getting their first choice have higher average utility for that school.

While the decentralized and common systems perform similarly in Panel A, Panel B tells a different story. When marginal costs are subtracted, the decentralized system performs notably worse than both the common and ranked systems. Figure 2 therefore addresses a theoretical ambiguity about welfare under different systems. Whether the decentralized system is actually better for welfare depends on the nature of the estimated application costs. If these costs represent actual resource costs (like time or money), then they reduce welfare and should be subtracted. If they represent psychological or behavioral frictions that don't involve real resource use, then they may not reduce welfare and can be ignored.

Finally, Appendix Figure D.4 reports an alternative comparison between systems by considering a "vote" between each pair of systems. This measure does not require taking a stand on interpersonal utility comparisons because it simply compares the same applicant across two allocations. The results reveal a consistent hierarchy: the ranked system is generally preferred over the common application system, which is generally preferred over the decentralized system, though the margins are relatively small.[26]

5.3 Stability, Option Value, and Access Across Systems

Our analysis has focused on comparing mechanisms from a preference-utilitarian perspective by examining how well students fare based on their assigned schools or expected utility. The ranked system generally outperforms both the decentralized and common application systems when evaluated by pairwise votes and total utility. We now examine three additional characteristics to compare these application systems: stability (whether students would want to trade assignments after the fact), stu-

[26] These magnitudes are not directly comparable to those in Table 5 since they represent a within-individual comparison which only capture whether an applicant's rank changes across assignments, and not the extent of the change in rank across assignments.

dent option value (the range of choices available to students), and access (whether students apply to schools that are better than their outside option). Table 6 reports our comparisons based on 100 simulation draws, with results shown as percentages across these simulations.

We measure the potential for instability by counting students eligible for beneficial pairwise, trades defined as students who could improve their outcome by trading placements with another student where both parties benefit from the exchange. For example, if student 1 could advantageously swap assignments with either student 2 or student 3, we count three students as eligible for pairwise trades in our measure.[27] Proposition 5 shows that the ranked application guarantees a pairwise stable assignment of students to schools. This means that if preferences remain consistent between application and enrollment stages, no student would benefit from swapping assignments with another student. Both ranked and common application systems allow for blocking pairs in the simulation because a student may experience a Stage-2 taste shock which makes an unranked school a desired choice. Common application systems also allow for blocking pairs due to the mismatch force described Proposition 5, which occurs even when preferences don't change. As shown in Panel A of Table 6, the ranked system performs best, with almost no eligible trades across simulations because it is rare for the combination of taste shocks to create a blocking pair among initially unranked schools. In contrast, approximately 9% of students are eligible for pairwise trades under both the decentralized and common application systems.[28]

We measure option value in the simulations by counting the number of applications to schools that students initially rank below their outside option. One advantage of a common application system over a decentralized system is that students can apply broadly and then choose which offer to accept after receiving all decisions, providing greater flexibility. In our choice model, students submit these applications based on anticipation of possible preference changes prior to their enrollment decisions. However, these applications can create system-wide congestion by adding applications to schools that students are unlikely to attend. Panel B of Table 6 shows the decentralized system yields the lowest rate, 10%, of such applications, by comparison to a much higher rate, 27%, with the common and ranked systems. (Note that we assume that students list the same set of schools with a ranked system that they apply to with a common application.) This difference represents an important tradeoff across application systems. While option value provides flexibility for students whose preferences

[27] Note that this represents an upper bound on actual trades, since in this example, either student 2 could trade with student 1, or student 3 could trade with student 1, but both exchanges cannot occur simultaneously.

[28] Though not shown in the table, the ranked system's superiority is evident when counting total potential trades for each simulation draw. The common application enables more potential trades than the ranked system in 97/100 of simulations. The decentralized system enables more potential trades than the ranked in each simulation. However, the common system has fewer potential trades than the decentralized system in 58/100 simulations.

may change, it can burden the system with applications that are less likely to result in enrollment, potentially making it harder for other students to access their preferred schools.

The third dimension we evaluate is how each system expands access to schools. We examine this by counting cases where application costs deter students from applying to schools that would generate more (Stage-2) utility than their outside option. Panel C of Table 6 reveals that in the decentralized system, 14% of schools that students didn't apply to were actually preferred to their outside option, whereas in the common and ranked systems, this occurred for only 1% of schools that students didn't apply to. This substantial difference in access (13% vs 1%) highlights how lower application costs in common and ranked systems reduce application barriers.

5.4 Decentralized Applications with Heterogeneous Costs

We next use the extension of our model where application costs vary across subsidized lunch status to examine claims that common applications could "level the playing field" by reducing barriers for disadvantaged students. Proposition 2 establishes conditions under which disadvantaged students benefit from a common application. Our analysis, based on estimating a model with group-specific costs, reveals a surprising pattern: subsidized lunch students face lower marginal costs in both systems compared to non-subsidized lunch students. Under the common application, subsidized lunch students have normalized marginal costs of $c/|\beta| = 0.75$ versus 1.13 for non-subsidized lunch students (Table G.3). This gap persists in the decentralized system, with normalized costs of 1.67 for subsidized lunch students versus 2.37 for non-subsidized lunch students.

While this finding might seem counterintuitive given financial constraints low-income families might face, it highlights that application costs encompass more than just monetary expenses. The estimated marginal costs capture various barriers including informational and psychological costs. Several factors could explain these lower costs for subsidized lunch students. For instance, many cities implement targeted information campaigns about charter schools specifically for low-income communities. These interventions may reduce the informational burden and psychological costs for disadvantaged students seeking applications, even if their financial constraints remain significant. As Cohodes, Setren, and Walters (2021) note, a 2010 Massachusetts state charter law requires charters to increase recruitment efforts of high-needs students.

Figure 3 compares common, ranked, and decentralized application outcomes under varying assumptions on the decentralized marginal costs for subsidized lunch students, while holding fixed costs constant for non-subsidized lunch students. The figure shows how the fraction of subsidized lunch students receiving their first-choice changes as their the marginal costs increase, examining both first-choice placement (Panel A) and combined first and second-choice placement (Panel B). Panel A shows that common and decentralized systems yield similar first-choice placement rates (36-37%) across all tested cost values, while a ranked system yields more first-choice placements (41%). Even with higher marginal costs, common applications do not significantly improve first-choice outcomes relative to the decentralized system. This occurs because increased marginal costs create a tradeoff: better targeting of applications but reduced access to potentially preferred schools. Panel B reveals that common applications do improve first or second-choice placements when subsidized lunch students face very high marginal costs, as access effects strengthen; this brings the share of subsidized lunch students receiving their first or second choice to almost the exact same level as the ranked system. However, at actual estimated marginal costs (shown in red), differences remain small. These findings suggest the estimated marginal costs under the decentralized system aren't high enough for common applications to meaningfully "level the playing field." Additionally, the large proportion of subsidized lunch applicants may limit the equal access rationale for a common application, as their substantial representation could minimize potential gains even with higher application costs.

5.5 Alternative Behavioral Assumptions

In our expected utility maximizing framework, students consider both their probability of acceptance and their future enrollment choices when deciding where to apply. However, recent evidence from Kapor, Neilson, and Zimmerman (2020) shows that families often misjudge admissions chances. Therefore, we briefly consider an alternative model where students ignore acceptance probabilities and the potential value of changing preferences when selecting schools in which to apply.

Appendix B provides details on this model. Here, we summarize the findings. This model implies much stronger preference changes than our baseline model, as seen in Appendix Table B.1. Appendix Table B.2 shows that the ranked system still outperforms both a common and decentralized application system for first-choice placements. The decentralized system performs slightly worse than the common application, partly because fewer students receive any acceptance under a decentralized system. This occurs because of the behavioral assumption that students only apply to schools they prefer over their outside option.

6 Simulations Beyond the Boston Context

Two specific features of the Boston charter schools context stand out in our analysis. First, 701 applicants compete for 352 seats in 2017. Second, some students ultimately choose an outside option upon admission and preferences change between application and enrollment stages. To assess how our findings extend beyond Boston, we examine variations along these two dimensions: (1) the degree of school oversubscription and (2) the extent of preference changes between application and enrollment stages. We calibrate our parameters so that Boston's actual values fall in the middle range of both dimensions.

To minimize degrees of freedom as we vary environments, we use the same applicants and estimated driving times from our structural estimation and hold fixed a distance coefficient ($\beta = 0.04$), school fixed effects ($\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0.0$), and fixed application costs ($C = 0.3$ for the decentralized and common applications). We vary only the school acceptance rates (identical across all four schools within each simulation) and the extent of preference changes (κ). For the common application, we set a low but non-zero marginal cost ($c = 0.03$) to prevent students from automatically applying to all schools. For decentralized applications, we test both low ($\tilde{c} = 0.06$) and high ($\tilde{c} = 0.30$) marginal cost scenarios.

Our analysis features two main scenarios (further detailed in Appendix Table E.1). The **heavy oversubscription** scenario is one where students apply broadly but average only one acceptance, with all schools maintaining 25% acceptance rates. The **light oversubscription** scenario features students applying more selectively while receiving most of their choices, with schools maintaining 75% acceptance rates. but otherwise identical preference parameters. The heavy oversubscription scenario represents more competitive environments with more applications and lower acceptance rates. Boston's context falls in between with about 2.7 applications per applicant, and acceptance rates across schools averaging about 41%.

We also allow for two levels of preference changes between application and enrollment stages: **no changes** ($\kappa = 0$) with perfect correlation between utilities at both stages, and **high changes** ($\kappa = 2$) with a 0.51 correlation. This level represents a much greater extent of preference changes than the 0.95 correlation found in the Boston study, so it should be seen as providing an upper bound on potential effects.

Table 7 reports the two main metrics: the fraction of total utility, which compares the actual outcome's total utility to the best possible outcome normalized by the difference between random neighborhood assignment and the utility-maximizing assignment (as in Figure 2) and the fraction of applicants receiving either their first or their first and second choice.[29]

The intuitive properties of oversubscription and preference changes hold across all environments in our simulations. Increased competition for seats under heavy oversubscription reduces both the proportion of students matched to first-choice schools and total utility (shown in Panels A and B) by comparison to the results under light oversubscription (shown in Panels C and D). Similarly, more students are assigned to first choice schools when preference changes are high than when preferences are stable, because students are more likely to prefer the outside option, thereby opening up charter school spots for other applicants.

In the heavy oversubscription environment with stable preferences, the decentralized system with high marginal costs yields the most desirable matches of students to schools, as shown in Panel A of Table 7. Excluding application costs, the the decentralized system with high marginal cost achieves in 68% of total utility compared to 64% under the ranked system, with 33% of applicants obtaining their first choice compared to 31% under the ranked system and 26% under common application. These comparisons suggest that when preferences are mostly known in advance, application costs built into the decentralized system facilitate sorting, since students then only apply to schools where they have relatively high utility values. However, the screening benefit of the decentralized system still comes with costs: when we net marginal costs, the ranked system generates the highest fraction of total utility. Here, the ranked outperforms the common system because it avoids it incorporates information from the students' ordinal rankings and because there are limited option-value benefits to the common system when preferences are stable.

We find relatively similar results with stable preferences and light oversubscription (Panel C), where once again, the fraction of total utility and the share receiving their first choice are highest under the decentralized system with high marginal cost, but the advantage of the decentralized system in terms of total utility vanishes when marginal costs are netted out. In this environment, applicants apply to a smaller number of schools, and light oversubscription means that applicants are likely to obtain their initial top choice and it is likely to remain the top choice. Moreover, the gap between ranked and common systems becomes smaller under light oversubscription, both for total utility and the share of students getting their first choice.

With high rates of preference change and heavy oversubscription (Panel B), the fraction of total utility and the share receiving their first choice are highest under the ranked system. The common system performs second best on the fraction of total utility, and leads to the highest fraction obtaining

[29] We report utility in terms of this normalization because when κ increases, the Stage-2 taste shock increases, which mechanically increases average utility.

their first or second choice across systems. Not surprisingly, the decentralized system performs worst in this instance even when we exclude application cost because it tends to match students based on Stage-1 rather than Stage-2 utility, with the result that under this system students tend to take the outside option after a negative preference shock to the school where they were assigned.

Finally, with high rates of preference change and light oversubscription (Panel D), the ranked system has the highest fraction of total utility and share receiving their first choice. This scenario represents the strongest case for using a common application because it prioritizes the option value properties of the common application. With light oversubscription, it is typically possible for a student to change schools in Stage 2 with full knownledge of their realized preferences. Thus, the common application system results in 98% of students receiving either their first or second choice school.

In sum, across all four scenarios, the ranked system consistently performs best. The decentralized system with high marginal costs shows potential when preferences are stable, but its benefits disappear if we view application costs as real rather than transitory psychic expenses. Compared to the decentralized system, the common application works best under light oversubscription when preferences change but never outperforms the ranked system.

7 Conclusion

This paper develops a theoretical model comparing three K-12 school application systems: common, decentralized, and ranked. We examine the effects of Boston's 2017 charter common application system compared to its previous decentralized system. Using estimates from a structural model of the common application, we measure student welfare and simulate counterfactual scenarios. Finally, we extend our Boston model to explore various scenarios with different characteristics, conducting empirical simulations that vary oversubscription levels, preference changes, and application costs to measure the relative performance of each system.

Our results offer an important caution about common application systems. First, theory shows common applications don't necessarily improve access. While common applications reduce application costs, they also increase congestion. Our framework reveals that certain application frictions can actually improve student-school matching. The ranked system strikes a better balance: lowering application costs while enabling effective sorting by using student preferences to guide allocations.

Second, our Boston charter case study confirms several of the model's predictions. Boston's common application increased applications and decreased admission rates, but didn't significantly change representation of low-income students among applicants, suggesting limited equity gains. We also found substantial gaps between preferences students expressed when applying and those that actually drove enrollment decisions, which is a potential advantage of common applications not captured in our theoretical model. However, this potential benefit proves limited in practice. Our estimates show the ranked system outperforms the common application across multiple dimensions, both in Boston specifically and under varying assumptions about oversubscription and preference stability. The decentralized system can sometimes match the ranked system's performance, but these gains disappear once application costs are considered.

References

Abdulkadiroğlu, A., N. Agarwal, and P. A. Pathak (2017): "The welfare effects of coordinated assignment: Evidence from the New York City high school match," *American Economic Review*, 107(12), 3635–89.

Abdulkadiroğlu, A., J. D. Angrist, S. M. Dynarski, T. J. Kane, and P. A. Pathak (2011): "Accountability and Flexibility in Public Schools: Evidence from Boston's Charters And Pilots," *Quarterly Journal of Economics*, 126(2), 699–748.

Abdulkadiroğlu, A., and T. Sönmez (1998): "Random serial dictatorship and the core from random endowments in house allocation problems," *Econometrica*, 66(3), 689–701.

Abdulkadiroğlu, A., J. D. Angrist, and P. A. Pathak (2014): "The Elite Illusion: Achievement Effects at Boston and New York Exam Schools," *Econometrica*, 82(1), 137–196.

Abdulkadiroğlu, A., P. Pathak, and A. E. Roth (2009): "Strategy-proofness vs. Efficiency in Matching with Indifferences: Redesigning the NYC High School Match," *American Economic Review*, 99(5).

Abdulkadiroğlu, A., P. A. Pathak, A. E. Roth, and T. Sönmez (2005): "The Boston Public School Match," *American Economic Review, Papers and Proceedings*, 95, 368–371.

Abdulkadiroğlu, A., and T. Sönmez (2003): "School Choice: A Mechanism Design Approach," *American Economic Review*, 93, 729–747.

Agarwal, N., and P. Somaini (2018): "Demand Analysis Using Strategic Reports: An Application to a School Choice Mechanism," *Econometrica*, 86(2), 391–444.

Allman, M., I. Ashlagi, and A. Nikzad (2023): "On rank dominance of tie-breaking rules," *Theoretical Economics*, 18(2), 707–748.

Angrist, J. D., S. R. Cohodes, S. M. Dynarski, P. A. Pathak, and C. R. Walters (2016): "Stand and deliver: Effects of Boston's charter high schools on college preparation, entry, and choice," *Journal of Labor Economics*, 34(2), 275–318.

Angrist, J. D., G. Gray-Lobe, P. A. Pathak, and C. Idoux (2024): "Still Worth the Trip? School Busing Effects in Boston and New York," Working paper, MIT Department of Economics, MIT Department of Economics and NBER.

Ashlagi, I., and A. Nikzad (2020): "What Matters in Tie-Breaking Rules? How Competition Guides Design," *Journal of Economic Theory*, 190, 1–64.

Avery, C. N., and J. Levin (2010): "Early Admissions at Selective Colleges," *American Economic Review*, 100(5), 2125–2156.

Chade, H., G. Lewis, and L. Smith (2014): "Student Portfolios and the College Admissions Problem," *Review of Economic Studies*, 81(3), 971–1002.

Che, Y.-K., and Y. Koh (2016): "Decentralized College Admissions," *Journal of Political Economy*, 124(5), 1295–1338.

Chen, Y., and Y. He (2021): "Information acquisition and provision in school choice: an experimental study," *Journal of Economic Theory*, 197, 105345.

Cohodes, S. R., E. M. Setren, and C. R. Walters (2021): "Can Successful Schools Replicate? Scaling up Boston's Charter School Sector," *American Economic Journal: Economic Policy*, 13(1), 138–67.

Deshpande, M., and Y. Li (2019): "Who is Screened Out? Application Costs and the Targeting of Disability Programs," *American Economic Journal: Economic Policy*, 11(4), 213–248.

Fu, C. (2014): "Equilibrium tuition, applications, admissions, and enrollment in the college market," *Journal of Political Economy*, 122(2), 225–281.

Grenet, J., Y. He, and D. Kubler (2022): "Preference Discovery in University Admissions: The Case for Dynamic Multioffer Mechanisms," *Journal of Political Economy*, 130(6), 1427–1476.

Handel, B. R. (2013): “Adverse Selection and Inertia in Health Insurance Markets: When Nudging Hurts,” *American Economic Review*, 103(7), 2643–2682.

Harris, D. N., and M. F. Larsen (2015): “What Schools Do Families Want (And Why)?,” Discussion paper, Education Research Alliance for New Orleans, New Orleans, LA.

Hoxby, C. M., and C. Avery (2013): “The Missing ’One-Offs’: The Hidden Supply of High-Achieving, Low-Income Students,” *Brookings Papers on Economic Activity*, 43(1): 1-65.

Hoxby, C. M., and S. Turner (2015): “What High-Achieving Low-Income Students Know about College,” *American Economic Review: Papers and Proceedings*, 105(5), 514–547.

Kapor, A., M. Karnani, and C. A. Neilson (2024): “Aftermarket Frictions and the Cost of Off-Platform Options in Centralized Assignment Mechanisms,” *Journal of Political Economy*, 132(7), 2346–2395.

Kapor, A. J., C. A. Neilson, and S. D. Zimmerman (2020): “Heterogeneous Beliefs and School Choice Mechanisms,” *American Economic Review*, 110(5), 1274–1315.

Kennedy, L. (2016): “Most Boston Charter Schools Now Offer Single Online Application,” WBUR, November 1.

Klasik, D. (2012): “Common Choices: The Effect of the Common Application on Students’ College Enrollment and Success,” Stanford University, Center for Education Policy Analysis.

Knight, B., and N. Schiff (2022): “Reducing Frictions in College Admissions: Evidence from the Common Application,” *American Economic Journal: Economic Policy.*

Liu, A. Y.-H., R. G. Ehrenberg, and J. Mrdjenovic (2007): “Diffusion of Common Application Membership and Admissions Outcomes at American Colleges and Universities,” NBER Working Paper 13175.

Pallais, A. (2015): “Small Differences that Matter: Mistakes in Applying to College,” *Journal of Labor Economics*, pp. 493–520.

Pathak, P. A., and P. Shi (2021): “How well do structural demand models work? Counterfactual predictions in school choice,” *Journal of Econometrics*, 222(1), 161–195.

Rees-Jones, A., and R. Shorrer (2023): “Behavioral Economics in Education Market Design: A Forward-Looking Review,” *Journal of Political Economy: Microeconomics*, 1(3), 557–613.

Satterthwaite, M. A., and H. Sonnenschein (1981): "Strategy-proof allocation mechanisms at differentiable points," *The Review of Economic Studies*, 48(4), 587–597.

Shapley, L., and M. Shubik (1971): "The assignment game I: The core," *International Journal of Game Theory*, 1, 111–130.

Singleton, J. (2019): "Incentives and the Supply of Effective Charter Schools," *American Economic Review*, 109(7), 2568–2612.

Smith, J. (2013): "The Effect of College Applications on Enrollment," *The BE Journal of Economic Analysis and Policy*, 14(1): 151-188.

Svensson, L.-G. (1999): "Strategy-proof allocation of indivisible goods," *Social Choice and Welfare*, 16(4), 557–567, Received: 15 September 1997; Accepted: 12 May 1998.

Train, K. E. (2009): *Discrete choice methods with simulation*. Cambridge University Press.

Vaznis, J. (2016): "Boston charter schools to launch common application," *Boston Globe*, October 30.

Walters, C. R. (2018): "The Demand for Effective Charter Schools," *Journal of Political Economy*, 126(6), 2179–2223.

Table 1: Examples of Metropolitan Areas with Common Application Systems

Metro Area	For School Year	Name of Portal
	(1)	(2)
Atlanta	2020-21	Apply APS Charter
Baton Rouge	2018-19	EnrollBR
Boston	2017-18	Boston Charter Public School Application
Buffalo	2021-22	Enroll Buffalo Charters
Kansas City	2019-20	Show Me KC Schools
Houston	2018-19	Apply Houston
Los Angeles	2019-20	ApplyLA Charter Common Application
New York City	2010-11	Common Online Charter School Application
Oakland	2017-18	Oakland Enrolls
Philadelphia	2019-20	Apply Philly Charters
Rhode Island	2020-21	Enroll RI
Rochester	2017-18	GoodschoolsRoc

Notes: This table presents a partial list of cities that have implemented a single common application system for charter schools, as compiled by the authors. The "For School Year" column indicates the academic year when each city first implemented its common application system.

Table 2: Descriptive Statistics for Charter Common Applicant and Non-Applicant Samples

	Charter Applicants (1)	Non-Applicants (2)
	A: Demographics	
Special Education	0.20	0.23
Subsidized Lunch	0.76	0.79
Black, Non-Hispanic	0.38	0.32
Hispanic	0.43	0.46
	B: Geography	
Closest Charter Transit Time (minutes)	21.90	22.76
Closest Charter Drive Time (minutes)	7.39	8.21
East Zone	0.41	0.32
North Zone	0.29	0.37
West Zone	0.30	0.30
	C: Grade 4 School	
Charter	0.09	0.12
Traditional Boston Public	0.91	0.88
	D: Grade 4 Test Scores	
Observations with Test Score	718	3815
Grade 4 MCAS Average Score	0.02	0.02
Observations	761	4311

Notes: This table presents descriptive statistics separately for applicants and non-applicants to Boston Public Charter School Application (BCPSA) Grade 5 charter schools in 2017. Each row shows the mean value, except for rows indicating the number of observations. The applicant sample includes students with an estimated location who applied to at least one BPCSA charter school in our sample. The non-applicant sample consists of students with an estimated location who did not apply to any charter schools in our sample and attended a non-BPCSA school within Boston for Grade 4 in 2016-17. All characteristics are measured as of Grade 4. Geographic zones in Panel B correspond to the zones shown in Appendix Figure G.1. Test scores in Panel D are based on the Massachusetts Comprehensive Assessment System (MCAS) exam in Grade 4, normalized to have mean zero and standard deviation of one among all Boston student test-takers that year. The score shown is the average of the standardized math and reading scores.

Table 3: Preference Estimates from Common Application

		Subsidized Lunch		Black/Hispanic	
	Full Sample	Subsidized	Not Subsidized	Black or Hispanic	Not Black or Hispanic
	(1)	(2)	(3)	(4)	(5)
			A: Applicants		
Number of Applicants	761	581	180	618	143
Number of Non-Applicants	4311	3390	921	3360	951
Applications/Applicant (2016)	1.60	1.60	1.58	1.69	1.22
Applications/Applicant (2017)	2.76	2.87	2.39	2.92	2.05
			B: Preference Estimates		
Travel Time Coefficient, 100*β	–5.48	–5.20		–4.90	
Fixed Cost, $C/\|\beta\|$	6.61	7.23	5.69	7.47	6.29
Marginal Cost, $c/\|\beta\|$	0.75	0.75	1.13	0.69	1.65
$\kappa/\|\beta\|$	9.37	12.23		10.94	
$\delta_1/\|\beta\|$	–4.80	–11.83		–13.37	
$\delta_2/\|\beta\|$	–6.27	–12.48		–13.49	
$\delta_3/\|\beta\|$	–23.49	–27.71		–29.37	
$\delta_4/\|\beta\|$	–3.77	–8.23		–12.08	
$\delta_5/\|\beta\|$	–28.43	–34.46		–36.12	
$\delta_6/\|\beta\|$	–28.58	–33.87		–35.04	
			C: Fraction of Applicants Applying to Each School		
School 1	0.45	0.46	0.42	0.49	0.29
School 2	0.54	0.51	0.64	0.49	0.78
School 3	0.38	0.40	0.32	0.41	0.28
School 4	0.51	0.55	0.38	0.58	0.22
School 5	0.42	0.43	0.36	0.44	0.34
School 6	0.45	0.51	0.27	0.52	0.15

Notes: This table presents simulated maximum likelihood parameter estimates from the expected utility model of applications for Boston in 2017. Three different model estimates are presented: one using the full sample (Column 1), one allowing cost heterogeneity by subsidized lunch status (Columns 2-3), and one allowing cost heterogeneity by racial minority status (Columns 4-5). Subjective admissions probabilities for each school equal the previous year's admissions rates. Models with cost heterogeneity constrain all parameters to be equal across groups except cost. Subsidized lunch status and racial minority status are defined based on status in Grade 4. Parameter estimates in Panel B are scaled by minutes of transit time. Panel C displays the share of applicants applying to each school in the Boston Public Charter School Application system.

Table 4: Implied Ranking Between Application and Enrollment Decisions

Ranking in Application Stage	First (1)	Second (2)	Third (3)	Fourth (4)	Fifth (5)	Sixth (6)	Seventh (7)
	Ranking in Enrollment Stage						
First	0.72	0.18	0.06	0.02	0.01	0.00	0.00
Second	0.15	0.53	0.20	0.07	0.03	0.02	0.00
Third	0.07	0.16	0.46	0.19	0.08	0.03	0.01
Fourth	0.03	0.07	0.16	0.46	0.20	0.07	0.02
Fifth	0.02	0.03	0.08	0.16	0.47	0.19	0.05
Sixth	0.01	0.02	0.04	0.07	0.15	0.54	0.16
Seventh	0.00	0.02	0.01	0.02	0.06	0.15	0.75

Notes: This table displays the transition matrix of implied school rankings between the application stage (Stage 1) and the enrollment stage (Stage 2), derived from the expected utility model of applications. The subjective admissions probabilities for each school are set equal to the previous year's admissions rates. The sample consists of 701 students who applied to at least one school through the Boston Public Charter School Application (BPCSA) in 2017. Seven options are included for each applicant: the six BPCSA charter schools and the applicant's outside option. The implied rankings were generated by running 100 simulations of error terms that rationalize each applicant's observed application and enrollment decisions.

Table 5: Distributions of Rankings across Application Systems

	Common		**Ranked**		**Decentralized**	
	Avg. Share	[90% CI]	Avg. Share	[90% CI]	Avg. Share	[90% CI]
Final Ranking	(1)	(2)	(3)	(4)	(5)	(6)
1st Choice	0.356	[0.340, 0.372]	0.387	[0.369, 0.405]	0.361	[0.344, 0.378]
1st-2nd Choice	0.734	[0.716, 0.752]	0.736	[0.717, 0.755]	0.703	[0.686, 0.721]
1st-3rd Choice	0.915	[0.902, 0.927]	0.899	[0.884, 0.913]	0.867	[0.851, 0.883]
1st-4th Choice	0.977	[0.971, 0.982]	0.968	[0.961, 0.975]	0.947	[0.938, 0.955]
1st-5th Choice	0.998	[0.997, 0.999]	0.994	[0.990, 0.998]	0.982	[0.978, 0.986]
1st-6th Choice	1.000	[1.000, 1.000]	1.000	[0.999, 1.000]	0.997	[0.996, 0.998]
1st-7th Choice	1.000	[1.000, 1.000]	1.000	[1.000, 1.000]	1.000	[1.000, 1.000]

Notes: This table shows the percentage of the 761 applicants in the Boston Grade 5 sample from 2017 who are predicted to enroll in schools at different positions of their implied preference rankings at the enrollment stage. The predictions use parameter values estimated from the demand model. Confidence intervals represent the 5th and 95th percentiles of 100 simulations. These simulations vary the error terms while keeping the original parameter estimates fixed.

Table 6: Stability, Option Value, and Access Across Application Systems

	Common (1)	Ranked (2)	Decentralized (3)
A: Stability			
Students Eligible for Pairwise Trades	8.92%	0.97%	8.74%
	[5.91%, 16.29%]	[0.00%, 4.60%]	[3.22%, 14.72%]
B: Option Value			
Submitted Applications Less	27.38%	27.38%	10.00%
Preferred to Outside Option	[26.16%, 28.66%]	[26.16%, 28.66%]	[9.00%, 11.08%]
C: Access			
Unsubmitted Applications More	0.78%	0.78%	13.36%
Preferred to Outside Option	[0.53%, 1.05%]	[0.53%, 1.05%]	[12.80%, 13.90%]

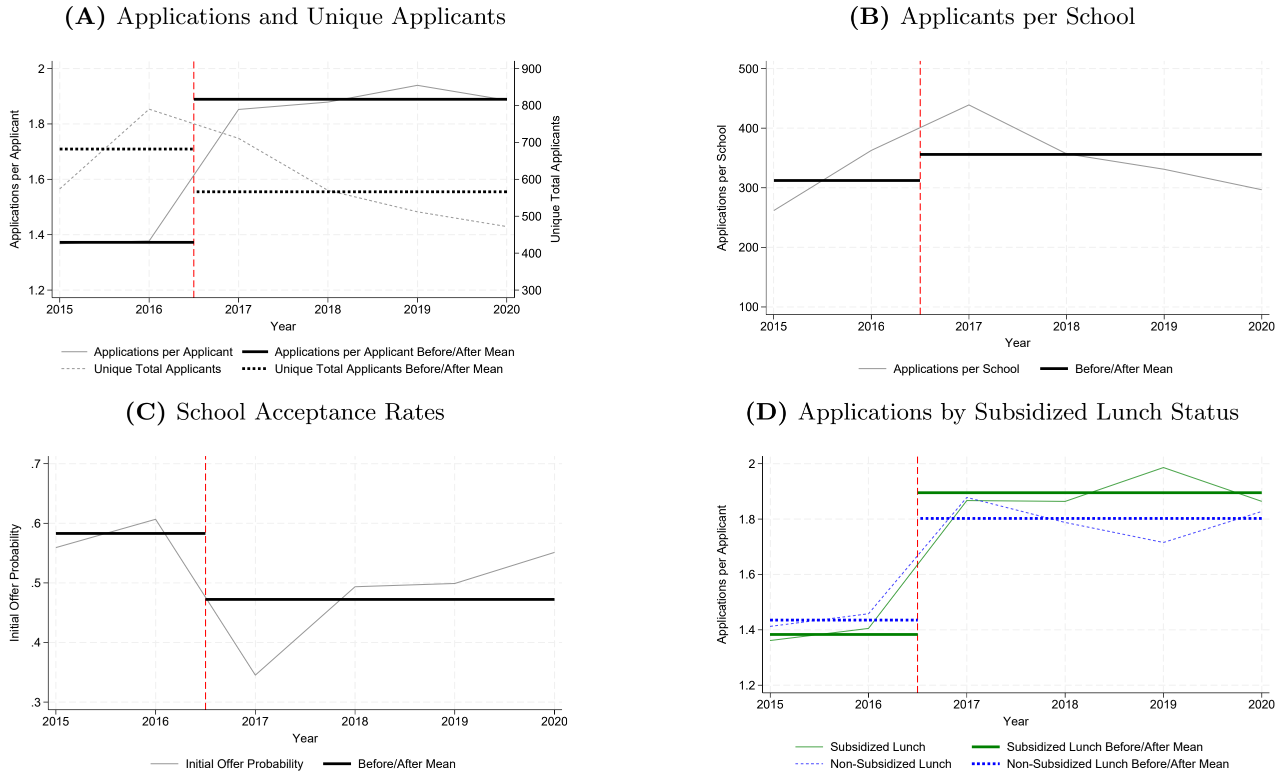
Notes: This table compares stability, option value, and access across different application systems. Each row presents the mean outcome from 100 simulations, with a 90% confidence interval in brackets below. Panel A shows the percentage of applicants could trade placements with another student for mutual benefit, based on Stage 2 utilities ($U_{ij}^{(s)}$). Panel B shows the percentage of applications submitted to schools less preferred than the outside option (applications submitted to a school j, where $u_{ij}^{(s)} < u_{i0}^{(s)}$). Panel C shows the percentage of potential applications not submitted to preferred schools despite being better than the outside option (potential applications not submitted to school j even though $u_{ij}^{(s)} > u_{i0}^{(s)}$). By construction, values for Common and Ranked have identical values in Panels B and C because the model assumes applicants apply to the same schools in both systems.

Table 7: Comparisons in Different Environments

	Ranked	Common	Decentralized: Low Marginal Cost	Decentralized: High Marginal Cost
	(1)	(2)	(3)	(4)
	A: Heavy Oversubscription and No Preference Changes			
Fraction of Total Utility	0.642	0.589	0.604	0.683
Fraction of Total Utility, net MC	0.602	0.549	0.529	0.424
Fraction w/ 1st Choice	0.313	0.260	0.267	0.332
Fraction w/ 1st-2nd Choice	0.674	0.700	0.695	0.654
	B: Heavy Oversubscription and High Preference Changes			
Fraction of Total Utility	0.595	0.487	0.398	0.458
Fraction of Total Utility, net MC	0.526	0.418	0.280	0.319
Fraction w/ 1st Choice	0.582	0.483	0.470	0.506
Fraction w/ 1st-2nd Choice	0.765	0.773	0.758	0.766
	C: Light Oversubscription and No Preference Changes			
Fraction of Total Utility	0.860	0.831	0.834	0.868
Fraction of Total Utility, net MC	0.833	0.805	0.784	0.665
Fraction w/ 1st Choice	0.806	0.754	0.758	0.809
Fraction w/ 1st-2nd Choice	0.923	0.959	0.953	0.929
	D: Light Oversubscription and High Preference Changes			
Fraction of Total Utility	0.879	0.837	0.813	0.762
Fraction of Total Utility, net MC	0.826	0.784	0.710	0.509
Fraction w/ 1st Choice	0.910	0.845	0.835	0.795
Fraction w/ 1st-2nd Choice	0.959	0.978	0.974	0.964

Notes: This table displays enrollment patterns for the heavy and light oversubscription environments defined in the text. Each table value represents the average across 10 simulations. Different panels show various levels of preference changes between application and enrollment stages, as well as different levels of oversubscription. The correlation between utilities across the two stages equals 1.00 when $\kappa = 0$ (Panels A and C) and 0.51 when $\kappa = 2$ (Panels B and D). The common application and ranked application simulations set marginal costs to 0.03. In the decentralized simulation, low marginal cost is 0.06 and high marginal cost is 0.30. "Fraction of Total Utility" rows show what fraction of the utility difference between neighborhood assignment and the utility-maximizing assignment is achieved by each application system, among all simulated applicants. The "Fraction of Total Utility, net MC" rows subtract the marginal costs from the Common and Decentralized Rows. Neighborhood assignment means assigning every student to their outside option, while the first-best allocation maximizes total utility subject to capacity constraints defined by observed enrollment under the common application system.

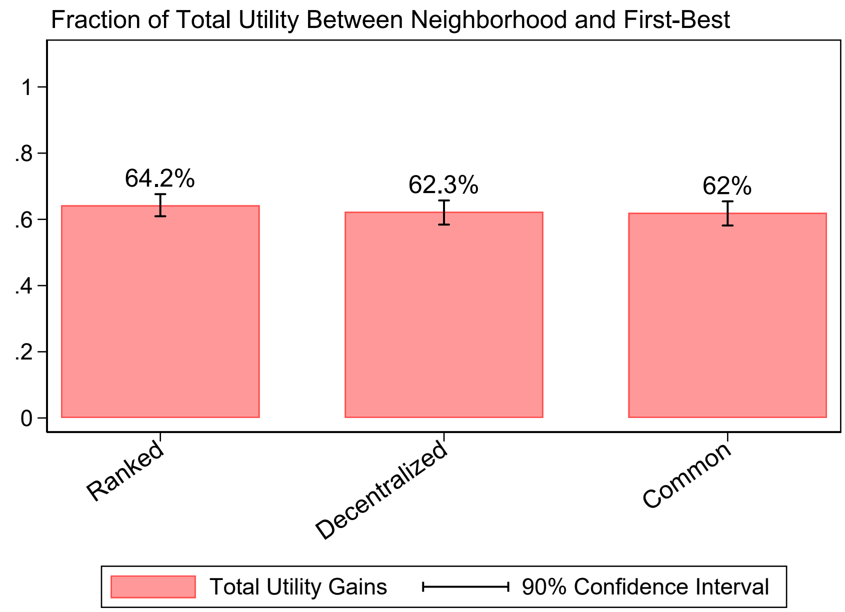
Figure 1: Grade 5 Applicants and Applications over Time



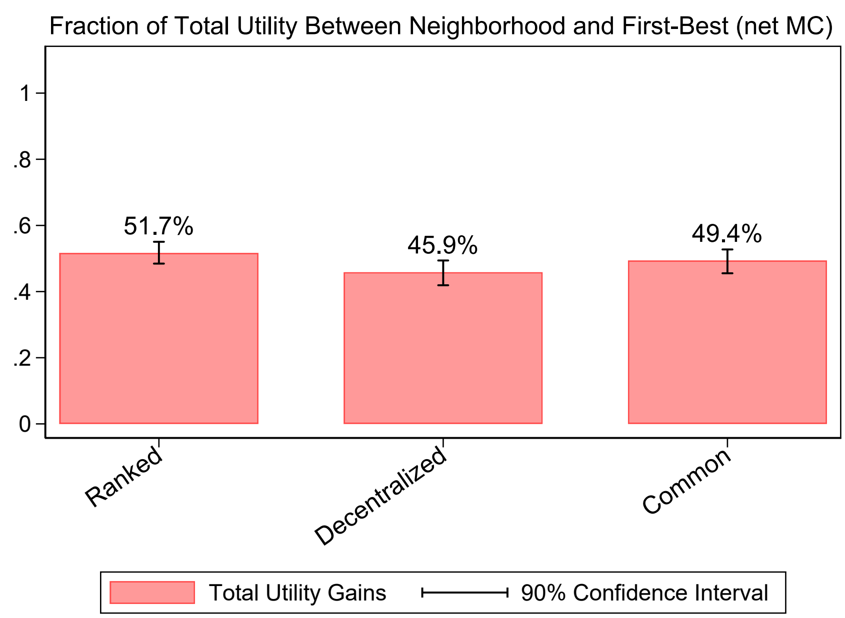
Notes: This figure presents application behavior and admissions outcomes from 2015-2020 for three Grade 5 Boston Public Charter School Application (BPCSA) schools with complete admissions and enrollment data across all years. The sample includes 3,576 unique applicants and 6,144 unique applications. Panel A displays the total number of unique applicants per year to any of the three schools, as well as the average number of applications submitted per applicant. Panel B shows the average number of applications received per school. Panel C shows the probability that each application results in an initial admissions offer, excluding waitlist offers due to potentially incomplete waitlist data. Panel D displays the average number of applications per applicant, separately by subsidized lunch status in 4th grade.

Figure 2: Total Utility Comparisons

(A) Comparisons without Marginal Costs



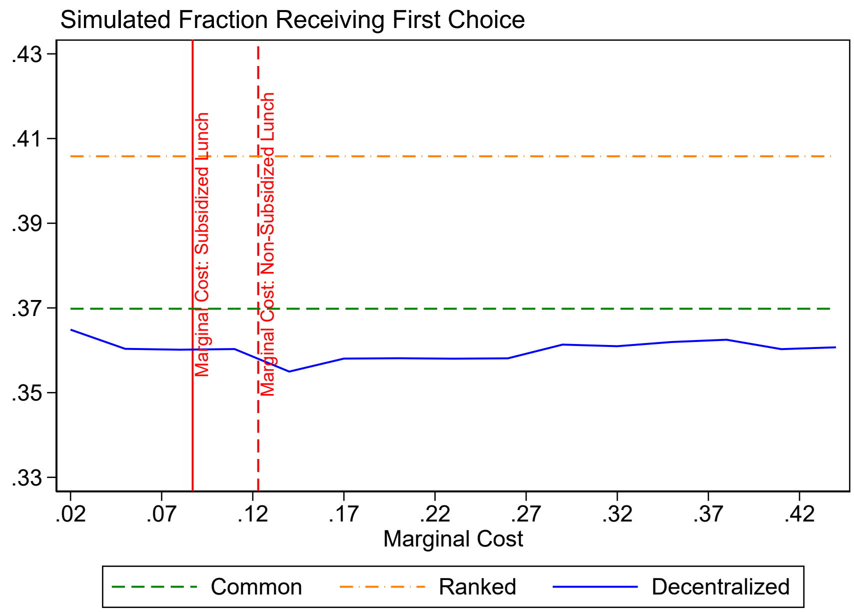
(B) Comparisons with Marginal Costs



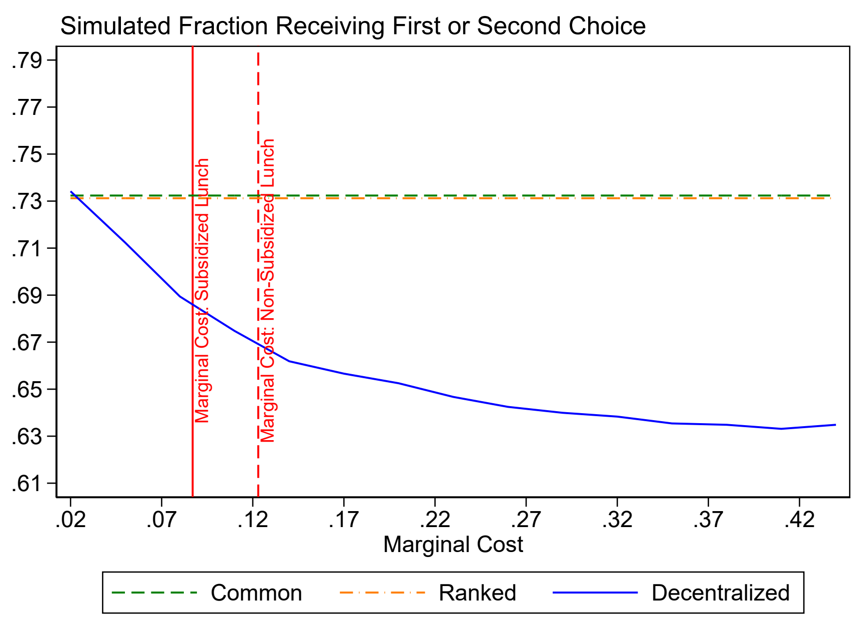
Notes: This figure shows what fraction of the utility difference between neighborhood assignment and the utility-maximizing assignment is achieved by each application system. The sample includes 761 students who applied to at least one Boston Public Charter School Application (BPCSA) school in 2017. Neighborhood assignment means assigning every student to their outside option, while the first-best allocation maximizes total utility subject to BPCSA school capacity constraints. Utility estimates are derived from actual application and enrollment decisions. Confidence intervals reflect variation across simulations, treating parameter estimates as fixed. Panel A does not subtract any marginal costs, while Panel B subtracts the marginal costs of each application.

Figure 3: Application Comparisons among Subsidized Lunch Applicants

(A) 1st Choice



(B) 1st or 2nd Choice



Notes: These figures show the estimated outcomes for 581 subsidized lunch applicants to Boston Public Charter Schools in 2017. Panel A shows the percentage of these students receiving their first choice, while Panel B shows the percentage receiving either their first or second choice (based on preferences at enrollment stage). The charts compare results from the common application and ranked system against a decentralized system where application costs for subsidized lunch students vary (shown on the x-axis), while costs for non-subsidized students remain fixed at the estimated value. Subsidized lunch status is based on Grade 4 data. All estimates come from 100 simulations which match each student's actual application and enrollment decisions.

Appendix A Theoretical Appendix

A.1 Existence of Equilibrium for the Common and Decentralized Application

Proposition A.1. *There exists a unique pure-strategy equilibrium for the Common Application system and it yields the same admission probability at each school. There exists a symmetric equilibrium for the Decentralized Application system, but it is not necessarily unique.*

Proof. We look for a symmetric equilibrium with probability p of admission at each school. Define $\phi_C(p)$ as the expected number of students who enroll at each school under the Common Application system with probability p of admission to each school. $\phi_C(p)$ is the same for each school given the assumption of a symmetric distribution of values and the same admission probability at each school. $\phi_C(p)$ is also strictly increasing in p (unless no student applies for the lowest values of p), since an increase in p induces more students to apply and also increases the expected number of existing applicants who are admitted. Furthermore, $\phi_C(p = 0) = 0$ since no one will incur cost to apply with no chance of admission and $\phi_C(p = 1) > K$ by assumption above. Thus, there is a single value of $p = p_C$ that produces a symmetric equilibrium with the Common Application.

The same logic applies to $\phi_D(p)$, the expected number of students who enroll at each school under the Decentralized Application system with probability p of admission to each school, where once again, $\phi_D(p = 0) = 0$ and $\phi_D(p = 1) > K$. This implies that there is a value $p = p_D$ that produces a symmetric equilibrium under Decentralized Applications. The distinction between $\phi_C(p)$ and $\phi_D(p)$ is that $\phi_D(p)$ need not be monotonic, which opens the possibility of multiple equilibria with decentralized applications, as illustrated by Example 1 in the main text.

Next, we show that there is no asymmetric equilibrium for the Common Application. Suppose that the unique symmetric equilibrium has admission probability p_C at each school. Any other equilibrium would have to have at least one school with admission probability below and at least one school with admission probability above p_C. Suppose without loss of generality that $p_1 > p_C$ and $p_2 < p_C$.

Consider any set of values $(y, x, v_3, v_4, \ldots v_S)$ such that a student submits a common application with these admission probabilities. If $y > x$, this student would also submit a common application with values $(y, x, v_3, v_4, \ldots v_S)$ since $p_1 > p_2$ and admission decisions are independent across schools. Further, since the joint distribution is symmetric over all S-tuples of values, these combinations occur at the same rate (density). Across these two combinations of values, the student is both more likely to be admitted to school 1 and is more likely to enroll at school 1 than at school 2. If instead $x > y$, the same logic applies unless the student applies with values $(y, x, v_3, v_4, \ldots v_S)$ but not with values $(y, x, v_3, v_4, \ldots v_S)$ but the same conclusion holds that across these two combinations of values, the student is both more likely to be admitted to school 1 and is more likely to enroll at school 1 than at school 2. So the proposed asymmetric admission probabilities cannot produce equal enrollment at both schools, ruling out the possibility of any asymmetric equilibrium. ■

A.2 Proof of Proposition 1

Proposition 1 consists of two parts, Proposition 1a, which pertains to application and admission rates for the Common and Decentralized Application, and Proposition 1b, which provides a stochastic dominance comparison of the ordinal ranks for student assignments for the two systems.

Proposition 1a:

Proof. (Admissions Rate) Assume symmetric equilibria with admissions rates p_C with the Common Application system and p_D for each school for the Decentralized system. If $p_C > p_D$, then each student who applies to at least one school under the Decentralized system will apply to all S schools with the Common Application, and so each of these students will have a higher probability of admission to at least one school with the Common Application system than with the Decentralized system. (In addition, some students who do not apply under the Decentralized system will apply under the Common Application). Then, more students will enroll at each school under the Common Application, which violates the capacity constraint for the schools, and so it must be that $p_D \geq p_C$. In general, $p_D > p_C$ except for exceptional cases (such as Example 1), where all students apply to all schools under the Decentralized system.

(Number of Applications) Define

$$\tau_j(p) = \frac{p_D + p_D(1-p_D) + \ldots + p_D(1-p_D)^(j-1)}{j},$$

which is the average contribution of applications 1 to j (for a student who applies to at least j schools) to the probability of admission to at least one school. $\tau_j(p)$ is decreasing in j since $p_D(1-p_D)^{j-1}$ is declining in j, so the expected number of enrollments per j applications is minimized when those applications are all submitted by a single student. That is, the Common Application system pattern minimizes expected enrollment for any fixed number of applications and probability of admission p. Thus, given the school capacity constraint, the Common Application system yields the maximum number of applications for admission probability p_C, which in turn is greater than the maximum number of applications for the (larger) admission probability p_D for the Decentralized equilibrium. This proves the theorem. ∎

Proposition 1b:

Proof. By symmetry, an equal number of students will be admitted to first choice schools, to second choice schools, ... to S^{th} choice schools in a Common Application equilibrium. Denote this number as $A_C(p_C)$, which is a function of the equilibrium admission probability p_C per application. A student who is admitted to a k^{th} choice school will attend that school if not admitted to a preferred school, which occurs with probability $(1-p_C)^{k-1}$. So the market-clearing condition is

$$A_C(p_C) + A_C(p_C)(1-p_C) + A_C(p_C)(1-p_C)^2 + \ldots + A_C(p_C)(1-p)^{S-1} = K * S. \quad (3)$$

Since the multiplier $(1 - p_C)$ is declining in p_C, $A_C(p_C)$ must be strictly increasing in p_C to maintain the market-clearing condition.

Define $\alpha_j(p_D)$ to be the proportion applying to a j^{th} choice school under the Decentralized system among those who apply to at least one school, where by construction $\alpha_S(p_D) \leq \alpha_{S-1}(p_D) \leq \ldots \alpha_2(p_D) \leq 1$.[30] The market-clearing condition with a Decentralized system is then

$$A_D(p_D) + A_D(p_D)(1 - p_D) + \alpha_2 A_D(p_D)(1 - p_D)^2 + \ldots + \alpha_S A_C(p_D)(1 - p_D)^{S-1} = K * S. \tag{4}$$

Once again, since the multiplier $(1 - p_D)$ is declining in p, $A_D(p_D)$ must be strictly increasing in p to maintain the market-clearing condition. Further, for each p, $A_D(p) \geq A_C(p)$ since (A) $p_D \geq p_C$ by Proposition 1a and (B) for each j, coefficient $(1-p_C)^j \geq \alpha_j(1-p_D)^j$ since $p_C \leq p_D$ and $\alpha_j \leq 1$ (with equality only if all applicants apply to all schools in the Decentralized case). That is, the multipliers on terms of form $(1 - p)^j$ are greater in Equation (3) than in Equation (4) and in addition the terms $(1 - p_C)^j$ in Equation (3) are also greater than the terms of form $(1 - p_C)^j$ in Equation (4).

Define $\psi_j(p_C, p_D) = \alpha_j(1-p_D)^{j-1}A_D(p) - (1-p_C)^{j-1}A_C(p)$ to be the difference in the number of students attending j^{th} choice schools for the Decentralized and Common systems. If $\psi_j(p_C, P_D) < 0$, then also $\psi_{j+1}(p_C, p_D) < 0$, $\psi_{j+2}(p_C, p_D) < 0$, ..., $\psi_S(p_C, p_D) < 0$ since α_j is declining in p and $(1 - p_D) \leq (1 - p_C)$. Further, $\sum_{j=1}^{S} \psi_j(p_C, p_D) = 0$ since the capacity constraint holds in both cases. Thus, $\psi_1(p_C, p_D), \psi_2(p_C, p_D), \ldots, \psi_S(p_C, p_D)$ is a sequence of positive terms followed by a sequence of negative terms, which is sufficient to prove the result. ■.

A.3 Proof of Proposition 3

Proof. Order the schools so that in expectation, if $j < j'$ then school j reaches capacity before school j' with Ranked Application. But with the Common Application, some students who are admitted to school 1 are not admitted to all other schools. Therefore the probability of enrolling at school 1 conditional on receiving an offer from school 1 is higher with the Common Application than with Ranked Application, which means in turn that school 1 fills its class with fewer offers using the Common Application than with Ranked Application.

Furthermore, with Ranked Application, every student admitted to school 2 is also admitted to schools 3, 4, 5, ..., S, and some proportion are also admitted to school 1. School 1 admits a lower proportion of students with the Common Application than with Ranked Application, so for school 2 the probability of competing with school 1 is lower with the Common Application than with Ranked Application. Thus, the probability of enrolling at school 2 conditional on receiving an offer is higher with the Common Application than with Ranked Application, so once again, school 2 fills its class with fewer offers with the Common Application than with Ranked Application. A similar argument demonstrates in order that schools 3, 4, ..., S, each make fewer offers in expectation with the Common Application than with Ranked Application. ■

[30] In the symmetric case, students apply to their top choice schools in order under the Decentralized system, so a student who submits j applications applies to each of their j most preferred schools.

A.4 Example 4: Comparison of Ranked and Common Application

This example shows that the ordinal distribution of assignment probabilities with the Ranked Application does not necessarily stochastically dominate the ordinal distribution of assignment probabilities with the Common Application system.

Example 4. *Suppose that there are three schools S_1, S_2, and S_3, each wishing to enroll 1/3 of all students, that 80% of the students have strict preference ordering (S_1, S_2, S_3) and that 20% of the students have strict preference ordering (S_2, S_3, S_1) over the three schools. Denote the probabilities of receiving an offer to each school as p_{1R}, p_{2R}, p_{3R} for the Ranked Application and as p_{1C}, p_{2C}, p_{3C} for the Common Application.*

With the Ranked Application system, when there are a large number of students, the first students in line choose either school S_1 or school S_2, with school S_1 reaching capacity after making offers to $(1/3)/(0.8) = 5/12$ of the students. The next students in the line are offered the choice between schools S_2 and S_3, and since all prefer school S_2, it reaches capacity when it has made offers to 2/3 of the students. Then school S_3 makes offers to the remaining students, who all enroll. The resulting offer probabilities are $p_{1R} = 5/12, p_{2R} = 2/3$ and $p_{3R} = 1$.

Similarly, with the Common Application, school 3 must make offers to all students to meet its enrollment target, so $p_{3C} = 1$. Then students with preference ordering (S_2, S_3, S_1) enroll at school S_2 with probability p_{2C} and at school S_3 with probability $1 - p_{2C}$. Students with preference ordering (S_1, S_2, S_3) enroll at school S_1 with probability p_{1C}, at school S_2 with probability $p_{2C}(1 - p_{1C})$ and otherwise enroll at school S_3. Solving in order for p_{1C} and p_{2C}, we have $0.8p_{1C} = 1/3$, or $p_{1C} = 5/12$ and $0.8\ p_{2C}\ (1 - p_{1C}) + 0.2p_{2C} = 1/3$, with solution $p_{2C} = 1/2$.

Under the Ranked Application, all students with preferences (S_2, S_3, S_1) enroll at a first-choice or second-choice school while 2/3 of the students with preferences (S_1, S_2, S_3) do so. Thus, $0.8 * 2/3 + 0.2 * 1 = 11/15$ of students enroll at either a first-choice or second-choice school. Under the Common Application, all students with preferences (S_2, S_3, S_1) enroll at a first-choice or second-choice school while $(5/12 + 1/2 - 5/12 * 1/2) = 17/24$ of the students with preferences (S_1, S_2, S_3) do so. Thus, $0.8*17/24+0.2*1 = 23/30$ of students enroll at either a first-choice or second-choice school. Here, the probability of enrolling at a first-choice or second-choice school is higher with the Common Application than with the Ranked Application, so the ordinal distribution of outcomes with the Ranked Application does not stochastically dominate the ordinal distribution of outcomes with the Common Application.

Appendix B Alternative Application Model: Behavioral Model

B.1 Model Setup

This section provides details of a behavioral model of applications. In this model of application decisions, students do not consider acceptance probabilities when applying. One may view this model as appealing in settings where there is little information about acceptance rates and acceptance rates change drastically from year to year. In addition, this model may be appealing if one wants to impose that there are zero marginal costs for applying to additional schools on the common application, due to the ease of applying to additional schools beyond the first school.

Application Decision: Common and Ranked Application

We impose the following behavioral assumptions on application behavior:

- Submitting any application has a fixed cost C which does not vary across individuals and there is no additional marginal cost for each school that a student applies to under the common application. Students will apply using the common application if the utility from at least one school is greater than the outside cost plus the outside option, so

$$\max\{u_{i1}, ..., u_{iS}\} \geq C + u_{i0}$$

- If a student applies using the common application, she applies to all schools for which $u_{ij} \geq u_{i0}$ due to the assumption of zero marginal cost for applications beyond the first application.

We assume that the set of schools that students will list under ranked application is the exact same as the set of schools that they would apply to under the common application model. This implies that the fixed cost C is the same in each system, each system has zero marginal cost beyond the first school, and students use the same behavioral assumption under each system. However, under the common application model, students simply indicate the schools for which they are applying. Under the ranked application model, students rank these schools based on their u_{ij}, reporting truthful preferences.

Application Decision: Decentralized Applications

The key feature of the decentralized applications is that it becomes more costly to submit the applications beyond the initial application. We model this by assuming that in the first stage, identical to the common application model, individuals submit an application if and only if

$$\max\{u_{i1}, ..., u_{iN}\} \geq C + u_{i0}.$$

For each subsequent application, there is a marginal cost $\tilde{c}$, where we hypothesize (but do not impose) that $\tilde{c} < C$. Students then apply to all schools for which $u_{ij} \geq \tilde{c} + u_{i0}$.

In the decentralized application model, the set of students that will submit an application in this model is identical to the set that will submit an application in the common application model because the decision to apply only depends on the maximum school utility in the first stage and the fixed cost of an application, which remains the same. Conditional on submitting an application, the number of applications per applicant will be lower in the decentralized application model than in the common application model. Finally, just like in the common application model, none of the costs C or $\tilde{c}$ are relevant for the preference ranking of schools or the enrollment decision after the first stage of deciding whether to submit an application.

Likelihood Functions and Estimation

The likelihood terms can be broken into three separate cases, depending on whether application and enrollment decisions are observed.

Case I: Non-Applicants. These are potential applicants who are not observed applying, so $A_i = \phi$. The likelihood of non-application is the probability that the outside option utility plus the application cost is greater than the utility from *all* of the common application model schools. The likelihood is given by:

$$\mathcal{L}_i = Pr(A_i = \phi) = \frac{1}{1 + \sum_j \exp(u_{ij} - C)}.$$

Case II: Applicants with No Acceptances. These are applicants who are not accepted to any school, so their contribution to the likelihood function is only given by the set of schools where they apply. Their contribution to the likelihood is:

$$\begin{aligned}\mathcal{L}_i &= Pr(A_i|\theta, X_i) \\ &= Pr(A_i|\theta, X_i, A_i \neq \phi)\ Pr(A_i \neq \phi|\theta, X_i).\end{aligned}$$

By the same logic as in Case I, we have $Pr(A_i \neq \phi) = 1 - \frac{1}{1+\sum_j \exp(u_{ij}-C)}$.

The term $Pr(A_i|\theta, X_i, A_i \neq \phi)$ can be estimated via simulation for each individual, by drawing a large number of error terms, keeping the simulations for which the individual would choose to apply, and then recording the empirical probability of the observed application set A_i among these simulations.

Case III: Applicants with Acceptances. These are applicants who apply to at least one school in the common application, and receive at least one acceptance, so that we observe a Stage 2 enrollment choice for these applicants.

Their (unconditional) likelihood is given by:

$$\begin{aligned}\mathcal{L}_i &= Pr(A_i, S_i|\theta, X_i) \\ &= Pr(A_i|\theta, X_i)\ Pr(Z_i|A_i, \theta, X_i)\ Pr(S_i|Z_i, A_i, \theta, X_i) \\ &= Pr(A_i|\theta, X_i)\ Pr(Z_i|A_i)\ Pr(S_i|Z_i, A_i, \theta, X_i).\end{aligned}$$

Conditional on the observed applications, the charter school acceptances do not depend on θ. Therefore, the θ that maximizes the *log* likelihood is equivalent to the θ that maximizes the following for each individual:

$$\ell_i = \log(Pr(A_i|\theta, X_i)) + \log(Pr(S_i|Z_i, A_i, \theta, X_i)).$$

The expression within the log in the second term is equal to:

$$\int Pr(S_i|Z_i, \theta, X_i, \epsilon_i) f(\epsilon_i|A_i, X_i, \theta) d\epsilon_i = \int \frac{Z_{ij}\exp(\frac{v_{ij}+\epsilon_{ij}}{\kappa})}{\exp(\frac{\epsilon_{i0}}{\kappa}) + \sum_{j'=1}^{J} Z_{ij'}\exp(\frac{v_{ij'}+\epsilon_{ij'}}{\kappa})} f(\epsilon_i|A_i, X_i, \theta) d\epsilon_i,$$

where $f(\epsilon_i|A_i, X_i, \theta)$ is the pdf of the ϵ_{ij} terms conditional on a given application decision, parameter estimates, and student characteristics. Note that we can simplify this conditional pdf as:

$$f(\epsilon_i|A_i, X_i, \theta) = \frac{Pr(A_i|\epsilon_i, X_i, \theta) f(\epsilon_i)}{Pr(A_i|X_i, \theta)}.$$

Since each error term is independent, $f(\epsilon_i)$ is simply the product of the unconditional pdfs of each extreme value error term. In addition, since the application decision is deterministically given by ϵ_i, X_i, θ, the quantity $Pr(A_i|\epsilon_i, X_i, \theta)$ is simply an indicator variable of whether an individual would have the observed application set. Finally, since $Pr(A_i|X_i, \theta)$ does not depend on ϵ_i, it can be taken out of the integral, and will cancel with the first term of ℓ_i. Putting this all together, the likelihood for these students is:

$$\ell_i = \log\Big(\int \frac{Z_{iS_i}\exp(\frac{v_{iS_i}+\epsilon_{iS_i}}{\kappa})}{\exp(\frac{\epsilon_{i0}}{\kappa}) + \sum_{j'=1}^{J} Z_{ij'}\exp(\frac{v_{ij'}+\epsilon_{ij'}}{\kappa})} \mathbb{1}_{(A_i|\epsilon_i, X_i, \theta)} f(\epsilon_i) d\epsilon_i\Big).$$

As in the main estimation, the likelihood calculation is implemented using a logit smoother and simulations to compute integrals.

B.2 Results

The primary difference in the parameter estimates for the behavioral model relative to the expected utility model is in the extent to which preferences change between the application and enrollment stages. In the behavioral model, we estimate much larger preference changes, as the decision to attend the outside option after being accepted to a Common Application school is interpreted as a change in preferences such as that the outside option is now preferred. Table B.1 shows the implied transition matrix of school rankings between the application and enrollment stage under the behavioral model. In this model, a student's first choice during the application stage remains their first choice at the time of enrollment only 26% of the time.

Table B.2 shows the distribution of rankings over final school assignments under the alternative behavioral model. Under this model, the Ranked system still gives more students their first choice than the Common Application. The Decentralized system, however, now performs slightly worse than the Common Application. The worse performance of the decentralized system in this model is due partially due to the fact that more students are accepted to at least one school under the Common Application than a decentralized system, and in this model, students only apply to schools that they prefer to the outside option.

Table B.1: Behavioral Model: Implied Ranking Between Application and Enrollment Decisions

	Ranking in Enrollment Stage						
Ranking in Application Stage	First (1)	Second (2)	Third (3)	Fourth (4)	Fifth (5)	Sixth (6)	Seventh (7)
First	0.26	0.22	0.17	0.14	0.10	0.07	0.04
Second	0.16	0.16	0.16	0.16	0.15	0.13	0.09
Third	0.14	0.15	0.15	0.15	0.15	0.14	0.12
Fourth	0.13	0.14	0.14	0.14	0.15	0.16	0.14
Fifth	0.11	0.12	0.14	0.14	0.15	0.16	0.17
Sixth	0.11	0.12	0.12	0.13	0.15	0.17	0.20
Seventh	0.10	0.10	0.11	0.13	0.15	0.17	0.25

Notes: This table shows the transition matrix of implied school rankings between the application stage (Stage 1) and the enrollment stage (Stage 2), among the 761 students who apply to at least one Grade 5 school on the Boston Public Charter School Application (BPCSA) in 2017. Seven schools are included for each applicant: the six BPCSA charter schools in our data, and the applicant's outside option. Implied rankings are generated by running 100 simulations of error terms that rationalize the observed application and enrollment decisions for each applicant.

Table B.2: Behavioral Model: Distributions of Rankings Across Application Systems

	Common		**Ranked**		**Decentralized**	
	Avg. Share	[90% CI]	Avg. Share	[90% CI]	Avg. Share	[90% CI]
Final Ranking	(1)	(2)	(3)	(4)	(5)	(6)
1st Choice	0.345	[0.314, 0.376]	0.372	[0.342, 0.401]	0.307	[0.278, 0.336]
1st-2nd Choice	0.581	[0.555, 0.606]	0.590	[0.563, 0.617]	0.529	[0.502, 0.556]
1st-3rd Choice	0.742	[0.717, 0.767]	0.736	[0.709, 0.763]	0.688	[0.658, 0.717]
1st-4th Choice	0.850	[0.828, 0.872]	0.839	[0.816, 0.862]	0.802	[0.777, 0.827]
1st-5th Choice	0.922	[0.907, 0.938]	0.913	[0.897, 0.930]	0.890	[0.871, 0.908]
1st-6th Choice	0.971	[0.960, 0.982]	0.966	[0.956, 0.977]	0.953	[0.942, 0.965]
1st-7th Choice	1.000	[1.000, 1.000]	1.000	[1.000, 1.000]	1.000	[1.000, 1.000]

Notes: This table shows the fraction of the 761 applicants in the Boston Grade 5 sample in 2017 predicted to enroll in a school that is in the given position of their implied rankings at the end of the enrollment stage, using the estimated parameter values from the demand model. Confidence intervals are based on the 5th and 95th percentiles of 100 simulations, and use variation in error terms across simulations while treating the original parameter estimates as fixed. Columns for Ranked applications assume that students are on the waitlist for any school they originally listed.

Appendix C Common Applications in the Field

Table 1 describes the adoption of a common application in several U.S. cities since 2017. This appendix provides a summary of the anticipated effects of the authorities, organized into three categories. Below are excerpts from press releases or newspaper interviews with individuals involved in the reforms.[31]

1) Logistical ease

   - "Previously, parents had to research grade levels at each school and file separate applications, a process that could take hours." (Boston)
   - "The goal of EnrollBR is to simplify the process and make it easier for families to explore the choices available to them." (Baton Rouge)
   - "No more trying to find how to apply and where to apply, no more hassle filing out multiple forms, no more confusion for parents but definitely better access to a school choice." (Buffalo)
   - "Oakland families no longer have to drive all over town from one charter school to another, fill out various different paper applications and keep track of different deadlines. More importantly families have benefited from learning that they have choices when it comes to their child's education and that includes charter public schools." (Oakland)
   - "It's all about making it easier for families in Philadelphia to find a school that's best for their child... Running dozens of separate application processes only exacerbates the problem. Many say this fractured landscape disadvantages those without time or wherewithal to fill out multiple forms." (Philadelphia)
   - "Traditionally, most charter public schools have their own application and enrollment processes, meaning families must juggle separate applications, multiple websites, and different deadlines if they want to apply to more than one schools. The ApplyLA Charter Common Application seeks to simplify the process." (Los Angeles)
   - "We are partnered with the Rhode Island Department of Education to allow for an easier and more streamlined application process." (Rhode Island)
   - "SchoolMint is an application platform that allows parents to apply to multiple schools, and for multiple students with a single application. This will make applying for any charter school within the Atlanta Public School system easier and more transparent." (Atlanta)
   - "Parents don't have to go to four different schools and fill out four separate applications... We really want to show the unity between charter schools and the ease of the application." (Kansas City)
   - "The need for change, they said, became clear in January after the charters set up information booths at Dorchester Collegiate Charter School, a day after the state voted to shut

[31] A full citation appendix for these quotes is available upon request.

it down. Charter staffs watched as families spent hours moving from one booth to another, filing out applications that requested mostly the same information as they agonized over their children's future." (Boston)

2) Increase information about options

   - "A common application for Commonwealth charter schools will make it easier for families to enter their children in our enrollment lotteries, and provide them with more information about their educational choices." (Boston)
   - "We think this is great for parents because it gives them the opportunity to explore multiple schools and make informed decisions about the best option for their children." (Baton Rouge)
   - "It is our hope that this platform increases access to and knowledge of the area's charter schools and simplifies the application process for families." (Buffalo)
   - "The promise of a marketplace of schools is also a promise that kids and parents can navigate that marketplace ... [Right now], there's no single place, time, or process for parents and kids to select and enroll in schools, so we're not really maximizing choice." (Detroit)
   - "Our main purpose was to make it easier in a choice environment for parents to choose." (NYC)
   - "The new process could help parents, who often rely on word of mouth for information, learn about schools they might not have considered." (Houston)
   - "Houston parents have become accustomed to having a diversity of choices and this movement – this ApplyHouston.org – is really just about helping parents become better consumers to be able to better navigate the marketplace of school options [...] Before families had to keep track of different forms for different charter schools, which ... [is] big hassle."' (Houston)
   - "I believe in school choice, and anything that helps families make wiser choices for their children is a plus. (The website) gives a family the chance to see all the offerings and easily apply to the school that fits their preferences." (Rochester)
   - "This will be great for families... [the online application] streamlines information for families and makes it easier for families to understand where there are seats across the charter sector." (Boston)

3) Leveling the playing field / equity

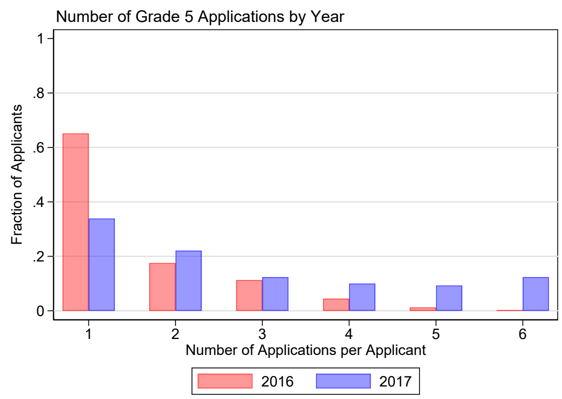
   - "He [Peterson] said he looks at the common application process in Baton Rouge as a step toward greater equity. 'We need to do anything we can to remove barriers and obstacles for families,' Peterson said." (Baton Rouge)

- "It is important that we are creating a system that is fair and easy for parents to access, and allows schools to design programs and staff around the needs of their students." (Baton Rouge)
- "Some believe that a single application for both charter and district public schools would simplify enrollment for all parents, especially those without the time, money or privilege to navigate multiple public school options with different application deadlines and processes." (Oakland)
- "The initiative's backers say they're increasing access and helping parents. Given the dismal lottery odds at some city charter schools, they say, many families feel they have to apply to a bunch of charters to ensure they get in somewhere. Now more city parents can do that quickly, easily, and without the kind of extra legwork that can be difficult for working families to manage." (Philadelphia)
- "It helps enormously, because it simplifies the process, it simplifies their lives. It also creates a much more equitable system for all families. Educated parents who have the time have a tremendous advantage in getting their kids into the bets schools. They know how to bake brownies for the principal and get to know the principal. They know other ways to circumvent the rules and get their child into a good school. Then there are other parents who don't know those ways. They don't speak English, they may be working two jobs and will not be able to spend that time. A common enrollment system tends to level the playing field and get more equal opportunity to all families." (Los Angeles)
- "Michael Duffy, the head of the city's charter schools, said the city's goal was 'to widen the access for families' to charter schools. Duffy previously spearheaded a push to increase recruitment by charter schools, and said that the new common application should help charters reach out to groups of students, including those learning English, that charter recruiters often miss." (New York City)
- "For families, schools, and the District, the former system of charter school enrollment was disjointed and cumbersome with different processes and timelines across charter schools. This new more centralized system our office has developed in collaboration with the District's charter schools will allow for more equitable access to school choice options for families and make the whole process of charter school enrollment in APS more efficient and transparent." (Atlanta)

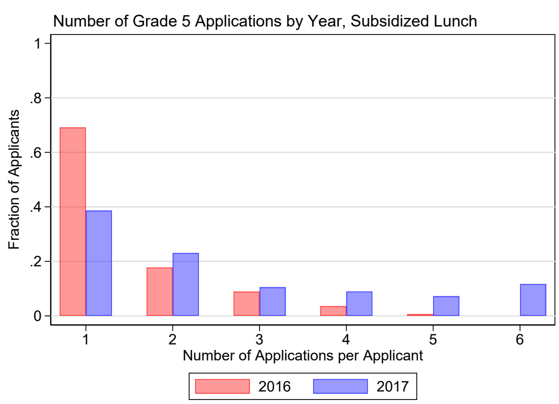
Appendix D Additional Empirical Results

Figure D.1: Distribution of Number of Applications

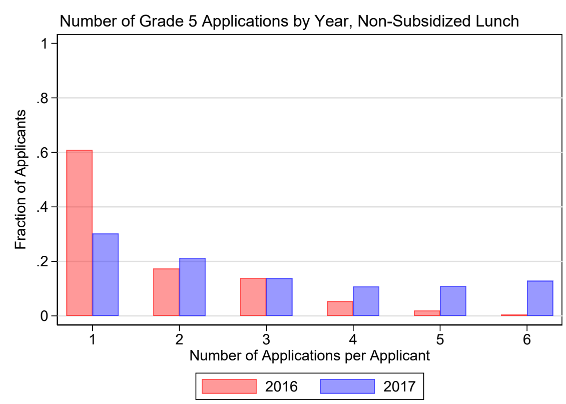
(A) Overall



(B) Subsidized Lunch

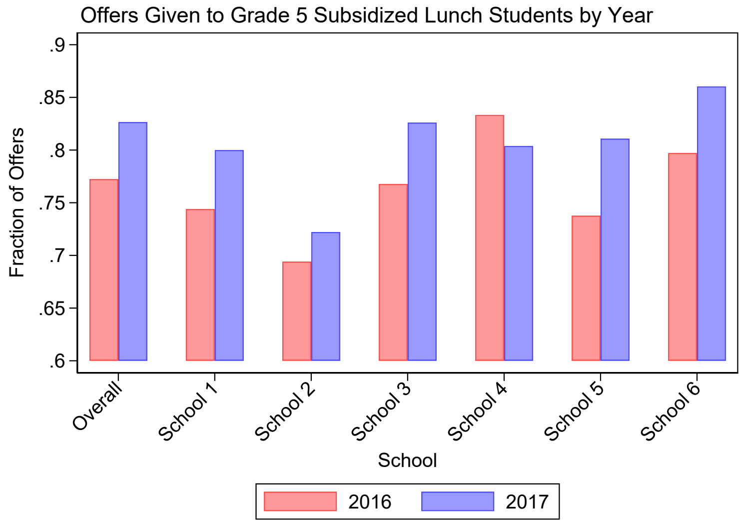


(C) Non-Subsidized Lunch



Notes: These figure show, separately for 2016 and 2017, the distribution of the number of schools that students apply to on the Grade 5 Boston Public Charter School Application (BPCSA). Panel A shows overall results, while panels B and C split results by subsidized lunch status, as measured in 4th grade.

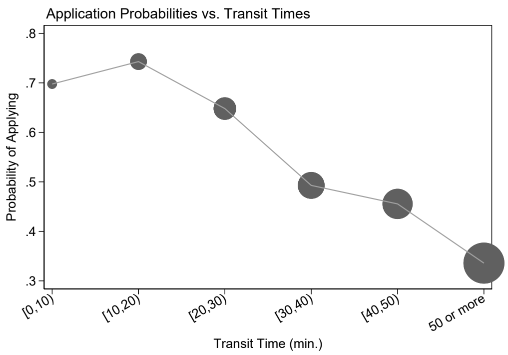
Figure D.2: Subsidized Lunch Share of Offers



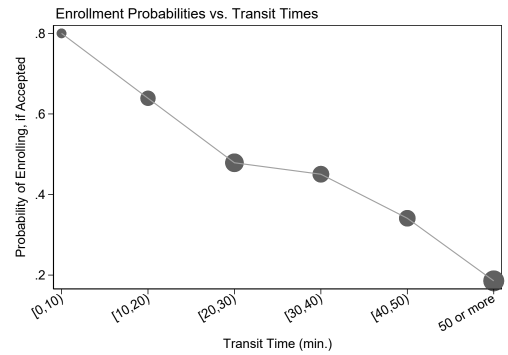
Notes: This figure shows, for Grade 5 schools on the Boston Public Charter School Application (BPCSA) in 2016 and 2017, the fraction of offers that are given to students on subsidized lunch. The first pair of bars shows this fraction for all six schools pooled together, while other bars show results separately for each school. Differences between 2016 and 2017 are statistically significant overall ($p = 0.0070$) and for School 6 ($p = 0.026$). No other differences are statistically significant at the 10% level.

Figure D.3: Application and Enrollment Probabilities vs. Travel Time

(A) Application Decision



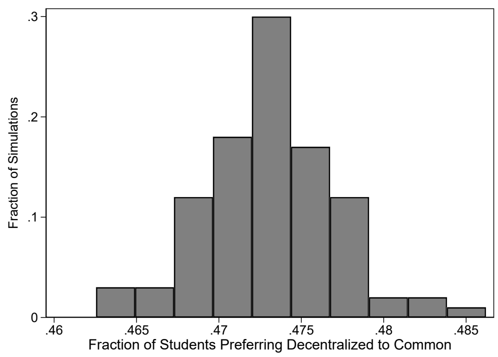
(B) Enrollment Decision



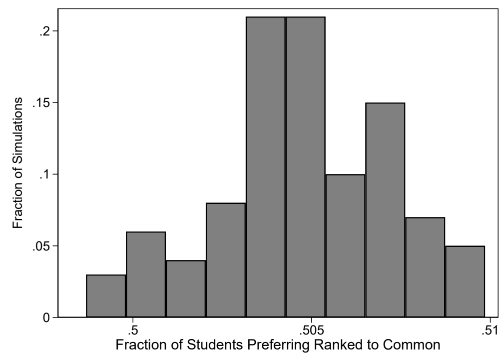
Notes: This figure shows the relationship between travel time and application and enrollment behavior. Travel time is measured based on transit time between each applicant's 4th grade school and the Boston Public Charter School Application (BPCSA) school. The sample consists of all applicants who apply to at least one BPCSA school. Panel A shows the relationship between application probabilities and transit time. Panel B shows the relationship between enrollment probabilities and transit time, conditional on receiving an admissions offer to a BPCSA school. The size of the point for each bin is proportional to the number of (applicant, school) pairs in the bin.

Figure D.4: Pairwise Votes between Application Systems

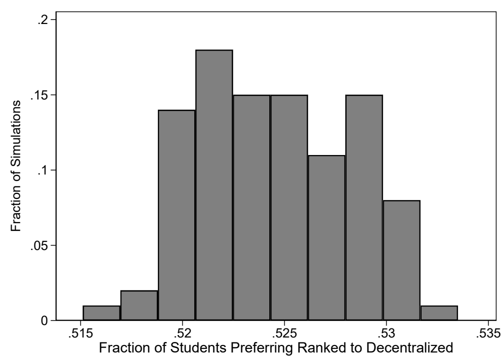
(A) Decentralized vs. Common



(B) Ranked vs. Common



(C) Ranked vs. Decentralized



Notes: These histograms show the percentage of 761 Boston Public Charter School Application (BPCSA) applicants from 2017 who would prefer each application system, based on 100 simulations. The utility estimates are derived from actual application and enrollment decisions. For ranked applications, we assume students remain on waitlists for all schools they initially selected. For decentralized applications, we only consider utility from final placement without deducting any application costs. When students would enroll in the same school under both systems, they count as half a vote for each system– this applies to 65% of students in Panel A, 69% in Panel B, and 65% in Panel C.

Appendix E Application Patterns in Environments Other than Boston

Table E.1: Application Patterns in Different Environments

	Ranked	Common	Decentralized: Low Marginal Cost	Decentralized: High Marginal Cost
	(1)	(2)	(3)	(4)
A: Heavy Oversubscription and No Preference Changes				
Number of Applicants	143.80	143.80	143.80	143.80
Applications per Applicant		1.56	1.44	1.00
Acceptance Rate		0.25	0.27	0.35
Fraction Attending Outside	0.65	0.65	0.65	0.65
B: Heavy Oversubscription and High Preference Changes				
Number of Applicants	627.60	627.60	627.60	627.60
Applications per Applicant		3.97	3.39	0.79
Acceptance Rate		0.25	0.27	0.68
Fraction Attending Outside	0.71	0.71	0.71	0.72
C: Light Oversubscription and No Preference Changes				
Number of Applicants	246.00	246.00	246.00	246.00
Applications per Applicant		1.35	1.28	1.03
Acceptance Rate		0.75	0.76	0.81
Fraction Attending Outside	0.19	0.19	0.19	0.19
D: Light Oversubscription and High Preference Changes				
Number of Applicants	745.70	745.70	745.70	745.70
Applications per Applicant		3.99	3.88	1.90
Acceptance Rate		0.75	0.76	0.93
Fraction Attending Outside	0.43	0.43	0.43	0.47

Notes: This table shows the application patterns for the heavy and light oversubscription environments defined in the text. Each table value represents the average across 10 simulations. Different panels show various levels of preference changes between application and enrollment stages, as well as different levels of oversubscription. The correlation between utilities across the two stages equals 1.00 when $\kappa = 0$ (Panels A and C) and 0.51 when $\kappa = 2$ (Panels B and D). The common application and ranked application simulations set marginal costs to 0.03. In the decentralized simulation, low marginal cost is 0.06 and high marginal cost is 0.30. The Fraction Attending Outside row shows the share of students who would end up in a school that is not part of the common application.

Appendix F Estimation Computational Details

The likelihood depends on whether or not we observe students making enrollment decisions that include the option of a BPCSA school. These cases are as follows:

Case I – BPCSA Acceptances Not Observed: This case includes both non-applicants and applicants who do not receive any acceptances, and the likelihood for both cases is based only on application decisions.

The likelihood for this group can be computed as:

$$\begin{aligned}\mathcal{L}_i &= Pr(A_i|\theta, D_i)\\ &= Pr\Big(A_i \in \text{argmax}_{a\in\{0,1\}^J} \sum_{z\in\{0,1\}^J} [\hat{\pi}(Z_i|a)w(Z_i)] - c(a)\Big)\\ &\approx \int \Big(\frac{\exp\Big(\Big(\sum_{z\in\{0,1\}^J}[\hat{\pi}(Z_i|a)w(Z_i)] - c(a)\Big)/\lambda\Big)}{\sum_{a'}\exp\Big(\Big(\sum_{z\in\{0,1\}^J}[\hat{\pi}(Z_i|a')w(Z_i)] - c(a')\Big)/\lambda\Big)}\Big) f(\epsilon)d\epsilon\end{aligned}$$

where the last line uses a small value of λ as a logit smoother. Note that for non-applicants, $c(\phi) = 0$ and $w(\phi) = 0$, since the difference in expected utility from the observed application relative to the outside option is 0. Therefore, for non-applicants: $\sum_{z\in\{0,1\}^J}[\hat{\pi}(Z_i|a)w(Z_i)] - c(a) = 0$.

Case II – BPCSA Acceptances Observed: When acceptances are observed, the likelihood terms consist of both the application and enrollment decisions. The likelihood is computed as:

$$\begin{aligned}\mathcal{L}_i &= Pr(A_i, S_i|\theta, D_i)\\ &= Pr(A_i|\theta, D_i) * Pr(Z_i|A_i) * Pr(S_i|Z_i, A_i, \theta, D_i)\end{aligned}$$

Note that properties of the extreme value Type I error term imply that the probability of enrollment given applications, acceptances, and known first-stage error terms ϵ_{ij} is:

$$Pr(S_i|Z_i, \theta, D_i, \epsilon_i) = \frac{Z_{ij}\exp(\frac{u_{ij}}{\epsilon_{ij}})}{\exp(\frac{u_{i0}}{\kappa}) + \sum_{j'=1}^{J} Z_{ij'}\exp(\frac{u_{ij'}}{\kappa})}$$

When computing the individual likelihood, $Pr(Z_i|A_i)$ does not depend on θ so can be pulled out of the log likelihood. The log likelihood is then equal to:

$$\begin{aligned}
\ell_i &= \log(Pr(A_i|\theta, D_i)) + \log\Big(\int Pr(S_i|Z_i, \theta, D_i, \epsilon) f(\epsilon|A_i, D_i, \theta) d\epsilon\Big) \\
&= \log\Big(\int Pr(S_i|Z_i, \theta, D_i, \epsilon) Pr(A_i|\epsilon_i, D_i, \theta) f(\epsilon) d\epsilon\Big) \\
&= \log\Big(\int Pr(S_i|Z_i, \theta, D_i, \epsilon) \mathbb{1}_{A_i|\epsilon_i, D_i, \theta} f(\epsilon) d\epsilon\Big) \\
&\approx \log\Big(\int \Big[\frac{Z_{ij}\exp(\frac{u_{ij}}{\kappa})}{\exp(\frac{u_{i0}}{\kappa}) + \sum_{j'=1}^{J} Z_{ij'}\exp(\frac{u_{ij'}}{\kappa})}\Big]\Big[\frac{\exp\Big(\Big(\sum_{z\in\{0,1\}^J}[\hat{\pi}(Z_i|a)w(Z_i)] - c(a)\Big)/\lambda\Big)}{\sum_{a'}\exp\Big(\Big(\sum_{z\in\{0,1\}^J}[\hat{\pi}(Z_i|a')w(Z_i)] - c(a')\Big)/\lambda\Big)}\Big] d\epsilon\Big)
\end{aligned}$$

where the last line applies a logit smoother via the λ parameter for a small λ.

To estimate the likelihood of observed applications and enrollments in the sample, we use two key computational steps. First, the integrals within each case cannot be computed explicitly, so they are estimated via simulation, with 50 draws of error terms used in practice to estimate the integral. Second, a logit smoother, following Train (2009) is used to avoid taking a logarithm of 0 for the probability of discrete events that are potentially rare. In both cases, we use a smoothing parameter value of $\lambda = 0.05$.

Estimation of the baseline model uses a grid of 32 initial conditions of sets of parameter values, with the optimal solution determined based on the maximum likelihood value across all initial conditions. For each initial condition in this grid, we use the built-in Powell's Method solver from the `scipy.optimize` package in Python to solve for the solution, with convergence reached based on a tolerance of 10^{-2} in the objective function across subsequent iterations. Our estimation procedure uses a smoothing parameter of $\lambda = 0.05$ for the logit smoother in each case, and uses 50 draws of error terms to estimate integrals.

Appendix G Data Appendix

Lottery Records

Information on applications to the common application charter schools, admissions outcomes, and sibling status come from lottery records that are separately collected from the schools. All of the common application schools use lotteries to admit students to schools when the number of applications exceeds capacity. We use lottery data from the school years beginning in 2015 through 2020, for the set of schools that include Grade 5 as a common entry point.

Table G.1 shows the set of schools and years included in both the structural estimation sample and the motivating reduced form graphs. Two charter schools that serve Grade 5 students were excluded because of unavailable data and six schools were excluded because Grade 5 is not a common entry point. In our structural analysis, all of these schools are grouped with the outside option.

The lottery files contain the full set of students who submitted an application, as well as whether they were admitted. For students who were admitted, the files indicate whether they received an initial offer or whether they ever received an offer, in cases where students were taken off of the waitlist. For 2017, our waitlist information is potentially incomplete for some schools, as some students are observed attending schools where they did not receive an offer. Therefore, in the reduced form exhibits, we only focus on initial offers. In the parameter estimation of the structural model, we only consider the application decision when calculating the likelihood for students who end up attending schools where they did not receive an admissions offer. In the simulations of the structural model, we only allow students to attend schools where they are observed to receive an admissions offer; therefore, simulated school enrollments are not always equivalent to observed school enrollments.

Student Locations and Travel Time

We do not observe the residential addresses of students, so compute travel time based on the school that students attended in Grade 4. We first map each Grade 4 school onto a geocode. Boston is split into 867 geocodes for the purposes of school assignment and transportation, and a geocode is a unit that is typically smaller than a Census Block Group. For reference, in the 2020 Census, Boston has 581 Census Block Groups and 207 census tracts.

We then compute the travel time that it takes to travel from the centroid of each geocode to each common application charter school. To do so, we apply the HERE Public Transit API to pairs of (geocode, school) coordinates. We compute the minutes of travel required to arrive to each school at 8:00 AM on Monday, January 31st, 2022. This uses the shortest combination of subway, local and express bus, and walking directions. We then winsorize the resulting distribution at the 1st and 99th percentiles.

Two schools on the common application – Excel Academy and Uncommon Schools – have multiple campuses for Grade 5. We compute a single distance between each student and each of these schools by treating the closest distance to any of the campuses as the relevant distance. For Excel Academy, we exclude the Chelsea campus, as it is located outside of Boston city limits. We view the modeling choice as reasonable to treat the closest distance as the relevant distance because of the strong overall relationship between distance and attendance in Figure D.3. In the Excel Academy lottery, students are assigned a campus during the lottery, and the school indicates that geographic proximity is a primary factor in determining the assignment.[32] In the Uncommon Schools lottery, applicants are allowed to indicate a location preference; application information indicates that students will be assigned to the preferred campus if possible, and that geographic proximity is also taken into consideration.[33] We do not observe the campus that students end up attending.

SIMS Data

Information on demographic characteristics and school enrollment comes from the Student Information Management System (SIMS), a centralized database that includes all Massachusetts public school students. We use SIMS data from 2015-16 through 2020-21. The data are measured in October of each school year and include information on enrollment, as well as demographics such as race and ethnicity, gender, and free and reduced price lunch status. We match charter applicants to the SIMS file using name and date of birth, following the procedure described in Abdulkadiroğlu, Angrist, Dynarski, Kane, and Pathak (2011).

Sample Restrictions

Table G.2 details the sample restrictions used in three different samples of students – Grade 5 common application applicants in 2017 for the structural estimation, Grade 5 common application non-applicants in 2017 for the structural estimation, and Grade 5 common application school applicants from 2015-2020 for the time series evidence. The table details both the number of unique students IDs and the number of applications that result when sequentially applying each sample restriction.

For the 2017 applicant sample in Panel A, we begin with all valid applications; this excludes applications marked as late or disqualified in the lottery files, as well as students who apply to more than one grade. We then drop applicants who are missing a student ID, which is necessary to match across data sets. We drop applicants who have sibling status at any of the common application schools in the sample, as these students have higher priority for admissions. Next, we require that we observe the 4th grade enrollment for the student in the SIMS file for 2016-17, and that the school attended in 4th grade is located in Boston; this ensures that students with lower priority due to geography are excluded. Finally, we drop students who attended an common application school in our sample for 4th grade; some charter schools in our sample serve students younger than 5th grade and these students can continue at the sample charter school. The resulting sample consists of 761 unique applicants who total applied to 2103 schools in our common application sample.

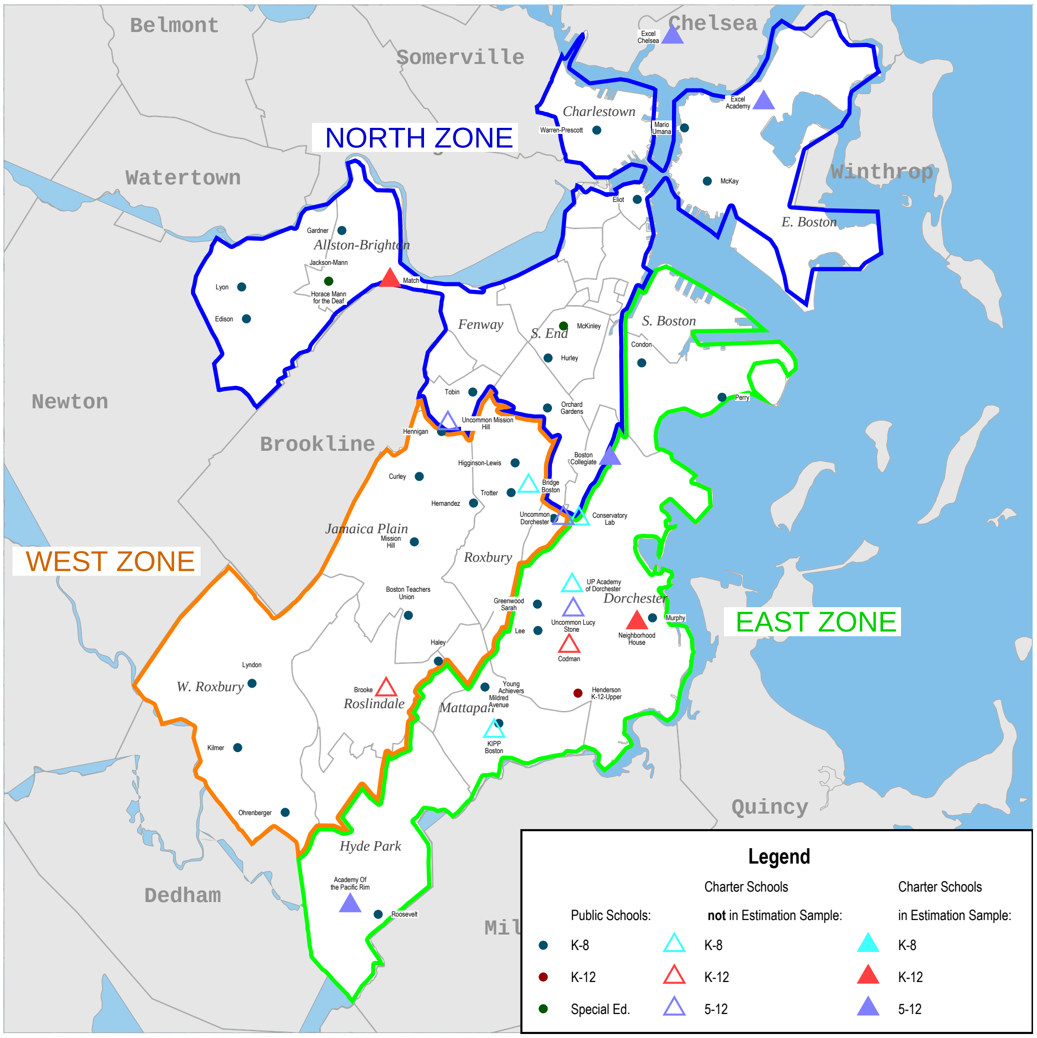
[32] https://www.excelacademy.org/ma-student-enrollment/

[33] https://roxburyprep.uncommonschools.org/wp-content/uploads/sites/5/2019/06/roxburyprep_enrollment_policy_2018.pdf

Panel B shows restrictions for the 2017 non-applicant sample, which is used in the structural estimation. We start with all students who attended grade 4 in Boston during the 2016-17 school year, and remove students who did not submit a common application for 2017. We further exclude students who attended any of the common application schools in our sample for 4th grade, as these students could generally continue at the same school without submitting an application. Finally, we drop the small number of students who attended a 4th grade school for which we cannot determine a unique location. The resulting sample consists of 4311 non-applicants who were eligible to apply for common application schools.

Panel C shows restrictions for the time series samples for 2015-2020. The time series sample consists of the three schools for which we have application data in all years 2015-2020; this is necessary to observe a pre-period prior to the implementation of the common application. Table G.1 shows the set of schools included. In this sample, we include all applications to these three schools that are valid (not late, disqualified, or from students applying to more than one grade in a school year). We further require the student ID to be available so that we can match students to demographics. The resulting sample, across all six years, consists of 3576 students who submitted a total of 6144 unique applications to these three schools.

Figure G.1: Map of Schools and Geographic Zones in Boston



Notes: This figure shows the Grade 5 schools available to students during the 2017-18 school year, along with their placement in three geographic zones corresponding to the zone configuration from the 1999-2013 Boston Public Schools choice system. Public schools appear as circles, charter schools as triangles, and charter schools included in our structural estimation sample as shaded triangles. Some charter schools were excluded from our estimation sample due to incomplete data or because Grade 5 is not a primary entry year for the charter school.

Table G.1: Charter Middle Schools in Boston

	(1)	(2)	(3)	(4)	(5)
	Year opened	Grade Span	Structural Analysis Sample	Reduced Form Sample	Reason Excluded
Academy of the Pacific Rim	1997-98	5-12	Y	Y	
Boston Collegiate	1998-99	5-12	Y		
Excel Academy	2003-04	5-9 (11)	Y		
MATCH Middle School	2008-09	PK-12	Y	Y	
Neighborhood House	2016-17	PK-8	Y		
Uncommon Schools: Dorchester Campus	2012-13	5-8	Y	Y	
Uncommon Schools: Lucy Stone Campus	2011-12	5-8	Y	Y	
Uncommon Schools: Mission Hill Campus	1999-2000	5-8	Y	Y	
Boston Renaissance	1995-96	PK-6			Data not available
Bridge Boston	2011-12	PK-4 (6)			Not Grade 5 entry
Brooke East Boston	2012-13	K-8 (9)			Not Grade 5 entry
Brooke Mattapan	2011-12	K-8			Not Grade 5 entry
Codman Academy	2001-02	K-12			Not Grade 5 entry
Conservatory Lab	1999-2000	PK-8			Not Grade 5 entry
KIPP Boston	2012-113	K-8			Data not available
UP Academy Dorchester	2013-14	PK-7 (8)			Not Grade 5 entry

Notes: This table includes charter schools serving grade 5 in the study period (school years 2015 through 2017). Column (2) displays the grades served in the initial school year of our study period (2015). If the grade span changed over the course of the study period, the grade number in parenthesis displays the highest grade served in the last year of the period.

Table G.2: Sample Restrictions

	(1)	(2)
	Unique Student IDs	Unique Applications
A: Structural Estimation Applicants (2017)		
Initial Valid Applications (Not Late, Disqualified, or More Than One Grade)	1118	2923
Student ID Available	1118	2735
No Sibling Status at Online Application School in Sample	1020	2591
Observed 4th Grade Enrollment	928	2416
Attended 4th Grade in Boston	775	2131
Did Not Attend Online Application School in Sample in 4th Grade	761	2103
B: Structural Estimation Non-Applicants (2017)		
Initial Non-Applicants who Attended Grade 4 in Boston	4419	.
Did Not Attend Online Application School in Sample in 4th Grade	4315	.
Attended School for Which We Can Estimate Locations	4311	.
C: Time Series Applicants (2015–2020)		
Initial Applicants with Valid Applications to Schools in Time Series Sample	3576	6160
Student ID Available	3576	6144

Notes: This table shows the remaining sample sizes at each stage of the sample restrictions, for both the structural estimation and time series samples.

Table G.3: Comparison of Common and Decentralized Systems

	2016	2017		
	Decentralized Observed	Common Observed	Common Simulated	Decentralized Simulated
	(1)	(2)	(3)	(4)
		A: School Acceptance Rates		
School 1	48%	34%	34%	37%
School 2	22%	13%	13%	16%
School 3	68%	63%	63%	66%
School 4	26%	26%	26%	24%
School 5	100%	12%	12%	17%
School 6	100%	100%	100%	100%
		B: School Enrollments		
School 1	52	56	38	38
School 2	49	62	34	34
School 3	44	54	57	57
School 4	28	29	30	30
School 5	21	23	13	13
School 6	155	170	170	129
		C: Estimated Costs		
Full Sample Model				
Fixed Cost			6.61	6.61
Marginal Cost			0.75	1.70
Heterogenous Cost Model				
Subsidized Lunch Fixed Cost ($C/\|\beta\|$)			7.23	7.23
Subsidized Lunch Marginal Cost ($c/\|\beta\|$)			0.75	1.67
Non-Subsidized Lunch Fixed Cost ($C/\|\beta\|$)			5.69	5.69
Non-Subsidized Lunch Marginal Cost ($c/\|\beta\|$)			1.13	2.37

Notes: This table compares the observed decentralized system in Boston in 2016 to the observed common and simulated decentralized systems in Boston in 2017 for Grade 5 applicants. Column (1) shows observed outcomes within the estimation sample for 2016 under the decentralized system. Column (2) shows observed outcomes for 2017 under the common application system. Column (3) shows results using simulated enrollments in 2017 from the common application system. These enrollment numbers differ from Column (2) because the simulation only includes observed acceptances, excluding some enrollments that came from waitlists we don't observe. Column (4) shows simulated outcomes in 2017 using the decentralized system (100 simulations). These simulations set marginal costs so that the average applications per applicant match Column (1), and school acceptance rates match enrollments in Column (3) unless the rate reaches 100 percent. On average, 8.71% of the applicants in Column (4) are estimated to not apply to any schools. Averages in Panels A and B are based on the averages across all 100 simulations and include only applicants within the sample. Panel C shows cost estimates in the model estimated among the full sample and in the model allowing costs to vary by subsidized lunch status. Fixed cost is normalized as $C/|\beta$ and marginal cost is normalized as $c/|\beta|$. Fixed cost is estimated in 2017 with the common model, and fixed costs are assumed to be the same for the decentralized model.