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Centralized School choice with unequal outside options ☆

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ABSTRACT

We study how market design choices exacerbate or mitigate pre-existing inequalities among participants. We introduce outside options in a well-known school choice model, and show that students always prefer manipulable over strategy-proof mechanisms if and only if they have an outside option. We test for the proposed relationship between outside options and manipulability in a setting where we can identify students' outside options and observe applications under two mechanisms. Consistent with theory, students with an outside option are more likely to list popular, highly-rated schools under the Boston mechanism, and this gap disappears after switching to a Deferred Acceptance mechanism.

1. Introduction

Participants in centralized matching markets often have access to outside options that the market designer cannot control. In markets that match individuals to public housing, participants may differ in their access to private housing. In markets that match kidney recipients to deceased donors, recipients differ in their access to family or other living donors. In markets that match job seekers to public-sector jobs, some workers may have access to private-sector alternatives. And so on. Using economic theory and a unique empirical setting, this paper shows that market design choices can exacerbate or mitigate the effect of such pre-existing inequalities on allocations determined by the centralized system.

We focus on an application of market design theory in which equity is an important concern: centralized public school choice. Students participating in the same school choice system often have very different options outside the centralized assignment process. These include the option to pay for and enroll in private schools, the option to participate in parallel choice systems for different types of schools, and the option to take a guaranteed spot in a neighborhood school. To the extent that household income is correlated with access to such outside options, heterogeneous outside options provide a channel through which socioeconomic inequalities can be reflected in school assignment outcomes.

Our central argument is that manipulable mechanisms—those that reward participants for submitting applications that do not reflect their true preferences over schools—give participants with better *outside* options an advantage *inside* the centralized system, while strategy-proof mechanisms do not. We make both theoretical and empirical contributions that support this argument.

On the theoretical side, we extend the well-known school choice model of Abdulkadiroglu et al. (2011) to include unequal outside options. This allows us to provide a novel result about the welfare implications of a switch from a strategy-proof to a manipulable mechanism: we show that a student always prefers

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a manipulable mechanism to a strategy-proof mechanism if and only if the student has an outside option. The underlying intuition for this result is that, under a manipulable school choice mechanism, access to an outside option allows students to submit applications which involve greater risks and greater rewards. As a result, students with an outside option are more likely to attend the most popular schools.

On the empirical side, we test the proposed relationship between access to an outside option and manipulability. Our model predicts that students with an outside option are more likely to attend the most popular schools under a manipulable mechanism (relative to strategy-proof mechanisms).

We study a unique quasi-experiment: the change from the manipulable Boston mechanism to the Deferred Acceptance (DA) mechanism in the New Haven, Connecticut school district in 2019. The two key features of the New Haven setting that enable our empirical analysis are (1) that students have heterogeneous outside options, and we can observe them, and (2) that the change in assignment mechanism helps us infer how otherwise similar choice participants with different outside options behave under different assignment mechanisms. In New Haven, some pre-Kindergarten schools allow students to continue to elementary grades without entering the centralized choice process, while others do not. Students in pre-Kindergartens that do not offer the outside option to continue are administratively assigned to a school with excess capacity if they are not placed in the centralized process. We implement a difference-in-differences design that compares choice behavior for students with and without the outside option both before and after the change from Boston to Deferred Acceptance.

Consistent with our theoretical predictions, the change in assignment mechanism closes the gap in rates of application to high-quality, sought-after schools by outside option access. Under Boston, applicants with continuation options are 18.5 percentage points more likely to list a school in the top tercile of the achievement distribution first on their application, compared to applicants without the continuation option. Students with the continuation option listed a first choice school with, on average, a 0.66 SD higher accountability score than students without the outside option. Under Deferred Acceptance, we observe no difference in the rate at which students list top tercile schools first, and the gap in mean accountability score at the first-ranked school falls to 0.20 SD. Looking across all application ranks, we find evidence that the accountability scores of schools at each rank depend less on access to the outside option under Deferred Acceptance than under Boston. Gaps in the popularity of first-listed schools by outside option availability also close under Deferred Acceptance.

Taken together, our theoretical and empirical findings support a new argument for using strategy-proof mechanisms in school choice and other settings. Economists often find strategy-proof mechanisms desirable because they reduce participation costs and prevent agents from making strategic errors (Abdulkadiroglu et al., 2006; Pathak and Sonmez, 2008), as well as because the resulting outcome does not depend on agents' higher-order beliefs (Vickrey, 1961; Wilson, 1985; Li, 2017). We show that there is an additional benefit: strategy-proofness neutralizes the effect of inequality in outside options. In doing so, it provides market participants with an equal opportunity to receive the most popular public resources. This benefit of strategy-proofness may accrue even if participation costs are small, strategic errors are unlikely, and beliefs are accurate. Given the centrality of equity concerns in the public education context and the continued widespread use of manipulable school choice mechanisms around the world (Neilson et al., 2019) our results constitute a key contribution to debates over the design of centralized school assignment systems.

Our paper builds on prior studies that have presented welfare- and equity-based arguments in favor of certain (classes of) school choice mechanisms. For example, Abdulkadiroglu et al. (2006) and Pathak and Sonmez (2008) have argued that Deferred Acceptance 'levels the playing field,' in the sense that it is less likely to disadvantage unsophisticated students.[1] The results in Ergin and Sönmez (2006) similarly support Deferred Acceptance, but on efficiency grounds. Abdulkadiroglu et al. (2011) provide a welfare argument in favor of the Boston mechanism instead. We contribute to this line of research by characterizing the welfare implications of unequal outside options in a more general version of the model in Abdulkadiroglu et al. (2011). Our main theoretical result shows that with inequality in outside options their argument in favor of the Boston mechanism may not hold.[2]

Our theoretical analysis is related to Calsamiglia et al. (2021) and Shorrer (2019). Although these papers use different models and do not characterize welfare consequences, they deliver similar predictions about application behavior to ours. Calsamiglia et al. (2021) study how private school options affect sorting under the Boston mechanism, using a model that endogenizes school quality as a function of peer quality. They find that the Boston mechanism leads to increased segregation by private school access, as compared to the Deferred Acceptance mechanism. Shorrer (2019) develops a search-theoretic framework to study school choice application behavior and similarly shows that segregation may arise endogenously under certain manipulable mechanisms. Our model is different from (and simpler than) both of these studies. Because we are solely concerned with the role of outside options, we abstract from the details of education production and search for schools.

The similarity of predictions on application behavior across theoretical frameworks underscores the importance of our second main contribution, which is to test these predictions empirically. Our setting for this is ideal. Directly observing a change in assignment mechanism is rare in the empirical literature, despite a large set of papers that consider the effects of mechanism changes on welfare using simulation-based approaches (De Haan et al., 2015; Agarwal and Somaini, 2018; Kapor et al., 2020; Calsamiglia et al., 2020). We are aware of two papers that report what happened before and after an observed change in a school assignment mechanism. The first is Pathak (2017), which documents changes in first-place assignment shares following Boston's 2005 mechanism change, and also presents descriptive statistics on changes in submitted applications following a 2009 mid-process change in the mechanism used to allocate spots in Chicago exam schools. The second is Terrier et al. (2021), which studies the effects of a mechanism change on school enrollment but does not use microdata on choice applications or outside options.

Other empirical papers study outside options but not mechanism changes. For example, Calsamiglia and Güell (2018) study how outside options affect application behavior, focusing on changes in priority groups within the Boston mechanism. They find that naive application behavior is associated with richer and better educated parents. This finding is consistent with the predictions of our model, since we would generally expect higher-income students to have access to private-school outside options. Our focus on the interaction between outside options and mechanism design also contrasts with Kapor et al. (2020), which considers the equity impacts of changes in aftermarket options holding the (strate-

[1] Babaioff et al. (2018) show that this result relies on schools' strict priorities—with coarse priorities, the results can go either way.

[2] We maintain the assumption from Abdulkadiroglu et al. (2011) that schools have no priorities over students. Troyan (2012) points out that relaxing this assumption can similarly change the welfare implications of switching between the Boston mechanism and Deferred Acceptance.

gyproof) mechanism fixed. Compared to this work, we highlight the importance of the assignment mechanism itself for determining the effects of outside options on choice behavior.

Stepping back, our analysis supports a novel and empirically substantiated equity-based argument in favor of strategy-proof school choice mechanisms. Like Abdulkadiroglu et al. (2006) and Pathak and Sonmez (2008), this argument favors Deferred Acceptance. However, in their models less privileged students are less sophisticated agents, thus they are *less* likely to strategize. In our model, students without the outside option are *more* likely to strategize, which is corroborated by the evidence from our empirical setting.

2. A school choice model with unequal outside options

This section lays out a simple model and derives novel theoretical results that motivate our empirical analysis. A simple example illustrates the key intuition before we state the more general model.

2.1. An illustrative example

Consider a setting with three schools, $\{s_1, s_2, s_3\}$ for which seats are assigned through a centralized mechanism, and one outside option school, s_o. There is a continuum mass 1 of students, half of whom have access to s_o. Students know their own types, but have only probabilistic knowledge of others' types. Each school in the centralized system has capacity $q = 1/4$, and ties are broken uniformly at random. All students agree on the desirability of the schools in the centralized system. However, students with the outside option only prefer s_1 over being unassigned (their preferences over assignments are $s_1 \succeq \emptyset \succeq s_2 \succeq s_3$), while students without an outside option would prefer s_2 and s_3 over being unassigned (their preferences are $s_1 \succeq s_2 \succeq s_3 \succeq \emptyset$). We restrict attention to the case where students without an outside option have the same cardinal valuations: their valuation of attending s_i is v_i. We assume $v_1 = 1, v_2 = v$ for some $v > \frac{1}{2}$, and $v_3 = 0$.

Comparing outcomes under two well-known school choice mechanisms—student-proposing Deferred Acceptance and the Boston mechanism—illustrates how outside options interact with manipulability. Under Deferred Acceptance, all students report truthfully, which leads to the following probability distribution over outcomes:

School	s_1	s_2	s_3	s_o
Outside option	1/4	0	0	3/4
No outside option	1/4	1/2	1/4	0

Under the Boston mechanism, students with the outside option do not have an incentive to misreport their preferences, but students without the outside option do. To see why, suppose everyone is truthful. Then the utility of a student without an outside option is $\frac{1}{4} + \frac{v}{2}$. Then a student without an outside option can report $s_2 \succeq s_1 \succeq s_3 \succeq \emptyset$ as her rank-order list. Since she is the only student who has done that, she will get admitted to s_2 with probability one, and get a utility of v, which is greater than the utility of truthful reporting since $v > \frac{1}{2}$.

To characterize the Nash equilibrium, note that each student without the outside option has two pure strategies available to him: to be truthful and report $s_1 \succeq s_2 \succeq s_3 \succeq \emptyset$, or to be strategic and report $s_2 \succeq s_1 \succeq s_3 \succeq \emptyset$. Then, solving for the symmetric (Bayesian) Nash equilibrium, we can show that the probability of reporting truthfully is

$$p = \frac{1 - v}{1 + v}.$$

When students without the outside option assign a positive probability to the non-truthful strategy, they decrease their likelihood of enrolling in s_1, which, in turn, increases the likelihood of students with the outside option being offered a seat at s_1. On the other hand, in any symmetric equilibrium, students without the outside option can never increase their likelihood of being accepted to s_2, relative to their likelihood of acceptance under Deferred Acceptance, because they are not competing for seats with students who have access to the outside option. As a result, competition among students without the outside option only increases their likelihood of going to s_3 at the cost of decreasing their likelihood of going to s_1. Manipulability makes students with the outside option better off, and students without the outside option worse off, relative to a strategyproof mechanism.

In this example, the manipulability of the Boston mechanism makes it more likely that students with the outside option attend the most popular school, and makes them better off, at the expense of students without the outside option.

2.2. Model

We now generalize the intuition from the simple example in the previous section in two ways. First, we consider strategy-proof versus general manipulable mechanisms, going beyond the comparison between Deferred Acceptance and the Boston mechanism. Second, we allow for more general preferences over $M \geqslant 3$ schools. Our model extends the model in Abdulkadiroglu et al. (2011) by allowing for unequal outside options. We retain their assumption that students share ordinal preferences over schools. This assumption captures the idea that schools are mainly vertically differentiated, but we note that it is quite restrictive, and, as in Abdulkadiroglu et al. (2011), our findings need not be robust to relaxing it.

As in our example, suppose there is a continuum mass 1 of students. A student is described by his type

$$\theta \in \Theta = \{\text{outside option}, \text{no outside option}\},$$

distributed according to

$$p(\theta) = \begin{cases} \eta & \text{if } \theta = \text{has outside option} \\ 1 - \eta & \text{if } \theta = \text{has no outside option} \end{cases}$$

for some $\eta > 0$ that is common knowledge. For ease of notation, we use w and w/o to denote students with and without the outside option, respectively.

There is a set of schools $S = \{s_1, s_2, \cdots, s_M\}$ that are part of the centralized system, where $M \geqslant 3$, and each school j has capacity $0 < q_j < 1$. There is one school outside of the centralized system, s_o, with infinite capacity. We assume schools have no priorities over students and break ties randomly.

As in Abdulkadiroglu et al. (2011), we assume student i has vNM utility value v^i_j when he attends school j, where $v^i = [v^i_1, v^i_2, \cdots, v^i_M, v^i_o]$ is the **valuation vector** of student i. Each student i draws a valuation vector v^i from a finite set $\mathscr{V} = \{(v_1, v_2, \cdots v_m, v_o) \in [0,1]^{M+1} | v_1 > v_2 > \cdots v_\ell > \quad v_o > v_{\ell+1} > \cdots > v_M\}$. This means that all students agree on their ordinal preferences, but they may have different cardinal preferences. The probability of a valuation vector $v^i \in \mathscr{V}$ is $f(v^i)$, where $\sum_{v \in \mathscr{V}} f(v) = 1$. We assume $f(\cdot)$ is common knowledge. To make sure that the least popular school is not irrelevant, we assume $\sum_{j \in S \setminus s_M} q_j < 1$. In addition, we assume $\sum_{j \in S} q_j = 1$. We assume schools have no priorities over students and break ties randomly.

We impose no assumption on the capacities, except that $\sum_{j=1}^{o} q_j < 1$, which ensures that the outside option is not irrelevant.

For a student with access to s_o, the truthful rank-order list over schools inside the centralized system is $s_1 \succ s_2 \succ \cdots s_\ell \succ \emptyset \succ s_{\ell+1} \succ \cdots \succ s_M$. For a student without access to s_o, the truthful ranking is $s_1 \succ s_2 \succ \cdots \succ s_M \succ \emptyset$.

A **strategy** is a mapping $\sigma : \Theta \times \mathscr{V} \rightarrow \Delta(\Pi)$, where Π is the set of all rank-order lists of S (potentially with truncation) and $\Delta(\Pi)$ is the set of probability distributions over Π. We focus on symmetric strategies in which students (of the same type) follow the same strategy.

An (ex ante) **assignment** is a matrix $\mathbf{X} = [\mathbf{X}(\theta, j)]$, for $\theta \in \Theta$ and $j \in S$. An assignment describes the allocation of students to schools in the centralized system. In particular, for any school s it assigns a probability $\mathbf{X}(w, s)$ to students with the outside option and a probability $\mathbf{X}(w/o, s)$ to students without, which represents the ex ante probabilities that these two types of students are assigned to school s. The capacity constraints require that $\eta\mathbf{X}(w, j) + (1 - \eta)\mathbf{X}(w/o, j) \leqslant q_j$ for all $j \in S$. An **assignment mechanism** (or simply, a mechanism) is a systematic procedure that results in an assignment.

We consider the class of symmetric and monotone assignment mechanisms that are non-wasteful, to which we refer as the class of *standard* mechanisms. We call a mechanism *monotone* if ranking a school higher does not decrease your chance of being admitted there. We call a mechanism *non-wasteful* if no student who would have preferred an unassigned seat from one of the schools in the centralized system is unassigned to that seat. We call a mechanism *symmetric* if it has a symmetric tie-breaking rule (i.e. ties are broken uniformly at random).

To state the main theorem, we need one more definition.

Definition 1. A student i **always prefers** an assignment mechanism A to an assignment mechanism B if he gets a weakly higher expected utility under any symmetric equilibrium of mechanism A than under any symmetric equilibrium of mechanism B.

We are now ready to state the main result. We prove this theorem in Appendix A.1.

Theorem 1. A student i always prefers a manipulable standard mechanism to strategy-proof mechanisms if and only if he has an outside option.

Theorem 1 shows that the main result presented in Abdulkadiroglu et al. (2011)—an unambiguous welfare improvement from the manipulable Boston mechanisms—will not go through for all students; only students who have an outside option are guaranteed to be better off under manipulable mechanisms (and the Boston mechanism, in particular). Our example in. efSec: illustrative shows that there are plausible cases in which students without the outside option are strictly worse off under manipulable mechanisms. Is it the case that without the outside option students are always worse off under the Boston mechanism? *No*—we provide a counterexample in efEx: Boston.

Example 1. Suppose there are three schools in the centralized system, each with capacity 1/3, and suppose all students value those schools at $v_1 = 1, v_2 = 0.9$ and $v_3 = 0$. Suppose there is also a school outside the centralized system that students with the outside option value at $v_o^w = 0.9 - \epsilon$ for some $\epsilon > 0$. Let $\eta = 2/3$. Then, for sufficiently small ϵ, a symmetric equilibrium of the Boston mechanism is for students with the outside option to report $s_1 \succ s_2 \succ \emptyset$, and for students without the outside option to report $s_2 \succ s_1 \succ s_3 \succ \emptyset$. Note that under these strategies, students with the outside option go to s_1 with probability 1/2 and to s_o with probability 1/2, while students without the outside option go to s_2 with probability 1. For sufficiently small ϵ, no deviation can make any student better off.

On the other hand, under Deferred Acceptance, all students go to s_1 with probability 1/3 and to s_2 with probability 1/3. Students without the outside option go to s_3 with probability 1/3, while students with the outside option go to the outside option school with probability 1/3. It is easy to check that all students are strictly better off under the Boston mechanism.

While our opening example in. efSec: illustrative shows that students without the outside option are strictly worse off under the Boston mechanism, the previous example shows that this is not a necessary consequence of manipulability. Whether students without the outside option prefer Deferred Acceptance over the Boston mechanism depends on the structure of preferences. Inequality in access to outside options can therefore change conclusions about welfare improvements previously associated with manipulable school choice mechanisms by, for instance, Abdulkadiroglu et al. (2011), who show that in a world without unequal outside options the Boston mechanism makes all students weakly better off.[3]

3. Empirical Analysis

3.1. Setting

3.1.1. School choice in New Haven

We focus our empirical analysis on the prediction that access to an outside option should lead choice participants to list more desirable schools first under the Boston Mechanism but not under Deferred Acceptance. We employ a difference-in-differences approach in which we compare choice behavior for students with and without an outside option, before and after the change from Boston to Deferred Acceptance.

We study centralized public school choice in New Haven, Connecticut. The New Haven Public School system (henceforth NHPS) has two features that make our empirical analysis possible. First, we are able to identify participants in the Kindergarten choice process who have access to schooling options outside the centralized system. Second, we observe choice behavior under both the Boston and Deferred Acceptance assignment mechanisms. Each of these features is rare in empirical studies of school choice. Both are critical for evaluating predictions about behavior that relate to both the availability of an outside option and the incentive properties of the centralized assignment mechanism.

3.1.2. The choice mechanism and how it changed

From 2016 through 2018, NHPS assigned students to schools using the Boston mechanism. Students could list up to four schools on their application. In 2019, NHPS switched to a Deferred Acceptance mechanism.[4] As part of this change, choice administrators conducted outreach with the goal of communicating to choice participants that, under the new mechanism, the best approach was to list the schools you like in the order that you like them.

Under both the Boston and Deferred Acceptance mechanisms, schools had coarse preferences over students determined by neighborhood, sibling, and zip-code priority groups, with ties broken by random lottery draws. An important feature of the choice process in elementary grades is that students do not have neighborhood

[3] In the appendix, we describe conditions such that students without an outside option always prefer the Deferred Acceptance mechanism to the Boston mechanism.

[4] The change to Deferred Acceptance took place in consultation with researchers and was based in part on evidence presented in Kapor et al. (2020) that the change would likely be welfare-improving; see New Haven Independent (2019) for details.

schools as outside options. Students wanting to attend a school in their zoned neighborhood must list that school on their choice application. Students who are not placed are administratively assigned to schools with excess capacity.

The initial switch to Deferred Acceptance in 2019 did not coincide with other changes to the choice environment. Students used the same online choice platform, were permitted to rank the same number of schools, and had access to the same official sources of information about school attributes and admissions outcomes. In 2020, the second year following the switch to Deferred Acceptance, there were two meaningful changes in choice policy. First, the number of schools students were permitted to rank rose from four to six. Second, NHPS conducted an information intervention that warned applicants submitting lists for which the predicted risk of non-placement was high.[5] To ensure that results we attribute to the mechanism change are not caused by these other 2020 policies, we supplement our main analysis of the full 2016–2020 period with additional specifications that exclude data from the 2020 application cycle.

3.1.3. Outside options and centralized choice

We identify students with options outside the centralized choice system using a unique feature of the Kindergarten choice process in New Haven. In New Haven, some elementary schools start in pre-K, while others start with Kindergarten. There are also stand-alone preschools that offer pre-K but are not affiliated with an elementary school. Students enrolled in pre-K at elementary schools have the option to continue on to Kindergarten at their school without going through the centralized choice process. Students enrolled in standalone NHPS pre-Ks or students entering NHPS for the first time in Kindergarten do not have this continuation option. If students with the continuation option want to switch schools—for example, to a school that does not offer pre-K—they must enter the centralized choice process.

Our empirical analysis compares the Kindergarten choice behavior of students with and without the option to continue at their current school, before and after the switch to Deferred Acceptance. There are two important things to understand about this environment. The first is why a family might want their child to change schools for Kindergarten when that student has the option to continue at their current school. In New Haven, some of the most sought-after schools do not enroll students before Kindergarten. These schools include the Achievement First charter school and the zoned neighborhood schools with the highest state accountability scores.

The second is how our setting relates to the theoretical model and to other settings in which heterogeneous outside options might affect choice behavior. We believe the theoretical exposition carries over well. The option to continue at one's current school eliminates the risk of being administratively assigned to a school with excess capacity (which may be very undesirable) if a student is not placed through the centralized process. Because this is a public outside option, students who have access to it are likely quite different from students with access to private outside options in this and other districts. Students with continuation options in our setting are likely more similar to students with other kinds of public outside options.

3.1.4. Describing schools

We use state accountability scores to measure vertical differentiation across schools. We focus on the headline school-level scores, which are weighted averages of a number of academic and non-academic subscores. We take school score data for the years 2014 through 2018, compute the mean value for each school over the period, and then standardize values in the sample of schools offering Kindergarten to have mean zero and standard deviation one. In some of our analyses we use a binary classification of schools as "high achieving," a designation that includes all schools in the top tercile of the application-weighted sample of the school achievement distribution.

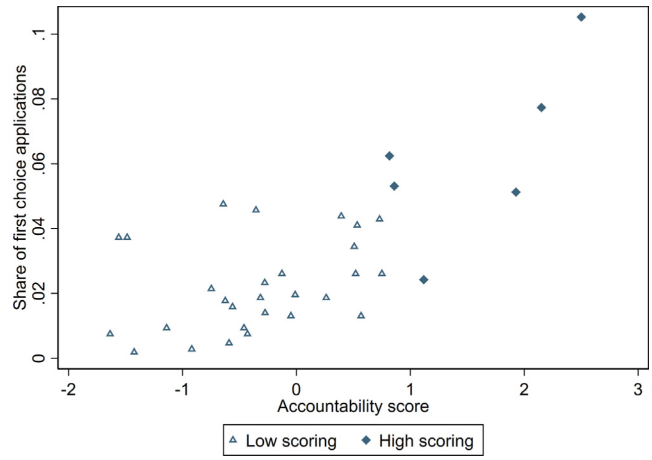

Fig. 1. Share of first choice applications by accountability score. This figure shows the share of first-choice applications in 2019 (vertical axis) by school-level accountability scores (horizontal axis). See Section 3.1 for details.

The schools identified as high achieving schools via this metric correspond roughly to those perceived as most desirable by district families participating in Kindergarten choice. Fig. 1 plots accountability scores (on the horizontal access) against the share of first-choice Kindergarten applications each school receives (on the vertical axis).[6] The six schools in the high achieving group include the five schools receiving the most Kindergarten applications. The schools with the highest accountability scores include the neighborhood schools in the highest-income neighborhoods, and the Achievement First No Excuses charter school branches.

3.2. Empirical strategy

We use a difference-in-differences approach to evaluate how the change to a Deferred Acceptance assignment mechanism affects the gap in application behavior between students who have outside options and students who do not. Our core specifications take the form

$$Y_{it} = \beta_0 + \beta_1 OO_i + \beta_2 DA_t + \beta_3 OO_i \times DA_t + \mathbf{x}_i \beta_4 + e_{it}, \tag{1}$$

where Y_{it} is the outcome of interest for individual i in year t, OO_i is an indicator equal to one if i has an outside option, DA_t is an indicator equal to one if the choice mechanism in year t is Deferred Acceptance, and $\mathbf{x}_i$ is a set of predetermined covariates that we allow to vary across specifications. The coefficient of interest is β_3, the effect of the interaction between the mechanism and outside option availability. β_3 captures the effect of switching from the Boston Mechanism to the Deferred Acceptance for students who have an outside option. The outcomes we consider are descriptors of achievement levels at and the popularity of the first-listed school on a student's application. We estimate these specifications in the sample of students enrolled in NHPS pre-Ks who participate in the Kindergarten choice process.

[5] In practice, this intervention caused applicants to add schools to lengthen their applications, which is not an outcome we study here. See Arteaga et al. (2021) for details.

[6] Application shares reported here are for 2019, the first year of Deferred Acceptance assignment. Patterns in other years are similar. See Online Appendix B.

Table 1
Sample descriptives of NH PreK4 students.

	Boston				DA			
	All	All in K Lottery	OO in K Lottery	No OO in K Lottery	All	All in K Lottery	OO in K Lottery	No OO in K Lottery
I. Demographics								
Tract poverty rate	0.249	0.254	0.218	0.257	0.251	0.255	0.217	0.259
Female	0.477	0.476	0.395	0.482	0.489	0.500	0.537	0.496
Black	0.452	0.437	0.661	0.420	0.417	0.406	0.575	0.388
White	0.105	0.088	0.113	0.086	0.105	0.099	0.163	0.092
Hispanic	0.443	0.475	0.226	0.494	0.479	0.495	0.263	0.519
Special education	0.106	0.103	0.129	0.101	0.146	0.124	0.087	0.127
II. Choice participation								
Participate in K lottery	0.666	1.000	1.000	1.000	0.578	1.000	1.000	1.000
Has OO	0.238	0.068	1.000	0.000	0.283	0.094	1.000	0.000
Participate if OO	0.191				0.192			
Participate if No OO	0.815				0.731			
List high scoring school 1^{st}		0.352	0.524	0.339		0.322	0.325	0.322
1^{st}-listed school quality		0.409	1.024	0.365		0.321	0.499	0.303
1^{st}-listed school demand share		0.041	0.055	0.040		0.042	0.043	0.042
III. Placements								
Any placement		0.963	0.879	0.969		0.958	0.887	0.965
Placement at high scoring school		0.278	0.371	0.271		0.295	0.287	0.296
N	2734	1822	124	1698	1471	850	80	770

This sample includes all students that are enrolled in a NHPS Pre-K school and eligible to apply to Kindergarten between 2016 and 2020. The panel includes students who apply (or could have applied) to Kindergarten between 2016 and 2018, when the Boston mechanism was in place. The DA panel includes students who apply (or could have applied) between 2019 and 2020. See text for variable definitions.

Our goal is to estimate the differential effect of outside option availability due to the mechanism change. These specifications produce unbiased estimates under the assumption that the outcomes we consider— attributes of applicants' first-listed schools— would have evolved in parallel for students with and without outside options in the absence of the change. This assumption will be violated if the characteristics of choice participants with and without outside options changed differentially over time in ways that affect the attributes of first-listed schools and are not captured by observable covariates $\mathbf{x_i}$. The assumption will also be violated if other aspects of the choice environment change in ways that differentially affect outcomes for students with and without outside options. We evaluate these assumptions to the extent possible in our data as part of the analysis below.

3.3. Data

We use data on school enrollment and choice participation between 2016 and 2020. We focus on families with four-year old students enrolled in their final year of NHPS pre-K. These students have the option to participate in the Kindergarten choice process.[7] Table 1 presents descriptive statistics for this population. We split the sample by the mechanism in place when these families make their Kindergarten choices (if they make them). The left panel, labeled "Boston," displays statistics for students enrolled between 2016 and 2018, while the right panel, labeled "DA," displays statistics for students enrolled in 2019 and 2020.

Panel I describes student demographics. As in many urban districts, students in New Haven come from relatively low-income neighborhoods and are mostly non-white. Students live in Census tracts where 25% of families are in poverty, well above the nationwide rate of 11%. Roughly half of students are female, and nearly 90% are Black or Hispanic, with the Hispanic share rising somewhat from the Boston period to the Deferred Acceptance period. 10–15% of students are designated as special education students by the district.

Panel II describes how students participate in the Kindergarten choice process. 67% of students participated in centralized choice in the Boston period, with that figure falling to 58% in the DA period. The second column of each panel shows statistics for participants in the choice process. Choice participants have similar demographic characteristics to the full sample in both periods. In the Boston period, 24% of all students are enrolled in pre-Ks that give them the outside option to continue through elementary grades. This figure rises slightly to 28% in the Deferred Acceptance period. As expected, choice participation is much lower for students who have the option to continue at their current school. Roughly 19% of students with an outside option participate in the centralized process in both the Boston and Deferred Acceptance periods, compared to 81% of other students in the Boston period and 73% in the Deferred Acceptance period.

Columns three and four of each panel display statistics for students with and without an outside option, conditional on choice participation. In both the Boston and DA periods, choice participants with an outside option are more likely to be Black and less likely to be Hispanic than participants without an outside option, and students with an outside option live in Census tracts with slightly lower poverty rates. The absence of differential selection on observable predictors of choice behavior across periods provides support for the assumption of no differential changes that underlies the difference-in-differences analysis.

3.4. Results

The last three rows of Panel II of Table 1 describe choice behavior and placement outcomes for choice participants. Our main difference-in-difference results can be read off of these sample statistics. Under the Boston mechanism, 52% of choice participants with an outside option list a high-achieving school first, compared to 34% of students without an outside option. Under DA, the figure is 33% for both groups. The gap in rates of listing a high-achieving school as a first choice that we observe under Boston disappears under Deferred Acceptance. We obtain similar findings when we take the achievement z-score of the first-listed school as the outcome. Under Boston, the gap in our standardized measure of school quality between students with and without an outside option is 0.66; under DA it is 0.20.

Gaps in the popularity of first-listed schools by outside option availability also fall. We take the share of first-choice Kindergarten

[7] See Appendix B for details of sample construction.

Table 2
Differences in the outside-option effect before and after the mechanism change to DA – *K lottery participants*.

Controls	List high scoring school 1st Prediction	Actual	Quality of 1st -listed school	Demand share of 1st -listed school
No controls				
Coeff.	0.010	-0.182	-0.463	-0.014
Std. err.	(0.019)	(0.072)	(0.189)	(0.004)
Demographics				
Coeff.		-0.190	-0.468	-0.014
Std. err.		(0.073)	(0.189)	(0.004)
+ school zone				
Coeff.		-0.195	-0.500	-0.015
Std. err.		(0.072)	(0.187)	(0.004)
N	2672	2672	2667	2643

Results from difference-in-difference estimates of Eq. 1 for the outcome listed in each column. "Prediction" is the predicted value from a regression of an indicator for listing a high-scoring school first on demographic covariates and school zone indicators. "Actual" is the indicator for listing a high-quality school first. "Quality of 1st-listed school" is the standardized quality measure for the first-listed school. "Demand share of 1st-listed school" is the share of all 2019 first-choice Kindergarten applications received by the school the student listed first. The coefficients reported are from the $OO_i \times DA_t$ interaction term. Sample: students who are enrolled in a NHPS Pre-K and participated in a kindergarten lottery between 2016 and 2020. Sample counts differ slightly between columns 2 and 3 because one school does not have an accountability score; it is included in the left columns as a non-high-scoring school. Column 4 excludes 2020 applicants whose first choice school was new in 2020 and therefore does not have a 2019 demand share. Robust standard errors in parentheses.

applications that each school receives (the vertical axis in Fig. 1) as a simple measure of popularity. Under Boston, first choice schools for applicants with an outside option were 1.5 percentage points (37%) more popular. Under Deferred Acceptance, this gap falls to 0.1 percentage points.

Table 2 presents our difference-in-difference findings using the regression framework given in Eq. 1. The first column shows the estimated effect for a linear index of observable predictors of choice behavior. We regress an indicator for listing a high scoring school first on demographic controls and school zone indicators, then put the predicted values from this regression on the left side of Eq. 1.[8] The resulting effect estimates are economically small and statistically insignificant. Changes in the observable characteristics of students with and without an outside option before and after the mechanism change cannot explain changes in choice behavior.

The second and third columns of Table 2 report results for our leading measures of choice behavior: an indicator for ranking a high-scoring school first, and the standardized quality measure for the first-listed school. The first panel of Table 2 reports results with no controls, reproducing the difference-in-difference findings we obtained from visual inspection of Table 1. The observed differences are statistically significant, with t-statistics around 2.5. The second panel adds controls for gender and race/ethnicity. These controls do not affect our point estimates or inference. The third panel adds additional controls for each students' neighborhood school zone. These controls also do not affect our findings.

The fourth column of Table 2 reports results for our measure of first-choice school popularity. Regression results again reproduce the basic difference-in-difference findings from Table 1 and are insensitive to controls. t-statistics are around 3.5.

Fig. 2 provides a graphical breakdown of the changing relationship between outside options and choice under the Boston and Deferred Acceptance mechanisms. The horizontal axis is the position on the application rank list. The vertical axis displays the difference in the share of students who list a high scoring school first by outside option access. Higher values mean that students with an outside option are more likely to list a high-quality school at the given rank under the listed mechanism. Under the Boston mechanism, students with an outside option are 18 percentage points more likely than other students to list a high-scoring school first on their application and 8 percentage points more likely to list a high-scoring school second. Students with and without an outside option are similarly likely to list high-scoring schools in the third and fourth positions. Under Deferred Acceptance, differences in choice behavior by outside option status are near zero across all ranks.[9]

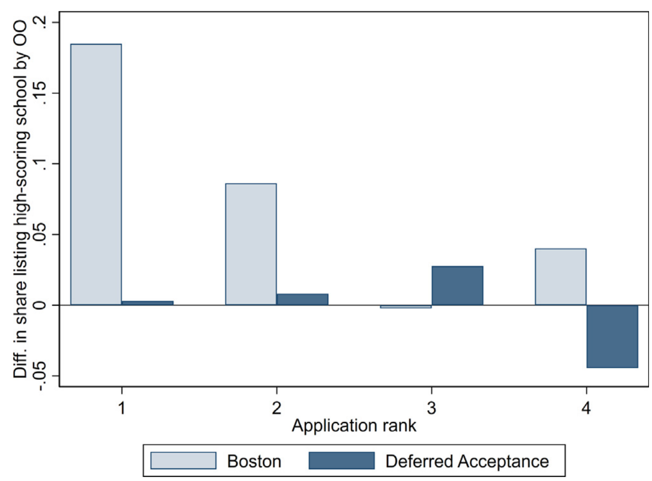

Fig. 2. Difference in share listing a high scoring school by outside option availability, split by application rank and choice mechanism. Bar height reflects the difference in the share of students with an outside option who list a high-scoring school at the given application rank and the share of students without an outside option who list a high-scoring school at that rank. Sample: Students enrolled in PreK4 at a New Haven Public School and participating in the NHPS Kindergarten lottery in a year in which either the Boston or Deferred Acceptance mechanism was in place. Under the Boston (Deferred Acceptance) mechanism 124 (80) students have the option to continue Kindergarten without application at their PreK school and 1698 (770) students don't have this option.

Panel III of Table 1 shows that differences in applications carry over to differences in placements. Under Boston, 37% of students with an outside option place at high-achieving schools, compared to 27% of students without an outside option. Under Deferred Acceptance, this difference disappears.

[8] We estimate this regression in the same sample as our main difference-in-difference specifications. The variables used for prediction are indicators for Black, Hispanic, and female students, as well as for each school zone.

[9] Both panels include blank student-rank combinations (other than the first rank, which cannot be left blank). Online Appendix Figure C1 displays rates of non-application by rank.

3.5. Discussion and robustness

Our difference-in-difference findings support the theoretical prediction that, relative to Boston assignment mechanisms, Deferred Acceptance assignment should reduce the difference between students with and without an outside option in their propensity to list sought-after schools at the top of their applications. Applications from students with and without an outside option are in fact more similar in terms of school quality across the full rank list under Deferred Acceptance than under Boston. We discuss additional results, robustness and limitations in Appendix C. Overall, we conclude that there is nearly-full convergence in choice behavior between students with and without an outside option once the mechanism is changed.

4. Conclusion

This paper argues that manipulable mechanisms give participants with better *outside* options an advantage *inside* the centralized system, while strategy-proof mechanisms do not. This argument is supported by our theoretical analysis, which generalizes a well-known model of school choice to include inequality in outside options. It is also empirically substantiated, using data from an empirical setting that has the institutional features we need to test the proposed relationship between outside options and manipulability.

We view our theoretical and empirical analyses as complements. The theoretical framework's sharp predictions clarify how to think about the role played by outside options under different mechanisms, and point to the features needed in an empirical setting to evaluate the role of outside options. However, in making the assumptions needed to analyze the equilibrium of manipulable mechanisms, we abstract away from some key aspects of the real world. One might ask whether our theoretical results are valuable in understanding the role of outside options in real-world school choice settings. We therefore test the model's predictions in the empirical analysis, and find that in this real-world setting, the evidence is consistent with the model's predictions on application behavior when switching from a manipulable to a strategy-proof mechanism.

Our findings show that unequal access to options outside of a centralized matching market can have distributional consequences. Hence, in settings where equity concerns play an important role, manipulability may be regarded as an undesirable feature of centralized assignment mechanisms. We show that this is true not just because there may be different levels of sophistication among participants, as has previously been pointed out, but that it is an inherent feature of manipulable designs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jpubeco.2022.104644.

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