



# Which Was Better in the Context of Bringing NCEE Back to the Country, the Deferred Acceptance Algorithm or the Boston Mechanism

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## ABSTRACT

Since its inception in Boston, the Boston mechanism has gained worldwide acclaim. Although there exist strong criticism and replacements happen often, economists have recently reconsidered its properties. The deferred acceptance algorithm (DA) has always been thought to be superior to the Boston mechanism because it has several distinguishing features when put in comparison. Countless studies have been conducted to investigate the two mechanisms, either directly in real-world market situations or through theoretical practices. But which is superior, and is one superior to the other in all circumstances? China's National College Entrance Exam, also known as Gaokao, was established in 1952 and has undergone numerous changes since then. It was canceled for ten years due to the Cultural Revolution, which had negative impacts on China's economy and the Chinese society. But NCEE was restored as the new leader came to prominence, with the Boston mechanism put in use. This paper compares DA with the Boston mechanism to investigate different implementation methods. Results show that DA would have played a better role if it was operated.

**Keywords:** *deferred acceptance, Boston mechanism, NCEE*

## 1. INTRODUCTION

### 1.1 Historical background

The mechanism first applied was the Boston mechanism, or the immediate acceptance algorithm (IA), in 1977. It was until 2001 that the ministry of education switched to a new system, pressured by intense criticism from the public. The most realistic model for NCEE and its admissions system today is the Parallel mechanism, studied by Chen and Kesten. The parallel mechanism replaced the former system and evolved over time, carefully designed by the ministry of education to prevent the same issues from striking. It is a hybrid between IA and DA [1]. It draws advantages from both IA and DA but avoids vulnerabilities of the two systems to the maximum extent. Whatsoever, DA and IA are two of the most classic models studied by scholars and in the field of market design.

The Cultural Revolution happened between 1966 and 1976. It was a sociopolitical movement led by Mao Zedong to prevent capitalism from restoring and preserving the orthodox of the Chinese Communist Party

(CCP) [2]. He also aimed to deplete corruption and bureaucracy. But the leader had wrong perceptions about what the party needed and what it was facing, which led to severe aftermaths. This included disruptions to the National College Entrance Exam and the wronging of numerous government officials.

During the ten years of revolution, the congress accused NCEE of lying under the framework of capitalism, Mao also reckoned high schools and universities as institutions controlled by capitalists. Condemnations toward colleges and other institutions providing higher education burst out, and NCEE ended up being canceled. Mao then claimed that students should work in the fields for some time, government officials explained that this movement educates students differently. So high schoolers and college students were forced to leave school, regardless of how close they were from completing their studies. All students were distributed to work positions, varying, but mostly physically demanding work. And this neglected what students learned in school.

However, all workers had a chance to attend schooling. All classes stopped only until 1972, when

high schools and colleges reopened because of the party's new plans. Those willing to get an education had to first win elections within the town, and then win favor of the local government to be recommended. But large vulnerability lies behind the process, workers with wealthier backgrounds may replace candidates voted by local workers, and corruption still exists. Mao failed to achieve his aims through the reform.

Even though education institutions reopened, Mao's behavior altered citizens' attitudes toward schooling; most of the workforce discriminate against those who study and reckon it as a betrayal of the communist party and the People's Republic of China. Students also formed small groups, some complained about the reform while others had strong beliefs in the government and Mao, as PRC's founder. It was hard for anyone to study in that environment, with going back to the fields in mind. People had it deep in their hearts, not discussed in front of the public, but almost everyone hoped for the back of NCEE and a well-facilitating education system.

The revolution only ended after Mao's death, in 1976. Deng then took the reins. He was imprisoned during the Cultural Revolution and accused of being an anti-revolutionist. But immediately after he was in charge, Deng put resuming NCEE on schedule. On October 21st, 1977, Congress announced that NCEE would be restored and launched a month later. The Boston mechanism was put in use at this point and operated as the core for the admissions system for NCEE for two decades.

Colleges in China are categorized into tier. This varies between provinces; most provinces categorize their colleges into 4 tiers while some remain with 5 tiers. Most prestigious colleges would be put into tier 1, and lower ranking colleges are categorized into other tiers in ascending order. Students take NCEE exams in the mid of June. Those with higher NCEE scores are usually matched with more prestigious colleges.

### ***1.2 Properties investigated***

We should first start by exploring some of the radical characteristics of matching mechanisms. All mechanisms are described by their own desirable properties, which produce distinctive matching results. In this experiment, functioning of mechanisms in the college admissions problem is investigated. This is a two-sided and many-to-one matching that matches students to colleges. Essentially, prices don't act as a market clearing tool.

Stability is a factor respected well when it comes to matchings. A matching is stable if it isn't "blocked" by pairs or agents. Matchings can be blocked by agents if they declare to not accept it before being assigned to the match [3]. For example, a student with a high NCEE score would rather retake the exam in the upcoming year than going to a tier 3 college if she was rejected by all

other options. This relates to individual rationality, that students should be making rational decisions and not end up with unacceptable matches. Blocking pairs may as well disrupt stability, in this case, colleges may be willing to admit students after all admissions have finished, and students may favor the university over its current match.

A stable matching should involve both individual rationality and robustness. A matching blocked by an individual or a pair formed by a college and a student is not pairwise stable. Furthermore, stability may extend to group stability. A matching is group stable if it persists with robustness to blocks of any size, these may be blocks larger than a pair.

Efficiency in the college admissions problem would more commonly be regarded as pareto efficiency. The outcome of a mechanism can be called pareto efficient or pareto optimal if all resources are allocated, that agents can only gain extra utility by harming other agents' benefits. In other words, matching is not pareto efficient, or can be pareto improved if an agent can be benefited while every other agent stays at least as good as before.

Strategy-proofness describes the incentive for truth-telling when agents are asked to submit their preferences. A mechanism is strategy-proof if no one can benefit by misreporting. But agents may choose to misreport if they will be paired with better matches than telling truths, which means the mechanism is vulnerable to one's strategic manipulation.

Priorities must also be considered. They are policies that govern how colleges prioritize students. In the case of NCEE, students are primarily prioritized based on their exam results. Those with higher scores should be given admission to prestigious schools. Students are prioritized in this manner before and after the reform. Importantly, priorities cannot be traded; otherwise, the system will fail. Priorities have an impact on stability; a priority violation is equivalent to a blocking pair.

These characteristics will be used to contrast the mechanisms. As the economy slowed, the government desperately needed skilled workers in the labor force, and students eagerly registered for NCEE and sought knowledge. Comparisons should be made to determine which mechanism is best suited.

## **2. RELATED LITERATURE**

DA has been studied by economists since it was first raised by Gale and Shapley in 1962. Its characteristics have been stated and tested in many ways, and multiple theorems have been raised following the existence of the concept itself. The article written by Alvin E. Roth and published in 2007 is related to this paper to certain extents. He first collectively summarized theorems proposed by other scholars to investigate the deferred

acceptance algorithm, then discussed open questions [4]. IA was comprehended by Abdulkadiroğlu, A., Pathak, P. A., Roth, A. E., & Sönmez, T. (2005). Processes were broken down and a brief overview of the mechanism can be learned, along with impacts it had on Boston [5]. This paper also relates to the study of Terrier, C., Pathak, P. A., & Ren, K. (2021). Where results of the transformation from IA to DA reduce measures of school quality for low-SES students more than for high-SES students. Data was used to support their argument and effects of the transition were clearly shown [6]. However, the study by Chen, Y., & Keston, O. (2011) is most close to this paper. They investigated a group of mechanisms, including the Boston, Shanghai, and deferred acceptance. Their results show that the proportion of truth-telling is the largest in DA and least in the Boston mechanism. DA is most stable out of the three, but efficiency varies in different environments [7].

### 3.OVERVIEW OF THE TWO MECHANISMS

#### 3.1The models

The mechanisms can be broken down into a few steps. Let's first define the fundamentals, they include:

A set of students  $S = \{s_1, \dots, s_n\}$

A set of colleges  $C = \{c_1, \dots, c_m\}$

A capacity vector  $q = (q_{c_1}, \dots, q_{c_m})$

A list of strict student preferences  $P_1 = (P_{s_1}, \dots, P_{s_n})$

A list of strict college priorities  $p = (p_{c_1}, \dots, p_{c_m})$

The Boston mechanism was used in Boston until 2005, when the Boston School Committee voted to replace the mechanism. It was replaced because parents can “game with” the system easily, as it aims to assign as many students as possible to their first choices [5]. But it is still a very popular mechanism used by schools around the world. Now let's follow Pathak and Sönmez to define the system. In the first round, schools consider offering seats to applicants who list it as the first choice, following the priority. And they start doing so, one student at a time. This continues until there are no students who list it as the first choice. In the  $k$ th round, only the  $k$ th choices of students are considered. Schools that have seats left offer seats to students, following their priority. The mechanism only ends when there are no unassigned students who have listed their  $k$ th choice or schools have all seats filled.

This paper assumes that DA works differently if operated. Students would only be prioritized by their NCEE scores, that colleges almost ignore their rankings on students' preference lists. If a student obtained a high score, then it is guaranteed that he will be offered a seat at a good college. And DA would provide after-exam

preference submission. The mechanism is studied by Shapely and Gale. In the first round, schools check applications received and offer seats to students while respecting priority. At this point, offers would only be sent to applicants with extremely high priority ranking. Colleges hold onto other applications and tentatively assign seats to students. This happens until the capacity is reached. In the  $k$ th round, schools consider students who have been rejected in the last round as their  $k$ th choices. And tentatively admit them with those who have just been assigned seats (following the priority) and stop when their capacities are reached.

#### 3.2Application

Schools in Boston prioritize students in more ways. Firstly, a younger sibling has priority to attend the same school as an older sib. Then half of each program's seats are students from the school's walk zone [5]. But for colleges in late 20th century China, the Boston mechanism worked like this:

1. Students from  $s_1$  to  $s_n$  take the exam.
2. Students list their preferences from  $P_{s_1}$  to  $P_{s_n}$  and submit them to the centralized system.
3. Colleges compare priorities of students who rank it as  $P_{s_1}$ .
4. Colleges decide whom to admit, respecting priorities—NCEE scores.
5. Second choices are then considered.
6. Colleges with remaining capacity continue the process until no students are left or all vacancies filled.
7. Colleges release their score lines.

How DA would work if applied:

1. Students take the exams.
2. Colleges provide minimum entry requirements (NCEE scores).
3. Students list their preferences and apply to colleges through the centralized system.
4. Colleges decide tentatively whom to admit.
5. Colleges provide adjustment suggestions for students who aren't competitive enough for popular majors.
6. The process continues until all seats are filled or every student is admitted.

### 4.CONCLUSION

DA is stable, as it performs matchings that can't be blocked. This means colleges will not regret their decisions and admit any other students after matchings are sorted out. And students end up studying in colleges

they accept; despite the possibility of it ranked low on their preference lists. There exists no chance for the formation of blocking pairs or any blocks of larger sizes as none of the two sides would turn to alternatives. On the other hand, the Boston mechanism lacks stability [8]. Talented students would prefer the most popular college and rank it top of the list, but they may be rejected by the college due to intense competition. In the next round, other acceptable colleges for these students may have already reached their capacity. In addition, students may fear to face failure, thus listing a less preferable college as the top choice. But they could have gotten into better colleges with outstanding NCEE scores. This is the result of pre-exam preference submission. Colleges involved in IA may be willing to admit more talented students while these students may not be studying in colleges they favor the most.

As DA is proposed by students in this context, it is student-optimal, that students are assigned to the best colleges amongst those willing to admit them after comparing to priorities of other students, and the process continues until the capacity is filled. DA only yields the best stable student-optimal matching, it can be Pareto improved by using other mechanisms in some situations. Although IA has several unsatisfactory properties, it is still Pareto efficient [9]. Parents may game with the system by submitting a preference list with a good college ranked as first choice while having a relatively lower score. Other students may underestimate their NCEE scores and list a less preferable college due to the fear of facing failure, given that preferences are submitted before NCEE scores are released. However, students may not study in better colleges without harming other students' benefits, regardless of their scores in the exam. Although not the best matchings are assigned for all students, capacities of colleges are filled.

DA is strategy-proof for students. Since strict priorities are respected and colleges barely consider factors except for students' NCEE scores, students should simply submit their true preferences. And their preferences should include colleges that match their scores, as DA is set to suggest a post-exam preference submission. Preferences also tell colleges students' interest in different fields of studies, submitting untruthful preferences may put students in odd majors, which adds burden and uncertainties to future careers of students themselves. In contrast, agents involved in IA may take advantage of the system's aim of assigning students to their first choices at utmost. Risks are taken as untruthful preferences are submitted, in the hope of entering better colleges as others are fearful of taking risks. Eventually, agents benefit by misreporting [5].

The issue needs to be considered from various perspectives. Properties of the mechanisms had been compared above, now let's reveal which would be better by referring to the situation back then. Although IA looks

at both students' first choice and their NCEE score while colleges involved in DA solely consider students' score, priorities are always respected when the two mechanisms are operated. This means the behavior of violating priorities can be ignored and agents have fewer concerns. China needed to recover from a long period of economic downturn, along with a series of consequences due to corruption and chaos within the Chinese Communist Party (CCP) [10]. Students desired education but lacked confidence. Colleges also wanted to tackle negative impacts left by the Cultural Revolution. Basically, the country needed a system that can enable reasonable allocation of educational resources and reduce citizens' resentment toward government officials to the maximum extent. Unique properties possessed by DA help with reducing resentments. DA matches students to colleges that are suitable for them in terms of their scores, and colleges tentatively admit students to prevent leaving regrets. Also, DA results in the best matchings for students, because colleges that admit them only made decisions after comparing with other students. They could have been matched with better colleges via other mechanisms such as IA but working with an alternative mechanism may affect stability. DA yields stable student-optimal matchings that Pareto dominates all other stable matchings from students' perspectives and is strategy-proof for students. DA would have reduced criticisms toward the government and allocated more intelligent students with richer resources. Students would have fewer concerns under DA and recovery of the economy would most likely be boosted. The situation may be different in different contexts, like what happened in Barcelona, where welfare decreased when switching from IA to DA [11]. But welfare of the general public would be improved if the change was made in China, as the country needed reasonable allocation of educational resources. In conclusion, DA would be more beneficial if it was used as assumed in this paper.

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