

# Research on Chinese College Admission Mechanism

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**Abstract.** College admission mechanism has been widely studied both theoretically and empirically for decades. Chinese education market with the largest population of students and number of colleges, comparing to all the other education markets, is definitely unique, typical, and can contribute diversity and richness to the studies of industry. However, few data set and research can be found that try to use tools of market design studying this particular centralized system, not even to mention how to improve it. This paper look at properties of other famous mechanism including student-optimal mechanism, Boston mechanism and top trading mechanism, and compare them with Chinese Parallel mechanism. This article also incorporates a new property introduced by Hatfield, Kojima, and Narita about the incentives for college to improve into consideration. In the future, this paper can bring attention to the authority, therefore attracting more diagnosis and analysis.

**Keywords:** College admission, Deferred acceptance, Immediate acceptance, Chinese parallel mechanism.

## 1. Introduction

Market design economists have devoted substantial time and energy to investigating different market structures and mechanisms in order to understand their roles in determining market efficiency. One of the archetypal markets consists of two sides, supply and demand, where agents of the two sides are matched to fulfill a set of wishes. The study of this type of markets constitutes the rich subject of matching theory. The most fundamental algorithm developed in 1962 by Gale and Shapley is the Deferred Acceptance (DA) algorithm, which is studied in many famous market design scenarios such as school choice problem, house allocation, hospital residency, and is further generalized in the following decades. Details of specific steps in DA mechanism applied on our topic, College Admission, will be discussed in the model section. With the introduction of modern tools such as lattice theory, economists were able to bridge auction theory and matching theory, the two previously distinct subfields of market design, to produce new, impactful results such as matching with contracts [1].

## 2. Background

In China, confronted with increasingly fierce competition, students tend to devote a substantial amount of time and energy to their study. Rushing nonstop from home to school, they are living and studying under unusually heavy burdens. Everyone is fighting for his or her chance of getting into college. Never has a topic regarding college admission failed to focus people's attention. Having glimpse of current situation about high-school education circumstance around China, we may marvel that a large number of students who study in high school have a great target, which is struggling their youth as great as possible for the winning of the university entrance exam, Gaokao, in order to find their faith of freedom and democracy as their long journey of future.

Debates and reforms associated with the innovation among the whole process in China, just as that as the United States. Moreover, some students with excellent grade rejected by the top university missed the chance to enter the ordinary university since the missing of the deadlines of application and examination. About 70 universities that wrote to the government trying to solve this dramatic problem gathered together in 1950s and found the solution, they finally decided to make a transition from their elder application systems to a modern constructed system called centralized matching mechanism, Gaokao. 1950s is a period of turmoil in the world's history; therefore, most of the financial expenditure

went to military. Under this global circumstance, the competition for the Gaokao was fierce because educational resources were really limited at that time.

The Chinese education system launched a brand-new matching rule for the high-school students, and the most important concept for students and their family during the process of filling out the application is called the batch admission control score. The batch admission control score line, also known as the provincial control line or batching line, is announced by a provincial admission examination institution after sorting provincial examinees' Gaokao scores from high to low according to the provincial exam procedures and their enrollment plans in recent years. After integrating various factors, the minimum entry score standard of the examinees is determined in batches according to a certain proportion. The Chinese higher education system was constituted by tiers of normal universities and vocational colleges. Tsinghua University, Peking University are definitely in tier one. The total number of university tiers is three, but some experts claim that the number may decrease to two in order to blur the boundaries of education hierarchy and to release the pressure for high school students. As a result, it becomes harder for universities to differentiate from others in the same tier since the size of each tier will become much larger.

Enrollment colleges and universities can only admit students above the batch admission control score line, only the college entrance examination scores meet or exceed the chase. To simplify the name of the general controlling system of Chinese Gaokao, let's call it Chinese college admission mechanisms (CCA). The game theory of Chinese college admission mechanisms is the tests of ability of parents and students to estimate their scores and rank in the same year. Candidates and parents need to fill in the first, second and third choice according to their own estimation of the score. Here there was a problem, because of the parallel principle, every school's admission of students will start from the first volunteer gradient downwards, in other words, if a student is given a first choice and have not been first choice school, so if his second-choice school will fill in as the first choice of candidates to fill the school's student enrollment. The student has no chance to enter the school where he applied for his second choice, and the correlation and logic between the second choice and the third choice are similar, which is commonly known as the "slippage" phenomenon. In the age before the reform of college entrance examination, this phenomenon was common and greatly troubled the examinees and their parents. Rather, it is the equivalent of a risky multiple-choice question in front of the examinee and their parents, using the economic analogy of opportunity cost. This uncontrollable risk will also make many high score students do not dare to apply for a better school, but in a stable and winning mentality to apply for a slightly lower than psychological expectations, but may be more stable and have a higher chance of winning. This phenomenon will not only make it difficult for top students to exert their advantages, but also lead to more competition among middle schools, which will upset the intended balance effect of the mechanism in terms of macro regulation. After analyzing the scores of examinees in the same year among all examinees, in fact, the first choice of China's college entrance examination is similar to the ED application in the United States. For students going to a better college, the first admissions or ED application is the best chance to get into a good school and the highest acceptance rate of the entire college application process. Among them, according to different examinees and parents of different psychological, at this stage, the choices we make will be very different. Some families think this is the closest chance to a dream school, so they need to make a little bit of a bet on the candidate's original ability to rush to a better school. Under this policy, some students do go to better universities, after all, the overall admission rate at this stage is obvious. But the risk is that if you don't get into your dream school, you'll waste your best chance of applying, and even if you could get into a school, you won't get in because of a decision mistake. This is a standard choice strategy problem. For some conservative families and examinees, they prefer to fill in the volunteer some safe, seize the opportunity to strive for a success, no merit but no fault. Of course, after being admitted to this part of the examinees and their parents may also feel a little regret.

### 3. The College Admission Problem and Mechanisms

The two sides, Colleges(C) and Students(S), constitute the classical college admission problem. This article define the space to be  $\langle S, C, Q, \succ \rangle$ , where S is a finite set of students that  $s_i, i \in \{1, 2, \dots, m\}$  and C is a finite set of colleges that  $c_j, j \in \{1, 2, \dots, n\}$ . Q represents the quota vector of each college,  $q_{c_j} = q_j$  being the maximum acceptable capability of the college. And the sum of all q has to equal or exceed the number of students.  $\succ$  is the complete strict preference profile of both colleges and students. For example,  $c_1 \succ_i c_2$  means student i prefers college 1 over college 2; while  $s_1 \succ_j s_2$  similarly means college j prefers student 1 over student 2, although in our settings, the factor of colleges' preference is the sorting of students' exact scores. Colleges' task will only be to determine the control score.

A matching  $\mu: S \cup C \rightarrow 2^S \cup 2^C$  assigns each student to at most one of the colleges or no college ( $\emptyset$ ).

$$\mu(s) \in 2^C, |\mu(s)| \leq 1; \mu(c) \in 2^S, |\mu(c)| \leq q_c \quad (1)$$

$$\text{i.e. } \mu: S \rightarrow C \cup \{\emptyset\} \quad (2)$$

$$\text{s.t. } |\mu^{-1}(c)| \leq q_c \quad (3)$$

In our case, consider the simplest example where there is only one student and one college with quota=1. If the college prefers recruiting the student over not taking him in, the college will set the control score to be lower or equal to the student's score, then  $\mu(s) = c$  here. Otherwise, the college sets the control score to be higher than the student's score, which leads to  $\mu(s) = \emptyset$ .

Usually, we assume the college preference to be responsive, a practically useful property in our situation of Chinese college admission process, which will be discussed later in Discussion section. If college preference profile does not satisfy responsive, there can be no stable matching. We define the college preference  $\succ_c$  over students to be responsive if:

With two students  $s_i$  and  $s_j \in S, i \neq j$ , for any  $S' \subseteq S \setminus \{s_i, s_j\}$ ,  $s_i \cup S' \succ_c s_j \cup S'$  if and only if  $s_i \succ_c s_j$

Similarly, with a student  $s \in S$ , for any  $S' \subseteq S \setminus \{s\}$ ,  $s \cup S' \succ_c S'$  if and only if  $s \succ_c \emptyset$ . A matching  $\mu$  is stable if it is not blocked by any student, college or student-college pair. On the one hand, the definition of a blocking student  $s$  is  $\emptyset \succ_s \mu(s)$ . On the other hand, the definition of a blocking college  $c$  is that  $\exists s \in \mu(c)$  s.t.  $\emptyset \succ_c s$ . The definition of a blocking student-college pair is that for a pair  $(s, c)$ :  $c \succ_s \mu(s)$  for  $s$ , and for  $c$ , either  $\exists s' \in \mu(c)$ , such that  $s \succ_c s'$  (justifiable envy), or  $|\mu(c)| < q_c$  and  $s \succ_c \emptyset$  (wasteful). A matching  $\mu$  is Pareto efficient if there does not exist a  $\mu'$  such that for all  $s \in S$ ,  $\mu'(s) \succeq \mu(s)$ , and  $\exists$  at least one student  $a \in S$  can be better off with  $\mu'(a) \succ \mu(a)$ .

Roth proved the Impossibility theorem in 1982 that: No stable matching mechanism exists for which stating the true preference is a dominant strategy for every agent [2]. The proof easily follows the corollary: Agents can, by manipulating their own preferences, achieve any outcomes of a stable matching. Therefore, we know there is no perfect mechanism satisfying these two most important properties. We look at the present algorithm and mechanisms that are adopted by different states and countries over the world.

#### 3.1. Deferred Acceptance Algorithm or Propose and-reject Algorithm

Deferred acceptance algorithm (DA) was first invented by Gale and Shapley in 1962 is implemented by the following rounds [3]: each student proposes to their favorite college and each college holds up to  $q_c$  of the proposed students according to their preferences,  $\succ_c$ , and reject the rest. In each subsequent round, each student proposes to their most-preferred college that he or she has not yet proposed and each college considers all the applicants of this round together with the students that it held, and chooses the new most favorable  $q_c$  student, holding them and rejecting the rest. The algorithm terminates at the first round at which no student applies to a college anymore. Truth-telling is a weakly dominant strategy for the student side when student-optimal stable matching,  $\phi^S$  is utilized [2].

Deferred acceptance mechanism is the unique stable and one-sided strategy-proof mechanism, but it is not *prae*tor efficient [4]. As a result, no stable mechanism where truth-telling is weakly dominant for all the colleges. To achieve more desirable students, coalition of them, or even a single college, by misreporting such as preference manipulation and capacity manipulation, can improve their quality of students. On the contract, the college-optimal stable mechanism is defined as college taking initiative and proposing.

### 3.2. Boston mechanism and Immediate Acceptance mechanism

The Boston mechanism  $\phi^B$  is an alternation of DA [5]. Students' propositions take place sequentially in each round, but for each college, instead of holding student to its capacity, it accepts the student directly at their proposition rounds to the remained capacity, offering each one a guaranteed seat. Unlike DA, in later rounds, a student will not be replaced by another student that the college prefers. Like what the other name, immediate acceptance mechanism, means, the deferring process become immediate acceptance. Even though  $\phi^B$  itself is not stable, all Nash equilibrium outcomes of the preference revelation game induced by the Boston mechanism are stable. The outcome of the Boston mechanism is Pareto efficient, provided that students truthfully reveal their preferences. In Boston,  $\phi^B$  was replaced by  $\phi^S$  in 2009.

### 3.3. Top trading cycle

Top trading cycle mechanism (TTC) was first introduced by Gale and Shapley in 1974 on the house-allocation problem [6].  $\phi^{TTC}$  has desirable property, *prae*tor efficient, unlike  $\phi^S$  the definition is as follows.

Consider each  $s \in S$  and  $c \in C$  as nodes in a graph. During each round, each student points to their favorable college or  $\emptyset$ , and each college points to their favorable student. Since the number of  $S$  and  $C$  is finite, there exists at least one closed cycle with the form like  $(s_1, c_1, s_2, c_2, \dots, s_r, c_r)$ :  $s_1$  points to  $c_1$ ,  $s_1$  points to  $c_2, \dots, s_r$  points to  $c_r$  and  $c_r$  points back to  $s_1$ . The students in each of the cycles will be assigned to the college they point to. Remove the college node when the capacity,  $q_c$  is met. The algorithm terminates when every student is secured a seat (including  $\emptyset$  if they choose to).

### 3.4. CCA or Chinese Parallel Mechanism

The current Chinese college admission mechanism (CCA) is something in between the immediate acceptance algorithm and deferred acceptance algorithm. Although different Provinces have slightly different versions of Parallel mechanism, they all fall into the same parametric family of application-rejection assignment mechanism [7]. The centralized immediately acceptance algorithm was implemented all over China until 2007 when the downsides could not be neglected anymore. The IA left the unmatched students no choice even they got relatively good scores but not ideal application strategy. Hundreds of thousands of high-school students got rejected by their first choice, and ended up repeating their senior year since "slippage" phenomena arise. If student chooses tier-one college during first round, it is not likely for them to pick another tier-one school at the second round since those are the most popular and the quotas are highly-possible achieved at the very first. Therefore, to replace IA, parallel mechanism was introduced by Zhenyi Wu and was adopted first in Hunan Province, then the whole educational system. The new mechanism increases the number of schools in a round. The level of desirability in each round varies in the decreasing sense. For example, if a student's true preference is  $c_1 > c_2 > c_3 > c_4$ , where  $c_1, c_2, c_3, c_4 \in C$ , then for deferred acceptance algorithm, he applies to these college sequentially, either gets hold or rejected in each round; while in Boston mechanism scenario, he gets accepted immediately or rejected in each round. Let the number of colleges students can apply each round in a particular province to be 2, then the student's first choices contain  $c_1$  and  $c_2$  with  $c_1 > c_2$  following deferred acceptance rule. If the student's score is ranked top- $q_{c1}$  in the applications, he will be hold by  $c_1$ , and will be compared with all the students putting college A as their second-highest-rank school in their first round. If he stands out, he will be offered a seat immediately, otherwise, he will be rejected in the first round. Consequently, he continues to round 2,

$c_3 > c_4$ : his second choices band, also following deferred acceptance algorithm. To conclude, inside each round, parallel mechanism is utilizing deferred acceptance; while between each round, immediately acceptance is taking place. And we define the number of colleges that students can apply in each round to be  $e$ .  $e = 1$  for Boston mechanism, and  $e = \infty$  for deferred acceptance mechanism. Parametric family of CCA mechanism includes  $e=2$  for Shanghai,  $e=3$  for Jiangsu,  $e=4$  for Anhui,  $e=5$  for Hebei,  $e=6$  for Hainan,  $e=10$  for Tibet. Define  $\phi^e$  formally with  $e \in \{1, 2, \dots, \infty\}$ :

Round 1: Step 1: each student proposes to their top-choice and each college holds up to  $q_c$  of the applicants, and rejects the rest. In the following steps within round 1, the students propose to their most-preferred that have not yet proposed to, while colleges reconsider the pool with original students being held along with the new applications received this round, generating a new tentative list and rejecting the rest. The round terminates when all  $e$  steps are run, each student is either assigned to a college, i. e. on a tentative list, or is rejected by all his  $e$  top choices. The schools' tentative lists become final, and the quotas decrease accordingly.

Round  $k$ : Step 1: Similarly, to round 1, the students left propose to their  $((k-1)e+1)$ st choice college. College's draft tentative lists. Deferred acceptance algorithm in this round continues, and the round ends the same way as the first,  $e$  steps being run. The algorithm terminates when every student is assigned a seat in a school with no more tentative lists.

#### 4. Discussion

In response to the above problems, in order to open up the "last mile" of the implementation of the new college entrance examination reform and promote the comprehensive implementation of the multi-evaluation and selection mechanism, it is recommended to comprehensively implement and systematically promote the following aspects [7]. Guided by deepening the reform of education evaluation, coordinate the promotion of various key reforms and supporting policies, and create conditions and environments conducive to the reform of the college entrance examination. The central government's deployment to promote the reform of education evaluation in the new era will surely lead and promote profound changes in all aspects and links in the field of education. It is necessary to include the new college entrance examination reform into the key items of "breaking the five uniques", and further refine the measures and requirements for comprehensive evaluation and multiple admissions under the framework of "two bases and one reference", and release a strong signal to break the "only score" [8]. It is necessary to strengthen the main responsibility of governments at all levels, increase the supervision of the implementation of the overall plan for education evaluation at the national level, improve the implementation of the negative list system, focus on solving the problems of "admission only" and "diploma only", and promote the formation of a systematic and scientific system. Education quality, educational performance evaluation and evaluation system, and selection and employment evaluation mechanism; in particular, coordinating the introduction of supporting policies for talent recruitment and selection, establishing and strengthening policy orientations such as having both ability and political integrity, putting morality first, and selecting meritocracy, and guide And promote the reform of education methods to improve the overall quality of personnel training. In addition, the implementation of "double reduction" will be further coordinated and effective, improve the diversion of general vocational education, promote the transformation of students from hierarchical elimination to classification and diversified development, ease social education anxiety, and form a good education ecology [9]. After reviewing the stability, fairness, and incentives for colleges to improve, parallel mechanism with large  $e$ , the mechanism more similar to DA, out-beat those with small  $e$ , the mechanism more similar to IA [10, 11].

#### 5. Conclusion

The prosperity of DA act as an incredible system following the law of economical market equilibrium that tremendously balance the supply and demand of education resources. The choosing

of university will no longer be a ridiculous and nasty thing that have incredible potential being a catastrophe of the future journey for every student, the likes of which has never seen before. And the bedrock of this prosperity is a crucial conviction, that a policy exists depends on academic that can provide every student with their own rights and freedom. The creating and advancing of DA system is no doubt an unprecedented success and serves as a shield to protect the freedom and democracy of the university admission. China's university system is developing toward more tier-one schools and more diversified colleges. So, the advantage of IA is that the excellent and highest-scoring students are relatively scattered and not concentrated in the same university or the same region. Overall, which exact e should be adopted by each province still need more empirical research to support. The overall goal of China's new college entrance examination reform is to achieve "classified examinations, comprehensive evaluation, and multiple admissions", and actively explore a comprehensive evaluation and admission mechanism that integrates the results of the college entrance examination and high school academic proficiency tests, and refers to the comprehensive quality evaluation. Comprehensive evaluation admission mainly goes through three stages: germination, pilot, and promotion. With the continuous advancement of the new college entrance examination reform, comprehensive evaluation admission enters the fast lane of reform. However, under the current policy system, fairness, science and efficiency still restrict the comprehensive promotion of comprehensive evaluation and admission. Practical strategies are proposed from three aspects: constructing a fair and scientific multi-evaluation system, effectively strengthening the professional construction of college admissions and admissions, and continuing to improve the comprehensive evaluation and admissions supervision and restriction mechanism.

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