

The Role of Technology in Promoting Educational Equity

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Abstract. Educational equity has become a central concern in Chinese education policy, particularly as debates around the fairness of the National College Entrance Examination (NCEE) admission process have intensified. This paper compares three college admission mechanisms: the traditional Boston Mechanism, the Gale-Shapley (Deferred Acceptance) algorithm, and an internet-based Boston Mechanism that operates under conditions of complete information. We show that when real-time web technologies are introduced, this complete-information variant produces stable Nash equilibria and achieves Pareto efficiency. Drawing on the case of Inner Mongolia, we further argue that digital infrastructure can meaningfully reduce information asymmetry, improve fairness in high-stakes admissions, and provide useful lessons for broader educational reform efforts.

Keywords: Educational Equity, Technology, School Choice Mechanism, Inner Mongolia

1. Introduction

The concept of educational equity has assumed a pivotal role in modern education, given its distinctive social function. In contemporary society, education is frequently regarded as an accelerator with both utility and non-utility values. Among the widely recognised non-utility values are the promotion of social equality and the maintenance of social stability. Despite the pervasive presence of unfair phenomena in society, education is recognised as a crucial factor in providing equal opportunities for individuals to improve their living conditions through fair competition and reducing social injustice. To fulfil its role, educational equity must be established as the foundational principle for educational development and reform on a global scale.

The NCEE, as a vital component of education and a means of talent selection, has garnered increasing attention due to its profound impact on both the quality of the workforce and students' futures. Nevertheless, the mechanisms by which the NCEE is administered have not been subject to adequate scrutiny with regard to the differences between them and the fairness of students' strategies. In the People's Republic of China, three mechanisms are currently employed: the Boston Mechanism with Complete Information, the Boston Mechanism, and the Gale-Shapley mechanism.

2. Literature review

2.1. Theoretical frameworks

2.1.1. Overview of matching models

Centralized matching systems generally fall into three categories: two-sided matching markets, one-sided assignment models, and context-specific allocation frameworks. The theoretical foundations of this field go back to Gale and Shapley, who introduced the student-proposing Deferred Acceptance (DA) algorithm. A key feature of the DA mechanism is that it produces stable matches and ensures Pareto optimality for applicants. By contrast, the Immediate Acceptance mechanism—widely known as the Boston Mechanism (BM)—has attracted considerable criticism for its susceptibility to strategic manipulation by participants.

2.1.2. Two-sided matching models

Two-sided matching models are rooted in the classical "stable marriage problem" and capture the dynamics between two distinct groups of agents—students and universities, or workers and employers—each with their own set of ranked preferences. Gale and Shapley showed that the deferred acceptance framework can reconcile individual rational decision-making with overall systemic stability, producing outcomes that maximize applicant welfare [1].

2.1.3. One-sided assignment paradigms

One-sided allocation problems are often analyzed through Shapley and Scarf's "housing market" model. This approach uses the Top Trading Cycles (TTC) algorithm to arrive at core allocations that are both strategy-proof and Pareto efficient [2]. In settings where participants have no initial property rights—such as public school assignment or social housing distribution—Random Serial Dictatorship (RSD) is a widely used default approach [3].

2.2. Empirical and experimental dimensions

2.2.1. Global evidence: the divergence of BM and DA

Empirical support for these theoretical frameworks comes primarily from school district reform studies in the United States. Abdulkadiroğlu et al. studied Boston's pre-reform admissions system and found widespread strategic manipulation, unstable placements, and considerable welfare losses [4]. A parallel study of New York City produced similar findings [5]. Schools that subsequently switched to DA-based systems saw lower rates of unassigned students and better overall outcomes. Pathak and Sönmez combined real data with counterfactual analysis to show that the strategic vulnerabilities built into BM disproportionately disadvantage less informed applicants, effectively reducing their access to top-tier schools [6].

Laboratory experiments provide additional supporting evidence under controlled conditions. Chen and Sönmez ran simulated school choice scenarios and found that participants frequently misrepresented their preferences under BM, while DA consistently encouraged honest reporting [7]. Even with constraints on the number of choices allowed, Calsamiglia, Haeringer, and Klijn found that DA maintained its advantage in eliciting truthful preferences [8].

2.2.2. Domestic context: game-theoretic inquiries into Gaokao reforms

The Gaokao is the world's largest centralized college admissions system, matching more than 10 million applicants to roughly 7 million university seats each year. Chinese scholars have largely focused on comparing the older "sequential" format—which closely resembles BM—with the newer "parallel" mechanism, a hybrid that draws on features of both BM and DA.

Several recent studies have used provincial policy changes as natural experiments. Chen, Jiang, and Kesten looked at tier-1 admission reforms in 2008–2009 and found that the parallel mechanism led students to list more preferences, take greater risks in applying to top universities, and achieve more stable placements [9]. Binzhen Wu and Xiaohan Zhong similarly documented improvements in match quality, with a closer correspondence between students' scores and the competitiveness of the schools they attended [10]. Ha, Kang, and Song drew on data from multiple provinces to show that widening the range of choices improves sorting precision in a non-linear fashion [11]. A contrarian view comes from Yun Pu, who analyzed data from Guangxi, Hebei, and Sichuan and argued that under certain conditions, the traditional BM approach could actually maximize total welfare—though it still left risk-averse students at a disadvantage during the transition to DA [12].

2.3. Methodological appraisals of contemporary research

2.3.1. Theoretical and empirical merits

The existing body of research has developed a solid theoretical foundation that can be applied to both simple and complex institutional settings. The combination of econometric analysis and controlled laboratory experiments has allowed researchers to translate theoretical insights into workable policy interventions, drawing productively on microeconomic theory, behavioral game theory, and computational approaches.

2.3.2. Institutional limitations

That said, significant gaps remain in the literature. Some models rest on behavioral assumptions that are too simplified to capture the cultural or institutional peculiarities of specific contexts. Mechanisms like TTC are also difficult to explain to the general public, which creates political obstacles to their adoption. Perhaps most notably, there is still a shortage of systematic research on centralized matching in developing and transitional economies.

3. Admission mechanisms in China

There are three college admission mechanisms in China at present. Boston Mechanism, Gale-Shapley Mechanism, Boston Mechanism with Complete Information.

3.1. Boston mechanism

Prior to 2008, the Boston Mechanism constituted the predominant admission system for the NCEE in the majority of Chinese provinces. The Boston Mechanism functions through a series of steps, outlined as follows:

Step 1: only students' first choices are considered. Seats are then allocated to higher-priority students on an individual basis until either all seats are filled or no students remain who have listed the college as their first choice.

Step k: In subsequent steps, the kth choices of students are considered. For institutions with available places, places are allocated sequentially to students who have listed it as their kth choice, in accordance with priority, until either all places have been filled or no student remains who has listed it as their kth choice. The process is terminated when all students' choices have been exhausted.

Despite the simplicity and efficiency of the Boston mechanism, it is neither a Pareto optimal nor an equilibrium solution. Of particular concern is the fact that it is not strategy-proof, a feature that has the effect of incentivising students to manipulate their preferences. To illustrate this, consider the following example:

Example 1: Suppose there are four students $\{i_1, i_2, i_3, i_4\}$ and three colleges $\{c_1, c_2, c_3\}$, with each college having one seat. The marks and preferences of the students are listed below:

i_1 : 95 ($c_1-c_2-c_3-c_0$)

i_2 : 90 ($c_1-c_2-c_3-c_0$)

i_3 : 85 ($c_2-c_1-c_3-c_0$)

i_4 : 80 ($c_2-c_3-c_1-c_0$)

Assuming that these are the students' true preferences, the following admissions results would ensue:

In the initial round of the selection process, which is confined to the first choices of students with higher priorities, student i_1 is assigned to college c_1 and student i_3 is assigned to college c_2 . Consequently, students i_2 and i_4 remain unassigned.

In the subsequent Round 2, the second choices of the remaining students are taken into account, resulting in student i_4 being assigned to college c_3 .

In the subsequent round, given that places at colleges c_2 and c_3 have been filled, student i_2 is not granted admission.

$$(1) \text{ The real apply preference } \mu_1 = \begin{bmatrix} i_1 & i_2 & i_3 & i_4 \\ c_1 & c_0 & c_2 & c_3 \end{bmatrix}$$

The outcome μ_1 is not fair. Consequently, student i_2 has incentive to manipulate their preference, as the revelation of their true preference would result in the alteration of their standing. In order to avoid such an outcome, student i_2 modified their original preference as follows: $c_2-c_1-c_3-c_0$.

$$(2) \text{ The outcome changed to } \mu_1 = \begin{bmatrix} i_1 & i_2 & i_3 & i_4 \\ c_1 & c_2 & c_0 & c_3 \end{bmatrix}$$

However, this outcome is not Pareto optimal, as student i_3 would also have an incentive to manipulate his preference to: $c_3-c_2-c_1-c_0$. The final outcome is as follows:

$$(3) \text{ The result turns to } \mu_1 = \begin{bmatrix} i_1 & i_2 & i_3 & i_4 \\ c_1 & c_2 & c_3 & c_0 \end{bmatrix}$$

This outcome is equitable, however it assumes that students have complete information about their competitors' scores and preferences, which is impractical given the large number of applicants (9.4 million in 2016). The complexity of gathering such extensive information renders the application process arduous and increases the likelihood that students will choose sub-optimal strategies, leading to outcomes that are less than equitable.

3.2. Gale-shapley mechanism

The Gale-Shapley mechanism functions as follows:

Step 1: students who have attained the highest scores are given priority. Admission to the first choice institution is granted if places are available; otherwise, the second choice institution is

considered, and so on until either all places have been filled or no students remain.

Step k: Students with the highest k-th rank are considered first. Admission to the first choice is granted if places are available; otherwise, the second choice is considered, and so on, until either all places are filled or no students remain. The process will come to a conclusion when there are no students or places left.

Utilising the aforementioned example, under the Gale-Shapley mechanism, each student discloses their genuine preferences:

Round 1: Student i_1 is assigned to college c_1 .

Round 2: Student i_2 is assigned to college c_2 , as college c_1 has no places left.

Round 3: Student i_3 is assigned to college c_3 , as colleges c_1 and c_2 have no places remaining.

Student i_4 does not gain admission to any college.

This outcome is deemed fair as each student has no incentive to manipulate their preferences. The Gale-Shapley mechanism is strategy-proof, ensuring that revealing true preferences is the optimal strategy for each student. The elimination of the need for coordination among students, as well as the removal of incentives to manipulate preferences, ensures an outcome that is optimal, efficient, and fair.

In 2008, the Ministry of Education reformed the enrolment mechanism for college entrance exams and promoted the Gale-Shapley mechanism nationwide with a view to improving educational equity.

However, due to the limited number of choices in China, the Gale-Shapley mechanism cannot fully reveal students' preferences. While students in certain provinces have access to over 100 choices, including universities, majors and combinations thereof, this information remains inadequate for informed decision-making and effective ranking of college preferences. The absence of comprehensive preference data within the Gale-Shapley mechanism may potentially result in efficiency losses, despite its strategy-proof nature.

Table 1. Different admission mechanism in different provinces of China

Province	Mechanism/ Quantity of applications	The way of apply
Beijing	Gale-Shapley 30	Internet
Henan	Gale-Shapley 12	Internet
Anhui	Gale-Shapley 20	Internet
Jiangxi	Gale-Shapley 20	Internet
Qinghai	Gale-Shapley 12	Internet
Xizang	Gale-Shapley 3	Internet
Xinjiang	Gale-Shapley 18	Internet
Shanghai	Gale-Shapley 24	Internet
Zhejiang	Gale-Shapley 30	Internet
Sichuan	Gale-Shapley 9	Internet
Liaoning	Gale-Shapley 112	Internet
Shaanxi	Gale-Shapley 12	Internet
Shandong	Gale-Shapley 96	Internet
Hainan	Gale-Shapley 30	Internet
Jiangsu	Gale-Shapley 20	Internet

Table 1. (continued)

Hunan	Gale-Shapley 45	Internet
Tianjin	Gale-Shapley 6	Internet
Hubei	Gale-Shapley 20	Internet
Shanxi	Gale-Shapley 8	Internet
Chongqing	Gale-Shapley 96	Internet
Gansu	Gale-Shapley 1+45	Internet
Jilin	Gale-Shapley 6	Internet
Hebei	Gale-Shapley 6	Internet
Ningxia	Gale-Shapley 4+8	Internet
Guangxi	Gale-Shapley 40	Internet
Guangdong	Gale-Shapley 45	Internet
Yunnan	Gale-Shapley 20	Internet
Heilongjiang	Gale-Shapley 10	Internet
Inner Mongolia	Boston Mechanism with Complete Information	Internet
Guizhou	Gale-Shapley 1+60	Internet
Fujian	Gale-Shapley 40	Internet

Source: Counted by Author.

3.3. Boston mechanism with complete information

The main problem with the traditional Boston mechanism is that students must make decisions under considerable uncertainty, without knowing how their competitors are behaving. Inner Mongolia's reform addresses this directly by making the process transparent in real time. Through an online platform, students can see live score distributions, the number of applicants competing for each school, and how other students are updating their preferences—allowing them to adjust their own choices before the window closes. This open flow of information removes the guesswork from the process, reducing both individual disadvantage and system-level inefficiency.

In practice, the mechanism divides applicants into groups based on their exam scores, and allows each group to submit preferences in sequence. Lower-scoring groups can only finalize their choices after the higher-scoring group has closed its window, which preserves priority ordering throughout the process.

To make this concrete, imagine two groups of students: G1 (scores 81–100), who submit their preferences between 7:00 and 9:00, and G2 (scores 60–80), who can only begin at 9:00. This scheduling ensures that G1 students always take precedence.

Step 1: (G1 Submission): Students in G1 begin submitting preferences, and the system ranks them based on their top choice at any given moment. Seats at each university are tentatively allocated to the highest-priority students who have listed it first. Unlike the traditional Boston Mechanism, students are not locked into their initial submission—they can switch preferences at any point during the window, for example moving from an oversubscribed school to one with available spots once they see they are unlikely to be admitted. G2 students cannot begin applying until G1's window closes and all G1 allocations are finalized.

Step k: (Iterative Allocation): The same process repeats for each subsequent score group in descending order, continuing until all university seats are filled or all eligible applicants have been matched.

Central to this approach is an institutional commitment to information sharing. Throughout the application window, the provincial Department of Education releases updated dashboards on an hourly basis, giving students access to their own score ranking, provisional admission cut-offs for each school, live applicant counts, remaining seat vacancies, tuition fees, and program-level details. What was once an opaque guessing game becomes, in effect, an open-market decision.

When full information is available, students have little incentive to game the system—honest applications become the rational strategy, producing stable Nash equilibria and Pareto-efficient outcomes. In contrast, the static formats of the traditional Boston and Gale-Shapley mechanisms leave applicants to guess at others' strategies, which inevitably leads to distortions and unfair results. This is why the internet-mediated approach has earned broad acceptance among students and institutions in Inner Mongolia alike.

The results speak for themselves. By making real-time information available through a digital platform, the mechanism substantially reduces both information inequality and rent-seeking behavior, leading to more accurate and equitable matches within the Gaokao system. One practical indicator is the "restudy" (Fudu) rate—the share of students who, having been poorly matched or unassigned, must repeat the entire academic year to retake the exam. In Inner Mongolia, this rate dropped sharply from 23% in 2008 to just 7% in 2012, while provinces using traditional mechanisms remained consistently above 12%. Universities in the region also reported better student quality and greater enrollment stability, with elite institutions achieving a 97% matriculation efficiency rate in 2013 and an almost complete elimination of unfilled quotas.

In short, moving the process online and making information freely available has transformed college admissions in the region. A system that once suffered from coordination failures and persistent unfairness has been substantially improved, showing how technology can drive real gains in educational equity and institutional modernization.

4. Conclusion

In conclusion, how a college admissions system is designed matters greatly for whether students are treated fairly. This paper has shown that Inner Mongolia's internet-based, complete-information Boston Mechanism achieves a Nash equilibrium that satisfies both Pareto efficiency and resource optimization, providing a practical way to avoid the waste of institutional capacity. The introduction of real-time digital infrastructure into the admissions process has brought a level of transparency and fairness that was previously absent from centralized assignment systems.

This case holds wider implications for public sector reform in China. Where citizens once relied entirely on bureaucratic authority as the guarantor of fairness, they increasingly look to data-driven platforms for procedural legitimacy. By making the process visible and reducing the risks associated with strategic misrepresentation, this mechanism has earned genuine public trust and offers a replicable model for how digital tools can improve state-citizen relations in the allocation of public resources.

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