

Application Analysis of DA Algorithm in Chinese College Entrance Examination Volunteer Filling

Hanyun Xiao

*Ulink College of Shanghai, Shanghai, China
hanyunxiao1204@gmail.com*

Abstract. Two-sided matching theory and the Deferred Acceptance (DA) algorithm were selected as the basis of analysis in this paper, multiple types of matching mismatches in the Gaokao admission market were classified, and information asymmetry was identified as the root cause of allocation inefficiency. Systematically compare the operating logic, stability attributes and incentive constraints of student-proposing and college-proposing DA mechanisms, clarify the structural limitations of parallel volunteering as a transitional matching system, and not fully eliminate blocking pairs and strategic manipulation. Layered optimisation solutions are also proposed at the macro institutional level and the micro-operational level in this study, such as increasing parallel volunteer quotas, piloting student-proposed DA matching rules, building a unified national admission platform, and adopting multi-dimensional comprehensive ranking criteria to reduce information friction and market malfunction. Theoretically, this study adds to the research on localized applications of matching market design in China's non-price public resource allocation, and in practice, offers feasible reform schemes for provincial education authorities and official volunteer recommendation platforms to enhance the stability and efficiency of matching, as well as fairness in higher education admissions.

Keywords: DA, Gaokao Volunteer Application, Two-sided Matching, Parallel Volunteering, Matching Market Failure

1. Introduction

Under the cognitive system of traditional mainstream economics, a market is generally regarded as a monetary commodity trading platform that allocates resources through supply-and-demand curves, and economic research has mainly focused on ex-post analysis of the rules of established market operation. Market Design Theory, however, extends the concept of a "market" significantly; it no longer refers to monetized transactions, and any situation involving limited resource allocation and two-sided quota matching falls under the scope of this research [1]. The application for China's National Higher Education Entrance Examination (Gaokao) operates under a two-way matching and allocation system for limited admission spots. The current system for submitting applications after the release of results, in conjunction with the parallel application system and various big data application tools, has simplified the application process; however, this system still has several problems: the rules governing the allocation of applications under the parallel application system

tend to promote strategic application behaviour among candidates, admission rankings fluctuate significantly due to changes in enrollment quotas and grading policies, a large amount of application data is difficult for candidates to process and use to make informed choices, a widespread lack of understanding of degree programs exists, existing prediction algorithms rely solely on score rankings, and the interests of candidates, universities and educational equity are not well balanced. As a result, many problems have arisen: some students who achieved good scores were placed at lower-tier universities; others could not achieve their desired university or fit well into the curriculum after entry; anxiety about higher education increased significantly; the stratification of universities has become more severe, and the appropriateness of placement for reallocation cannot be guaranteed; and inequality in access to information has further widened the gap in educational opportunities.

This paper investigates the different forms of market failure in the current university admissions matching system and identifies three main market deficiencies: information asymmetry, manipulation of preference strategies, and structural matching imbalances. The first theory of bilateral matching was proposed by Gale and Shapley, and the classical DA algorithm and a proof for the existence of stable matches in the context of university admissions were developed [2]. Niederle and Roth further built on this foundation to refine the market design framework and proposed that a good matching market should meet three necessary conditions: sufficient depth, risk-free truth-telling, and the absence of transaction congestion [3]. He verified the actual effect of the DA mechanism through reform cases in the United States, such as physician recruitment and the selection of public schools. Given China's special university admission system, Chen and Kesten built a unified parametric mechanism framework that categorised sequential volunteering, provincial parallel volunteering, and candidate-initiated DA under the same family of acceptance-rejection rules [4]. Theoretically, they have shown that increasing the number of parallel volunteering slots can reduce speculative applications and improve the stability of matching; at the same time, they have also noted that parallel volunteering is merely a temporary measure and cannot fully resolve blocking and mismatches. Currently, the two complementary but not yet integrated areas of domestic research are: one focuses on intelligent application prediction algorithms that optimise the accuracy of university and programme recommendations through machine learning and data mining; the other studies the decision-making strategies of applications under existing parallel rules from the perspective of candidates' actual experiences [5, 6]. However, most of the domestic research has not explored the institutional roots of matching friction from the perspective of underlying market design. It does not provide an organized comparison of the inherent defects of the parallel application system and the strengths of the DA algorithm in terms of stability and resistance to manipulation, nor has it developed implementable, tiered improvement plans tailored to China's current practice of tiered admissions organised by province and admission batch. Based on the comparison of the strengths and weaknesses of mainstream intelligent application algorithms and the parallel application matching mechanism over the past five years, this paper analyzes the dual efficiency shortcomings that have occurred due to the combination of technical tools and admission rules; finally, by drawing on the core logic of deferred acceptance matching, it proposes an integrated optimisation pathway for the three dimensions of information provision, application rules and intelligent recommendation models, balancing educational equity, matching stability and resource allocation efficiency.

This paper will study the problems of market failure in the present university admissions matching system and identify three main deficiencies in the market: information asymmetry, preference manipulation, and matching imbalance. Then it will compare the strengths and

weaknesses of the main intelligent application algorithms and the parallel-volunteer matching mechanism over the past five years to analyze the synergistic deficiencies of both the technological tool and the institutional rules. Finally, according to the concept of delayed acceptance matching (DA), this paper proposes an optimisation path for fairness, stability and efficiency in the three areas of information provision, application rules and intelligent recommendation models.

2. Mismatch performance and cause analysis

2.1. Mismatch manifestations

The primary types of mismatches in matching markets are unstable matching, structural welfare imbalance, and broken supply-demand adaptation [7-10]. The university admission mechanisms provide a typical case.

First, blocking mismatches exist at the individual and bilateral levels. Individual mismatch occurs when applicants are assigned to unsuitable universities and, as a result, leave for other reasons. Bilateral blocking mismatch occurs when a student and a university are mutually interested in each other more than their assigned matches, thus forming a blocking pair. The unstable pair shows an allocation inefficiency and fails to meet both parties' demands.

Group structure mismatch also occurs in college admissions. The student-optimal stable matching may be suboptimal for the universities in terms of student quality, and a university-favourable stable matching may harm the general welfare of the students. Among the set of stable matchings, the interests of applicants and institutions are in conflict, and thus a persistent structural resource mismatch occurs.

Many-to-one university admission systems frequently exhibit priority violation mismatches. A student with a high academic priority may be turned away by a university that is full or has lower-ranked enrolled students, thus violating the consistent priority rule. Random tie-breaking for equally ranked applicants further introduces artificial mismatches and yields results that are Pareto-dominated by other fair allocations, thus reducing overall market efficiency.

Strategic Mismatch is also caused by agent manipulation. Since there is no guarantee device for strategy-proofness, the applicant may choose to conceal or alter their true interests to avoid the risk of not being admitted. A cautious or discriminatory application mode will not achieve the desired effect, and thus talented individuals may be overlooked [5].

2.2. Information asymmetry: cause of mismatch

All matching inefficiency in the university admission market stems from information asymmetry and information frictions.

First, the applicants' real preferences for universities, majors, locations and future careers are private information. Market platforms and universities cannot observe the real willingness of students at zero cost, and only see submitted application lists that do not perfectly reflect actual demand. There will be missing data.

Second, Roth believes that there will be a problem of asymmetric information. Students and their families adjust the reported preference strategically to increase the chances of admission by concealing their true ranking. Due to this false information, the platform had reserved seats and formed blocking pairs; therefore, the allocation was unstable and the welfare rights of the elderly were infringed. Matching theory indicates that neither a full-stability mechanism nor an all-truthfulness mechanism can be realised; thus, strategic mismatch is unavoidable.

Third, partial priority information increases misallocation. University admission rules are generally based on broad rankings and grades, and many students fall into the same priority group. As there is no detailed data on applicants' all-around abilities and programme suitability, the platform will randomly assign them; thus, this allocation will be inefficient and unfair.

In short, the reasons for the continuous mismatch in university admissions are unknown private preferences and strategic behaviour. The DA algorithm will be used to collect preference data and ensure an even distribution of allocation by correcting for the problem of market failure due to information asymmetry.

3. Analysis of the matching mechanism based on the DA algorithm

College admissions are a many-to-one two-sided matching market, which can be solved by the DA algorithm, and it is divided into college-proposing DA and student-proposing DA, resulting in college-optimal and student-optimal stable admission matchings, respectively. Any match generated by the DA algorithm is stable, as shown in the two dimensions of individual rationality and the absence of blocking pairs. Proposers only send offers to the acceptable participants, and receivers only keep the acceptable admission options without individual blocking. Proof by contradiction shows that there are no blocking pairs in the market; otherwise, assuming a blocking pair formed by a student and a college would violate the iterative screening rules of the DA algorithm. Under strict preferences, every stable admission matching is Pareto optimal, and this can also be demonstrated by contradiction: if a Pareto improvement exists for a stable matching, a blocking pair will be formed and thus violate the definition of stability. On the other hand, if weak preferences with ties are permitted, a stable admission matching can be constructed that is not Pareto efficient. The two required attributes for the entire set of stable matchings are: First of all, the group preferences of colleges and students are in complete opposition: given two stable matchings, if all the colleges favour one matching over the other, then all the students will uniformly prefer the alternative. Secondly, the Singles Theorem indicates that students who are not accepted in a single stable admission plan will not be accepted in any stable matching, and colleges with unfilled enrollment quotas will never fill those seats across all stable outcomes. In terms of incentives, no device for producing stable matching is completely strategy-proof. The college-proposing DA rewards truthful preference reporting for colleges, but students are motivated to misreport their preferences in order to obtain better admission results; thus, no stable matching mechanism has been achieved that is incentive-compatible for both colleges and students simultaneously. The operation of college-proposing DA is as follows: colleges with vacant seats extend temporary admission offers to the highest-ranked students they have not yet contacted. Each student keeps only their favourite offer and rejects all others. Colleges that have been rejected will contact their next-best-option candidates to re-apply for offers repeatedly until no new offers are extended; all temporary offers will then be converted into formal, stable admissions [6].

4. Suggestions

4.1. Macro-level institutional optimisation suggestions

Based on the matching theory framework and regional admission reform evidence from Shanghai, Sichuan and Hunan, this section proposes targeted macro institutional reforms to alleviate various mismatches caused by information asymmetry and defects in the matching rules [11, 12].

The education authorities of the province should expand the number of available parallel schools and specialisations, thus reducing the gap between the current parallel mechanism and the standard student-proposed DA algorithm. Chen and Kesten built a parameterized mechanism system to reduce strategic manipulation in more parallel choices and achieved a more stable matching [4]. A larger quota for parallel applications will reduce the need for conservative reporting and strategic mismatch; provinces with a small number of voluntary slots should increase the batch size of available choices to lower the sliding risk and balance the welfare of students and universities. The old Immediate Acceptance sequential volunteering system should be fully phased out, and all its equilibrium outcomes are Pareto-dominated by DA matching results.

The national education authorities can build an all-weather nationwide admission platform in accordance with Roth's three standards for a sound matching market: sufficient market thickness, operational safety, and unobstructed procedures. The separated provincial enrollment systems have fragmented the matching market and created an incomplete information network. A single platform will be built to integrate the national enrollment plan and historical admission data to prevent cross-regional information inconsistencies. The authorities need to disclose the logic of the matching iteration, tie-breaking rules and real-time university vacancy information in the market. Optimised Computing Systems and Extended Operation Periods Can Avoid Peak Congestion and Artificially Created Blocking Pairs.

Pilot reforms of the student-proposed DA algorithm can be carried out in all-college admission reform provinces. Parallel volunteering only serves as an intermediate measure between IA and DA, and the problems of blocking and priority-violation mismatch cannot be fully resolved. Given the positive effects of the parallel mechanism reforms in many areas, the examination authorities may test DA matching rules for a few admission batches. Unlike the one-time filing mode of parallel volunteering, DA keeps temporary admission offers and supports multi-round invitations between universities and applicants to reduce the proportion of students who do not gain admission and have to reapply. The regulatory authorities will collect data on the scale of blocked trading and the proportion of regulatory misstatements to gain local experience for nationwide application [5].

Use the standardised multi-dimensional evaluation indicators to replace random selection for tie-breaking. Random ranking of equally scored applicants results in inefficient allocation; therefore, all-encompassing criteria that consider both subject strength and major adaptability can reduce the priority information gap and related mismatches.

4.2. Micro-level operation optimisation suggestions

The three subjects of micro-adjustments in the college admission market are universities, student applicants and provincial enrollment platforms; information friction and strategic manipulation based on incentive characteristics have been reduced, as shown by Gale & Shapley [2].

Universities should release enrollment data and add more kinds of tests to improve the efficiency of matching. Under college-proposing DA, the primary approach to truthful preference reporting for higher education institutions is used [1]. Schools need to publish all relevant information on the main training mode, employment data and talent selection requirements to close the information asymmetry with applicants. In addition to the original examination scores, all-encompassing assessment materials can be used to differentiate between applicants with the same rank and prevent the waste of talent due to a random tie-breaking procedure. Under centralised matching, universities can submit genuine preference rankings and avoid a fixed score limit to improve the efficiency of DA iterative screening.

Applicants and their families should report their true preferences with the support of matching theory popularisation. The student-proposed DA constructs a weakly dominant truthful strategy for applicants, and listing genuine school and major preferences can improve the chances of admission without unnecessarily truncating the preference list. The examination office can hold a general science class for the volunteers before they start to explain the harm of serious false reporting. Applicants should arrange the preference order according to their actual willingness and not intentionally select low-tier backup schools to avoid high-score/low-admission mismatches. Households with poor information access cannot use the official public admission data to assess their own competitiveness and are thus excluded from the two sides of the market.

Provincial enrollment platforms may optimise matching logic by referencing the iteration of DA's deferred acceptance. Current parallel volunteering has a one-time filing system without multiple rounds of temporary offer retention and easily creates blocking pairs. Operators can organise additional volunteer collection sessions to fill the empty university slots and unmatched applicants for the secondary matching, thus reducing resource waste. Personalized recommendation modules based on student rankings and preference tags can reduce the cost of information search and overcome the barrier of private preference information to address market mismatches at their root. The platform should show the process of a match operation and release an annual efficiency report containing blocking pair numbers and repetition rates to help all participants be aware of institutional defects and optimisation progress.

5. Conclusion

Based on the theory of bilateral matching in market design and the DA algorithm, this paper will conduct a full-process study of China's parallel-volunteer admission system for the National College Entrance Examination. First, it identifies four types of major mismatches in the current university admissions market: unstable matching, structural welfare imbalances, priority violations, and strategic manipulation; Second, it systematically analyzes the operational process, stable matching properties and incentive-constraint features of the two types of DA algorithms—university-initiated and student-initiated—compares their strengths and weaknesses with those of the current parallel application system, and confirms that the parallel application system is merely a temporary arrangement unable to solve matching blockages and strategic misreporting by candidates; Finally, from the perspectives of macro-level institutional reform and micro-level operational practice, it puts forward a tiered set of implementation measures, including increasing the number of parallel application options, piloting a student-invitation-based DA system, building a unified national admissions platform, optimizing the multi-dimensional comprehensive evaluation system, standardizing the application behavior of both universities and candidates, and optimizing the matching logic of the platform. Based on the above analysis, the reasonable application of DA matching rules can promote the optimisation of the stability and efficiency of the university admissions market and improve educational fairness.

This study still has some deficiencies: it is based solely on theoretical models and lacks quantitative empirical analysis of real-world admission data from individual provinces; it has not designed differentiated Development Area pilot schemes for different new college entrance examination reform models or different admission batches. In the future, micro-level admission data from several provinces over multiple years can be collected to build a quantitative matching model and determine the actual welfare improvement achieved by the DA reform. At the same time, because of the different local admission policies, various areas and groups of students could be established with different implementation paths.

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