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The Design of College Admission in China

中国大学招生机制

Articles in our Policy Forum series are commentaries on current political issues. They reflect the opinion of the authors and – although researched to our best knowledge – are not scientific papers. If there are CFDS papers on related issues, they will be referred to in the text.

Students of economics and business learn the fundamentals of game theory that enable them to make rational decisions in complex situations with strategic interaction. However, for most Chinese students this introduction comes too late. When they enter college, they have already participated in the complex high-stakes game of college admission.

Every year about 10 million Chinese high school students take the National Higher Education Entrance Examination, the so-called gaokao. The Chinese colleges and universities have the capacity to accept about 6 million of them. In 1952, the very first gaokao exam took place. In addition, college admission was centralized and this was already a great improvement compared to the previous system of decentralized admission by individual colleges.

But even with a centralized system, there are many conceivable ways of allocating students to colleges. Unsurprisingly, a student's exam score is extremely important in determining if and where she will go to college. However, in addition to

在大学里学过商科和经济学的同学都接触过博弈论的基本原理，博弈论教会他们如何在复杂的情况下做出理性的判断和决定。但是在中国的教育制度下，对于学生到大学才了解博弈理论可能就太晚了。因为当他们进入大学以后，就错失了一次对他们整个人生都非常重要的一场“博弈游戏”——选择报考的大学。

中国每年都有约 1000 万名高中生参加国家高等教育入学考试，也就是众所周知的“高考”，但受到招生名额的限制，只有其中 600 万才能顺利地进入大学。1952 年，进行了第一次高考，同时也是第一次采取中央集中录取的制度，与之前各个大学分散招生制度相比，这是一个在教育史上具有里程碑意义的改革。



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taking the gaokao exam, the prospective students have to make a sometimes exceptionally difficult decision: They have to choose the colleges they apply for and how they rank them in their application. As a result, while Chinese high school students are unlikely to have ever heard of game theory, they and their families have to play a game whose outcome will have a huge impact on their lives. This real-world game is perfectly suited for the analysis with the help of formal game theory: The rules of the game are fixed in advance and known to all players (the prospective students), the outcome of the game (the college assignments) depends on the strategies (an ordered list of colleges they apply to) of the players for whom a lot depends on what the outcome of the game will be.

But for economists not only the decisions of the prospective students who play the admission game are interesting. They also go one step back and ask what difference different possible rules of the college admission are likely to have in order to understand how the college admission game has to be designed to achieve desirable outcomes. The field of economics that tries to answer such questions is called mechanism design. The term “mechanism” refers to the rules of the game that the designer needs to decide upon. While there are many plausible criteria to evaluate the properties of a mechanism, more often than not the mechanism designer has to consider trade-offs between different desirable properties when deciding between different possible mechanisms. Some of these trade-offs will become clear in the discussion that follows. I first explain two relatively straightforward mechanisms to match students and colleges. While nowadays Chinese provinces use mechanisms that combine features of both, it is important to understand the two pure mechanisms first.

College admission in China used to be dominated by the immediate acceptance (IA) mechanism that was exclusively used until 2001.¹ The IA mechanism proceeds as follows: First, all students’ applications are sent to their first choice colleges.² If the number of students who ranked its first is larger than its capacity, a college accepts only the students with the best test scores among its applicants. Acceptance is immediate and never overturned in later rounds of the mechanism.

即使是中央集中制的录取体系，依然还有很多种分配学生到不同大学的方法。在选择学校的时候，一个学生的高考成绩是其决定因素的，但是学生依然要进行一个非常困难的选择：他们必须选择他们报考的学校，并且还要知道如何排名他们的申请顺序。因此，虽然中国的高中生可能没有听说过博弈论，但是他们和他们的家长企其实已经参与进这场博弈游戏之中，并且博弈游戏的结果会对他们的生活产生无比巨大的影响。真实世界中发生的博弈游戏是非常适合经济学家对博弈论进行研究的：游戏的规则是提前制定好的，并且所有的玩家（申请大学的学生）熟悉规则，游戏的结果（大学的分配）取决于玩家自己采取的策略（学生们如何排列自己申请学校的顺序）。

对于经济学家而言，感兴趣的不止是申请大学的学生们如何作出他们自己的决定，他们还会探究大学的录取制度不同会导致出不同的记过，以及大学入学的规则应该如何制定才是最合理的。而试图解答这些问题的经济学研究领域被称为“机制设计”（博弈论的分支领域）。“机制”的意思是指游戏的设计者需要制定游戏的规则。虽然有许多看似合理的标准可以用来评估机制的属性，但通常的情况下，机制的设计者需要在不同的“机制”间权衡利弊，设计出最理想的机制属性。在接下来的讨论中，我会详细的分析设计机制时的各种权衡。首先，我先介绍两个相对简单的机制用于解释学生和大学之间是如何匹配的。虽然现在中国的各个省份已经将这两个机制进行有效的整合，但分开理解这两个机制仍然十分重要。

2001年前，中国的大学录取机制一直采取的是直接录取（IA）机制。^a 直接录取

Students who are not admitted in the first round are then considered by their second choice college. However, only the colleges which have capacity left after the first round offer their remaining places to the students who have ranked them second and were rejected in the first round. As a consequence, a student with a test score that would have secured her a place in a college if she had ranked it first instead of second might not be accepted by the same college in the second round because students with lower test scores who ranked the same college first have already secured their acceptance there. The procedure continues in this way³ until either all college places are filled or no yet unmatched student is willing to accept any of the college places that are still unassigned. It is obvious that with the IA mechanism only the very best students can rank the most attractive colleges first without running the risk of ending up with a mediocre college or no acceptance by any college at all. And while the IA mechanism is somewhat easier to explain than most alternative mechanisms, it is difficult for the participating students to find the optimal application strategy. The problem is somewhat mitigated by the fact that the results of past years give the students some idea of what test score they need to get into a specific college, but it is nonetheless severe.

These disadvantages and perceived injustices of the IA mechanism were a main reason to consider alternative mechanisms, not only for college admission in China, but for similar matching problems around the world. The most important alternative is provided by deferred-acceptance (DA) mechanism. The DA mechanism was initially proposed by David Gale and Lloyd Shapley (a 2002 Nobel laureate in economics) in 1962. Just as in the IA mechanism, students have to rank colleges. In the first round, all students are first applying to the colleges they rank first. These colleges preliminarily accept the students with the best scores who apply to them and reject the others. In the second round, the students who were rejected by their first choice are applying to their second choice. In contrast to the IA mechanism, the colleges now choose the best students among the students whom they tentatively accepted in the first round and the students who listed them as their second choice and got rejected by their first choice colleges.

机制的具体操作介绍如下：首先，所有学生的申请表被送到他们的首选大学。^b 如果一个大学的报考人数超过其招收人数的话，那么这所大学只录取申请者中成绩优异的学生。在 IA 机制中，在每一轮的报考时，学生一旦接受分配，那么录取结果马上生效。第一志愿没有被录取的学生将被他们的报名的第二志愿大学所考虑。但是，只有那些第一批没有完成招生名额的大学才会考虑这些在第一轮中被拒绝而且在第二志愿报考他们学校的学生。因此，当一个学生将某大学作为第一志愿时，他将被录取，但如果这所大学是他的第二志愿，他就可能不被录取。因为成绩不如他的学生将这所学校作为第一志愿，从而锁定了录取名额。整个录取过程将一直以这种方式重复着继续下去^c，直到所有的大学所有的招生名额被填满，或者没有一个学生愿意接受未完成招生名额大学的录取。很显然，在 IA 机制下，只有成绩最好的学生可以对心仪的大学进行排名，并且不必冒着被一般的大学录取或不被所有大学录取的风险。虽然相对于其他机制而言，IA 机制非常容易解释，但对于申请大学的学生而言却非常难以找到一个最理想的应对策略。随着时间的推移，这个问题在某种程度上已经得到缓解，因为应届毕业生通过了解历年高考的录取结果，可以估算出不同大学的录取分数线。

不止中国受到 IA 机制的缺点和不公平带来的影响，其实全球的国家都在寻找新的替代机制，而延期录取 (DA) 机制是替代机制中非常重要的一个。DA 机制最初是由 David Gale 和 Lloyd Shapley (2002 年诺贝尔经济学奖得主) 提出的。像 IA 机制中一样，在报考大学之前，学生需要先对大学

Thus, while rejections in the IA mechanism are final and irrevocable, in the DA mechanism acceptance to a college is only finalized once the mechanism terminates. All students who are rejected by a college in the second round are in the third round applying to the college that comes next on their ordered list.⁴ This process is repeated until either all the colleges are filled up to their capacity or no student who is yet unmatched would accept an offer from any of the colleges that have still college places available. It has been proven that independently of what the other students do, when the DA mechanism is used the best strategy for all students is simply to truthfully rank colleges according to their preferences. A prospective student is never better and sometimes worse off if she applies to colleges in a different order. Thus, telling the truth is a (weakly) dominant strategy and consequently a prospective student has no possibility to manipulate the college admission game to her advantage when the DA mechanism is used. Moreover, the DA mechanism ensures that the best students are accepted at the best and most attractive colleges.

So far we have only discussed the advantages of the DA mechanism compared to the IA mechanism. However, there is one potential drawback of the DA compared to the IA mechanism that has recently got some attention. By giving the students every incentive to truthfully rank the colleges, the DA mechanism makes it impossible to consider the degree of the students' preferences over colleges. This is somewhat different when the IA mechanism is applied. To see this, consider the following situation: There are two prospective students and one of them achieved a slightly better result in her gaokao exam than the other. Assume that all other college places have been filled with better students so that we have assign one of the students to college A and one to college B, the only two college places that are left. While both students prefer college A over B, the student with the slightly better test result is almost indifferent between the two colleges. However, the slightly worse student has an extremely strong preference for college A over B. With the DA mechanism that encourages truth telling the better student will end up at college A. With the IA mechanism this is probably not the case. The reason is that because of his strong

进行排名。在第一轮中，所有学生先申请他们排名第一的大学。这些被申请的大学初步录取那些成绩最好的学生，并拒绝其他学生。在第二轮报名中，被第一志愿拒绝的学生将申请他们的第二志愿。与 IA 机制不同的是，大学可以在将他们列为第一志愿或者第二志愿的学生中选择成绩更好的，并且可以拒绝第一轮被初步录取的第一志愿学生。

因此，在 IA 机制中被学校拒绝是最终结果并且不可逆的，但在 DA 机制中，对学校（录取通知）的接受才是最终确认和（招生）机制结束。所有在第二轮中被大学拒绝的学生将根据他们列的志愿名单顺序开始第三轮的大学申请。^d 整个录取过程将一直以这种方式重复着继续下去，直到所有的大学所有的招生名额被填满，或者没有一个学生愿意接受未完成招生名额大学的录取。事实证明，在 DA 机制下，所有学生最好的策略是根简单并且诚实地对大学进行排名。如果某个学生用不同的顺序去填报志愿的话，那么他（她）永远不会得到更好的结果，有时候甚至更加糟糕。因此，当 DA 机制被应用时，讲真话是一种（弱的）主要策略，任何一个学生都不可能操控大学录取这个游戏。另外，DA 机制可以确保每一个最好的学生都可以被最好的大学录取。

目前为止，我们只讨论了 DA 机制相对 IA 机制的优越性，但是最近的研究显示，DA 机制也存在潜在缺点。DA 机制引导学生更真实的给学校进行排名，而忽略了学生对学校的偏好程度，当 IA 机制被应用时就会有所不同。通过一个例子对 DA 机制的缺点进行了解：有两个应届毕业生，其中一个在高考中却得到成绩比另一个要好，假设所有的大学已经招到了比这两个学生更好的学

preference for college A over College B, the slightly weaker student is likely to have ranked College A higher than the better student. Thus, while the DA mechanism is totally ignorant of the degree of a student's preferences, the IA mechanism can accommodate them to some degree. It is possible to construct examples in which this leads to higher total welfare in equilibrium when the IA mechanism is used instead of the DA mechanism.

Nonetheless, the arguments in favor of the DA mechanism seem more convincing. When the IA mechanism was still applied in China, it regularly occurred that students who missed their favorite college because of just a few points in their gaoko exam ended up at a much less prestigious college or even with no college admission at all while worse students got admitted. Such cases put the legitimacy of the whole admission process into doubt. Moreover, the DA mechanism makes the college admission game very simple for the prospective students. They just have to be made aware of the fact that truthfully ranking colleges is the best strategy they can choose. In contrast, the IA mechanism will always lead to time and resources being invested into finding a good strategy and gives the admission process to some degree the features of a lottery, especially for prospective students who are willing to take a certain risk.

While admission to colleges in China has not moved fully from the IA to the DA mechanism, most Chinese provinces have moved to some degree in this direction. What has been adopted are different versions of what is known as the parallel mechanism. This parallel mechanism was proposed by Zhenyi Wu, a former director of undergraduate admissions at Tsinghua College. In the parallel mechanism, students select several "parallel" colleges within so-called choice bands. Students have priority for colleges that they have listed in their first choice band over other students who have listed the same college in the second choice band (and the second choice band has priority over the third and so on). However, assignments for parallel colleges listed in the same band are considered temporary until all choices of that band have been considered. Thus, the parallel mechanism is a compromise between the IA mechanism, where every choice acceptance is final, and the DA mechanism, where every choice

生,只剩下两所学校和两个名额,这两个学生中一个去A大学,另一个去B大学。当这两名学生都更倾向于选择A大学的时候,选择哪所大学对于成绩稍好的学生已经没有任何区别。但是如果成绩稍差的学生极度的选择A大学的时,DA机制会诚实地告诉成绩稍好的学生应该选择A大学。如果在IA机制下,结果可能就会不同,因为受偏好影响,成绩差的学生给A大学的排名会高于成绩好的学生,从而被A大学录取。在这个例子中,如果用IA机制取代DA机制的话,在平衡状态的时候,可能会导致更多总福利。

因此,尽管DA机制完全忽略了学生的偏好程度,而IA机制可以在一定程度上满足学生的需求。

尽管如此,赞成DA机制的论据似乎更有说服力。在IA机制仍然在中国应用的情况下,学生因高考错失几分而与心仪学校失之交臂,最终去了一个二流大学,甚至好学生没有大学上,但录取了较差学生的情况时有发生。这些例子让录取过程的合法性收到诸多质疑。此外,DA机制让新生的大学录取变得非常简单。他们只需要去了解一下大学的真实排名,然后择优选择。相比之下,IA机制始终让时间和资源投入到寻找优良策略,并在一定程度上让入学具有彩票性质,特别是对愿意冒一定风险的新生来说。

虽然中国大学的入学并没有完全从IA转变为DA机制,但大多数中国省份都在一定程度上向着这个方向发展,采用所谓不同版本的并行机制。这种并行机制是由清华大学前招生办主任吴振义提出。在并行机制中,学生在所谓志愿范围内挑选几个“并行”大学。与第二志愿相比,学生将优先被其列为第一志愿的大学录取(第二志愿将优

is temporary until all college places are filled. How many colleges are contained within a choice band varies between different provinces. The IA acceptance mechanism can be interpreted as a special case of the parallel mechanism with choice bands that contain only one college, while the DA mechanism is a parallel mechanism in which all colleges a student can apply to fit into the first choice band. Thus, it seems intuitive that the more colleges are contained in each choice band, the closer the parallel mechanism becomes to the DA mechanism. Chen and Kesten (2017) show that this is the case for the properties of the IS and the DA mechanisms that we have discussed. The more colleges are contained within a choice band, the less reason have prospective students to try to manipulate the mechanism by misrepresenting their preferences over colleges. Within choice bands, it is always optimal for them to state their preferences correctly. Nonetheless, the Chinese parallel mechanism, contrast to the DA mechanism, allows prospective students to express strong preferences for some colleges they cannot be certain of being admitted to by including them at the top of their first choice band. They can insure themselves against very bad outcomes by also including colleges they find acceptable and can be reasonable confident of being admitted to at the end of the first choice band. This feature of the parallel mechanism is highly appreciated by the prospective students and their families. I refer the reader to Chen and Kesten (2017) for a careful theoretical analysis of the Chinese parallel mechanism and some empirical evidence.

I conclude that the move away from the IA mechanism into the direction of the DA mechanism is a highly welcome development. While a full-fledged DA mechanism might be even more desirable, the parallel mechanism seems to be a huge improvement, especially in the provinces in which the choice bands are chosen wide enough. It seems likely that provinces with very small choice bands will move further in the direction of a DA mechanism by widening their bands once the advantages have become clear.

Further reading:

Chen, Y., Kesten, O., 2017. Chinese college admissions and school choice reforms: A

于第三志愿，以此类推)。但是，在同一志愿内的并行大学全部被考虑前，并行大学的分配都是暂时的。因此，并行机制是每次都是最终性选择的 IA 机制和每次都是暂时性选择，直到所有大学都招满的 DA 机制的一种折中。不同省份的大学数量选择范围是不同的。IA 机制可以被理解为仅有选择中仅有一所大学的并行机制特例，DA 机制也是一种所有学生都能申请到他们第一志愿的并行机制。因此，直观看来每个志愿中的大学越多，并行机制就越接近 DA 机制。Chen 和 Kesten (2017) 表示，这就是我们所讨论过的 IS 特性及 DA 机制。志愿选择中的学校越多，就越没用理由让新生对大学的偏好被曲解而对升学机制产生影响。在志愿选择范围内，他们始终能最优且正确的表达其偏好。尽管如此，中国的并行机制与 DA 机制形成明显对比，它允许新生表达对某些无法确定被录取的学校列入第一志愿，以表达他们强烈的喜好。他们可以在第一志愿中填写一个有自信会被录取的学校以避免非常糟糕的考分。并行机制的这一特点受到新生及其家长的高度赞扬。请各位读者参考 Chen 和 Kesten(2017)的报告中对中国并行机制的详细理论分析及一些实验性证据。

总而言之，从 IA 机制向 DA 机制是趋势所向。虽然完善的 DA 机制更具吸引力，但并行机制似乎是一项巨大改进，特别是在志愿选择足够多的省份。对于志愿选择较少的省份，一旦 (DA 机制) 优势变得清晰，这些省份将通过扩大志愿选择范围，向 DA 机制改进。

延伸阅读:

Chen, Y., Kesten, O., 2017. Chinese college admissions and school choice reforms: A

theoretical analysis. Journal of Political Economy 125

Wu, B., Zhong, X., 2014. Matching mechanisms and matching quality: Evidence from a top college in China. Games and Economic Behavior 84

Zhu, M., 2014. College admissions in China: A mechanism design perspective. China Economic Review 30

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¹The IA mechanism is also known as sequential mechanism or Boston mechanism.

² All the described steps in the different mechanisms are dealt with centrally using computers for the necessary calculations. Thus, when I state that “all students’ applications are sent to their first choice colleges” this is not true in the literal sense, but simply the most straightforward way to explain the mechanism.

³ By considering the third choice of so far unmatched students next and so on.

⁴ For the students who had been tentatively accepted in the first round this is the second college on their list, for the students who have been rejected for the second time this is the third college on their list.

theoretical analysis. Journal of Political Economy 125

Wu, B., Zhong, X., 2014. Matching mechanisms and matching quality: Evidence from a top college in china. Games and Economic Behavior 84

Zhu, M., 2014. College admissions in china: A mechanism design perspective. China Economic Review 30

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^a 直接录取机制也被称为排序机制或波士顿机制。

^b 在不同的机制中，所有对步骤都是用计算机集中处理和计算的，所有，当我说“所有学生’的申请表被送到他们首选的学校”的时候，其实字面表达的意思是不准确的。

^c 若果学生第三志愿依然不能匹配，那么匹配将继续下去，不停地循环。

^d 或者是第一轮被暂时录取的学生的第二志愿，或者第二次被拒绝的学生的第三志愿。