Targeted College Admission

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Introduction

- Targeted Admission: Matching students, programs, and firms

Main Contributions:

1. Formulate a new market design problem inspired by Russian practice
2. Prove impossibility of stable matching between firms, programs, and students
3. For fixed firm capacities: Design stable mechanism
4. (In progress) Analyze additional properties and alternative frameworks

Brief History of Targeted Admission in Russia

Soviet Union:

1. 1933: Mandatory 5-year job placement for all graduates (Narkom assignments)
2. 1962: Top workers sent to targeted PhD programs (aspirantura) with return obligations
3. 1987: Transition to a new system based on TA

Russian Federation:

1. 1995: Budget students allowed optional 3-year employment agreements
2. 2002: Separate quotas for state/municipal employers
3. 2013-2019: Reserved seats for students with state contracts
4. 2019: Minimum employment term set to 3 years
5. 2024: 150000 of total 600000 budget seats were reserved for TA (10% - 100% per program)

TA: Scope and Procedure

General Admission:

- Students apply to ≤ 5 programs across ≤ 5 universities
- Rank preferences within each university
- Programs rank applicants by Unified State Exam scores
- Single enrollment consent submitted before deadline
- Universities assign seats via Deferred Acceptance (DA)

Targeted admission:

- Students select **one** program and **one** employer
- Binding contract for **3–5 years** post-graduation
- TA seats filled before general admission

TA Shortcomings

Current inefficiencies stem from regulatory mismatches

Student Challenges:

- Restricted to **one** TA program (strategic uncertainty)
- TA seats allocated first — may lead to suboptimal matches
- Risk of overcommitment to less-preferred options

Employer Challenges:

- No explicit capacity controls → potential over-enrollment
- No way to get students committed, thus overbooking
- Risk to get more students

Literature

College Admission:

- Gale and Shapley (1962)
- Roth and Sotomayor (1990)

Affirmative Action in College Admission and School Choice:

- Abdulkadiroğlu and Sönmez (2003)
- Abdulkadiroğlu (2005)

Literature

Three-sided matchings:

- Alkan (1987): nonexistence of stable threesome matchings
- Danilov (2003): existence of stable matchings in some three-sided systems (acyclic preferences)
- Boros et al. (2004): stable matchings in three-sided systems with cyclic preferences

Setting

The targeted college admission problem is defined by the following components:

- A finite set of students $I = \{i_1, \ldots, i_n\}$
- A finite set of schools $S = \{s_1, \ldots, s_m\}$
- A finite set of firms $F = \{f_1, \ldots, f_k\}$
- Each school $s \in S$ has capacity q_s, with vector $q_S = (q_{s_1}, \ldots, q_{s_m})$ representing all school capacities
- Each firm $f \in F$ has capacity q_f, with vector $q_F = (q_{f_1}, \ldots, q_{f_k})$ representing all firm capacities
- Each student $i \in I$ has ordinal preferences P_i over $S \times F$ (school-firm pairs)

Setting

- Each school $s \in S$ has an ordinal priority P_s over the power set of students 2^I. The priority is assumed to be responsive, meaning that the school's preferences over groups of students are consistent with its preferences over individual students.
- Each firm $f \in F$ has an ordinal preference P_f over the set $2^{S \times 2^I}$. The preference is also assumed to be responsive.
- The capacity vector $q = (q_S, q_F)$ combines the capacities of schools and firms.
- The preference profile $P = (P_I, P_S, P_F)$ represents the preferences of all students, schools, and firms.

The tuple (I, S, F, q, P) defines the *targeted college admission problem*

Matching and Mechanism

- A **matching** μ is a function
  - Assigns each student to at most one school-firm pair
  - Satisfies $|\mu(s)| \leq q_s$ for all schools
  - Satisfies $|\mu(f)| \leq q_f$ for all firms
- $\mu(i)$: student i's assignment ($\emptyset$ if unmatched)
- $\mu(s)$: students assigned to school s
- $\mu(f)$: student-school pairs assigned to firm f
- A **mechanism** ϕ is a function that to each problem finds a matching

Key requirements:

- **Stability**: No blocking by students/firms/schools
- **Respecting Reserves:** No acceptable student is left unmatched while reserves are not filled

Properties

We identify two key properties

- Preferences are called **homogeneous** if they follow the structure: $P_{f|s} = P_s$, meaning that firms rank schools and, within each school, replicate their preferences over students. Preferences may additionally be **sparse** - firms may reject some students, but the ranking order within schools remains unchanged
- A capacity is **fixed** if a firm and a school pre-negotiate the number of slots allocated to students from that school. Otherwise, the capacity is **flexible**: for instance, a firm needs to hire 10 students, but their distribution across programs is unspecified in advance

Result 1. Impossibility of Stable Matching (Flexible Capacity & Heterogeneous Preferences)

Setup

$|I| = |S| = |F| = 3,\ q_{s_i} = q_{f_i} = 1\ \forall i \in \{1, 2, 3\}$
Preferences follow *lexicographic relaxation of cyclic preferences*

Firms' Preferences (F)	**Students' Preferences (I)**	**Schools' Priorities (S)**
$f_{1,3} : (s_1, i_i) \succ (s_2, i_j) \succ (s_3, i_k)$	$i_{2,3} : (f_1, s_i) \succ (f_2, s_j) \succ (f_3, s_k)$	$s_{1,3} : (i_1, \cdot) \succ (i_2, \cdot) \succ (i_3, \cdot)$
$f_2 : (s_2, i_i) \succ (s_3, i_j) \succ (s_1, i_k)$	$i_1 : (f_2, s_i) \succ (f_3, s_j) \succ (f_1, s_k)$	$s_2 : (i_2, \cdot) \succ (i_3, \cdot) \succ (i_1, \cdot)$
$f : (s_i, i_2) \succ (s_i, i_1) \succ (s_i, i_3)$	$i : (f_i, s_2) \succ (f_i, s_1) \succ (f_i, s_3)$	

Key Features

- Cyclic preferences create unavoidable blocking pairs
- Flexible capacities prevent stable allocations
- Heterogeneity breaks possible symmetries

Result 2. Stable Matching under Fixed Capacities

Key Assumptions

- **Partnership structure**:
  - Either: 1 school $\leftrightarrow$ 1 firm (firms may partner with multiple schools)
  - Or: Treat each school-firm pair as distinct "sub-school"with fixed capacity
- **Fixed capacities**: Pre-negotiated quotas between schools and firms

Under these conditions, a **stable matching exists** and can be found via an adapted Gale-Shapley algorithm.

Proof Sketch

The algorithm proceeds as follows:

1. Students apply to top-choice (s, f) pair
2. Each school-firm pair (s, f):
   - Rank applicants by school's P_s
   - Accept top $q_{s,f}$ students
   - Reject others
3. Rejected students apply to next preference. The process repeats until no further rejections occur

Result 3. Special Case: Flexible Capacities

Identical School Rankings

When:

- Schools rank students identically (e.g., via unified exam)

Dictator Algorithm

- Students processed in exam score order (best to worst)
- Each selects top available school-firm pair
- Yields stable matching by construction

In progress ...

When capacities are flexible, we hypothesize that stability can be achieved under mild preference restrictions - notably, homogeneous preferences across firms. To prove this, we employ **matching-with-contracts theory**, extending the model to accommodate multi-dimensional constraints while preserving stability conditions.

Conclusion

Thank you for your attention!

Questions? Discussion?