The Design of School Choice Clearinghouses: NYC and Boston

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Today's plan

NYC Schools:

- design of a centralized high school allocation procedure, implemented in 2003-04, for students entering Sept. '04

Boston Schools:

- redesign of a school allocation procedure, implemented for students entering grades K, 6, and 9 in September 2006.

Economists As Engineers

- In recent years, game theorists have become usefully involved in the design of markets. E.g.
  - Labor markets (doctors and other health professions)
  - Auctions
  - Kidney Exchange and other organ transplants
  - School matching (NYC, Boston)

- A certain amount of humility is called for: these things consist of complex, overlapping institutions, and there are often subtle social and political goals.
  - The role of the economist is to help make sure that whatever is being done is being done efficiently, in a way that makes participation safe and simple.

A general market design framework to keep in mind:

- To achieve efficient outcomes, marketplaces need make markets sufficiently
  - **Thick**
    - Enough potential transactions available at one time
  - **Uncongested**
    - Enough time for offers to be made, accepted, rejected, transactions carried out…
  - **Safe**
    - Safe to participate, and to reveal relevant preferences

The **Old** New York City High School Choice System

Decentralized application and admission

- ***congested***: left 30,000 kids each year to be administratively assigned (while about 17,000 got multiple offers)
  - Waiting lists run by mail
  - Gaming by high schools; withholding of capacity
  - Unsafe for families to truthfully reveal preferences

- The new mechanism is a **centralized clearinghouse** that produces **stable matches**.
  - We now have enough data to begin to say something about how it is working.

Old NYC High School Match

(Abdulkadiroglu, Pathak, Roth 2005, 2009)

Overview:

- Over 90,000 students enter high school each year in NYC
- Each was invited to submit list of up to 5 choices
- Each student's choice list distributed to high schools on list, who independently make offers
- Only approx. 40% of students receive initial offers, the rest put on waiting lists—3 rounds to move waiting lists…
- Approx. **30,000** students assigned to schools not on their choice list.

Issues in old (2002) system

- Schools see rank orders
  - Some schools take students' rankings into account & consider only those that rank their school first
  - So a student whose second choice school will only consider those who list it first has a difficult choice, especially if the true first choice is hard to get into
- Students need to strategize (not safe to reveal true preferences):
  - The 2002-03 *Directory of the NYC Public High Schools* : "determine what your competition is for a seat in this program"

Issues in old (2002) system

- Principals concealing capacities

  Deputy Chancellor (NYT 11/19/04):

  "Before you might have had a situation where a school was going to take 100 new children for 9th grade, they might have declared only 40 seats and then placed the other 60 children outside the process."

Issues in old (2002) system

1. “5” choices
   - 52% of kids rank five choices→ constraint binding
   - Congestion: Not enough offers and acceptances could be made to clear the market
   - Only about 50,000 out of 90,000 received offers initially.
   - About 30,000 assigned outside of their choice
2. Multiple offers—are they good for some kids?
   - about 17,000 received multiple offers
   - Students may need time to make up their mind, especially if we want to keep desirable students from going to private school
   - Only 4% don’t take first offer in 02-03 at the cost of over 30,000 kids not getting any offer

NYC School System

The high schools are organized to achieve a number of social goals

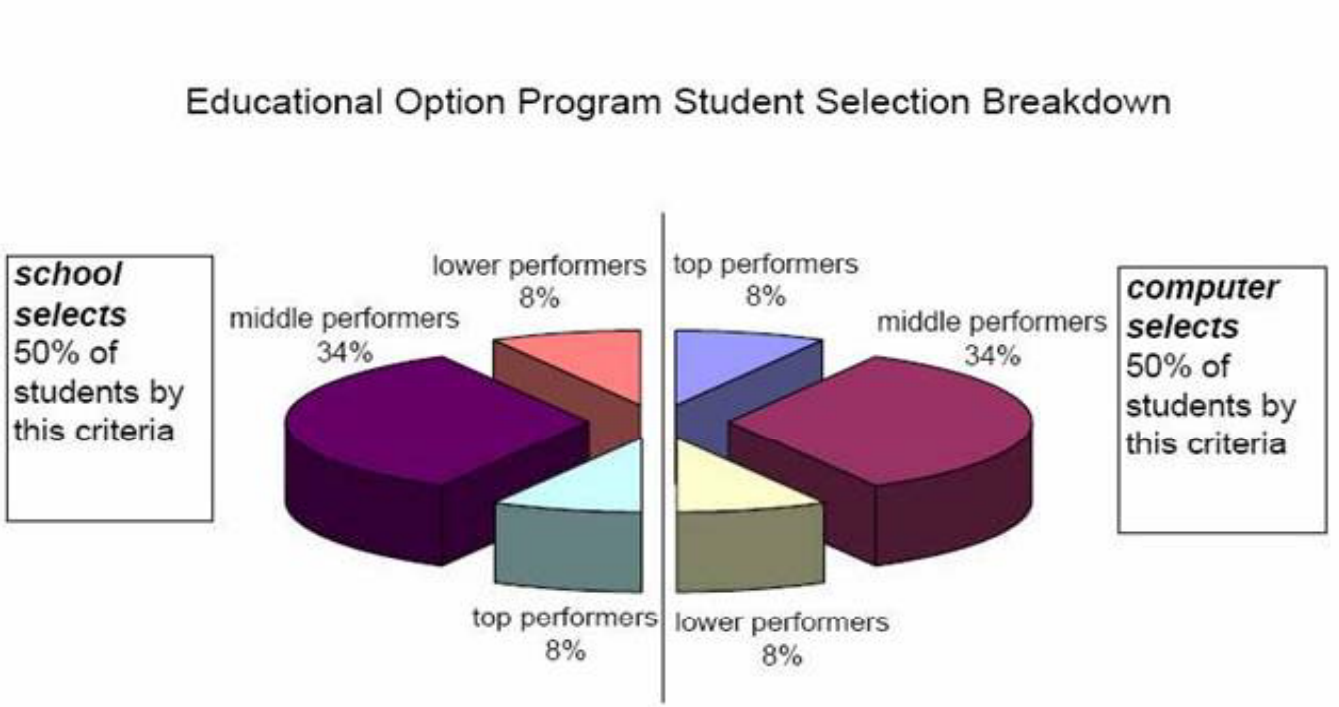
	# of Programs
Unscreened (no preferences)	86
Screened & Auditioned	188
Specialized HS	6
Educational Option (no preferences for half seats)	252

- In Brooklyn, Bronx, Manhattan, and Staten Island
- Unscreened capacity largest
- Roughly 25,000 kids take Specialized High School Test

NYC School System

Ed-Opt Schools – based on city or state standardized reading test score grade 7

(preferences for only half the seats)



Are NYC Schools a *two-sided* market?

i.e. are the actors just families, or are the schools also strategic actors?

Two facts:

1. Schools conceal capacities

   i.e. principals act on instabilities

2. Principals of different EdOpt schools have different preferences even over the students with the lowest scores, some preferring higher scores, some preferring better attendance records

A (too) simple basic model

- Schools = $\{s_1,..., s_n\}$ Children = $\{c_1,..., c_p\}$
  # positions $q_1,...,q_n$

- PREFERENCES (complete and transitive):
  $P(s_i) = c_3, c_2, ... s_i \quad [c_3\ P(s_i)\ c_2]$ (not all strict)
  $P(c_j) = s_2, s_4, ... c_j ...$

- An OUTCOME of the game is a *MATCHING*:
  μ: $S \cup C \rightarrow S \cup C$
  such that $\mu(s) = c$ iff $\mu(c) = s$, and for all s and c
  $|\mu(s)| \leq q_s$, and
  either $\mu(c)$ is in S or $\mu(c) = c$.

Stable matchings

A matching μ is

- *BLOCKED BY AN INDIVIDUAL* k if k prefers being single to being matched with $\mu(k)$, i.e. $k >_k \mu(k)$

  ($\mu(k)$ is *unacceptable*).
- *BLOCKED BY A PAIR OF AGENTS* (s,c) if they each prefer each other to μ, i.e.
- $c >_s \mu(s)$ and $s >_c \mu(c)$
- A matching μ is *STABLE* if it isn't blocked by any individual or pair of agents.

Basic Deferred Acceptance (Gale and Shapley 1962)

- Step 0.0: students and schools **privately** submit preferences
- Step 0.1: arbitrarily break all ties in preferences (via a lottery)
- Step 1: Each student "applies" to her first choice. Each school tentatively assigns its seats to its applicants one at a time in their priority order. Any remaining applicants are rejected.

  …
- Step k: Each student who was rejected in the previous step applies to her next choice if one remains. Each school considers the students it has been holding together with its new applicants and tentatively assigns its seats to these students one at a time in priority order. Any remaining applicants are rejected.
- The algorithm terminates when no student application is rejected, and each student is assigned her final tentative assignment.

Theorems (for the simple model)

1. The outcome that results from the student proposing deferred acceptance algorithm is stable, and (when preferences are strict) student optimal among the set of stable matchings (Gale and Shapley, ‘62)
2. The student proposing deferred acceptance algorithm makes it a **dominant strategy for students to state their true preferences**. (Dubins and Friedman 1981, Roth, 1982, 1985)
    1. This means it is safe for families to submit their true preferences: e.g. even if they don’t get their true first choice, it won’t hurt their chance of getting their second choice.

The New (Multi-Round) Deferred Acceptance Algorithm in NYC

- We advised, *sometimes convinced*, the NYC Department of Education
- Software and the online application process has been developed by a software consulting company
- The new design adapted to the regulations and customs of NYC schools

Some (Imperfectly Resolved) Design issues

(It’s important to choose your fights:)

Redesign: 12 choice constraint

- DOE thought this would be sufficient, we encouraged more

New Process: Average Number of Rankings Each Round

	Ranking											
Round	1	2	3	4	5	6	7	8	9	10	11	12
Round 1	91,286	84,554	79,646	73,398	66,724	59,911	53,466	47,939	42,684	37,897	31,934	22,629
	100%	93%	87%	80%	73%	66%	59%	53%	47%	42%	35%	25%
Round 2	87,810	81,234	76,470	70,529	64,224	57,803	51,684	46,293	41,071	35,940	29,211	18,323
	100%	93%	87%	80%	73%	66%	59%	53%	47%	41%	33%	21%
Round 3	8,672	8,139	7,671	7,025	6,310	5,668	5,032	4,568	4,187	3,882	3,562	3,194
	100%	94%	88%	81%	73%	65%	58%	53%	48%	45%	41%	37%

3,476 Specialized High Schools Students
91,286 Total students

Partial incentive compatibility for constrained choosers

- **Proposition** (Haeringer and Klijn, Lemma 8.1.): In the student-proposing deferred acceptance mechanism where a student may only rank k schools,
  - if a student prefers fewer than k schools, then she can do no better than submitting her true rank order list,
  - if a student prefers more than k schools, then she can do no better than employing a strategy which selects k schools among the set of schools she prefers to being unassigned and ranking them according to her true preference ordering.

Multiple Rounds

- Historical/legal constraints: difficult to change specialized high school process/cannot force a student who gets an offer from a specialized high school to take it
  - Round 1: run algorithm with all kids in round 1, not just specialized students; only inform specialized students
    - Unstable if a specialized kid does not get a spot at a non-specialized high school when considered at round 1, but could get that spot in round 2
  - May not a big problem if students with specialized high schools offers are ranked high in all schools' preferences, and/or if most students prefer to go to a specialized school
    - In old system, ~70% of kids with an offer from a specialized program took it, 10% of kids went to private school and 14% kids went to either their first or second choice from the other schools.
      - Potential instabilities among these 14% will not be large if they are also considered highly desirable by the non-specialized schools they apply to.
      - …(however, we do observe several hundred children who decline a specialized school for their not-top-choice mainstream school…)

Multiple Rounds

- Need to assign unmatched kids; unlike medical labor markets everyone must go to school

  → Round 3

  - "No time" for high schools to re-rank students in round 3, so no new high school preferences expressed
    - Another place where random preferences are used for some screened schools.

Lotteries: Equity and perception

How should we rank students in schools that do not have preferences over students?

- For unscreened schools and in round 3
- A single lottery that applies to each school?
- Or a different lottery for every such school?

- A single lottery avoids instabilities that are due to randomness

Lotteries, cont.:
Explaining and defending

NYC DOE argued that a more equitable approach would be to draw a new random order for each school:

Here are some of the emails we got on the subject:

- "I believe that the equitable approach is for a child to have a new chance... This might result in both students getting their second choices, the fact is that each child had a chance. If we use only one random number, and I had the bad luck to be the last student in line this would be repeated 12 times and I never get a chance. I do not know how we could explain that to a student and parent."

- "When I answered questions about this at training sessions, (It did come up!) people reacted that the only fair approach was to do multiple runs."

Lottery, cont.

- Ran simulations. These simulations showed that the efficiency loss due to multiple draws was considerable; and increases with correlation in students' preferences.

- We pushed hard on this one, but it looked like the decision was going to go against us. But we did get the NYC DOE to agree to run the algorithm both ways and compare the results on the submitted preference lists.

- They agreed, and eventually decided on a **single rank order** after seeing welfare gains on the submitted preferences

Tie-breaking in Student-Proposing Deferred Acceptance in the First Round 2003-04

Choice	Number Ranking	Single Tie-Breaking (250 draws)	Multiple Tie-Breaking (250 draws)
1	5,797 (6.7%)	21,038 (24.82%)	19,783 (23.34%)
2	4,315 (5.0%)	10,686 (12.61%)	10,831 (12.78%)
3	5,643 (6.6%)	8,031 (9.48%)	8,525 (10.06%)
4	6,158 (7.2%)	6,238 (7.36%)	6,633 (7.83%)
5	6,354 (7.4%)	4,857 (5.73%)	5,108 (6.03%)
6	6,068 (7.1%)	3,586 (4.23%)	3,861 (4.56%)
7	5,215 (6.1%)	2,721 (3.21%)	2,935 (3.46%)
8	4,971 (5.8%)	2,030 (2.40%)	2,141 (2.53%)
9	4,505 (5.2%)	1,550 (1.83%)	1,617 (1.91%)
10	5,736 (6.7%)	1,232 (1.45%)	1,253 (1.48%)
11	9,048 (10.5%)	1,016 (1.20%)	894 (1.05%)
12	22,239 (25.8%)	810 (0.96%)	372 (0.44%)
unassigned	-	20,952 (24.72%)	20,795 (24.54%)

No stochastic dominance

First Year of Operation

- Over 70,000 students were matched to one of their choice schools
  - an increase of more than 20,000 students compared to the previous year match
- An additional 7,600 students matched to a school of their choice in the third round
- 3,000 students did not receive any school they chose
  - 30,000 did not receive a choice school in the previous year

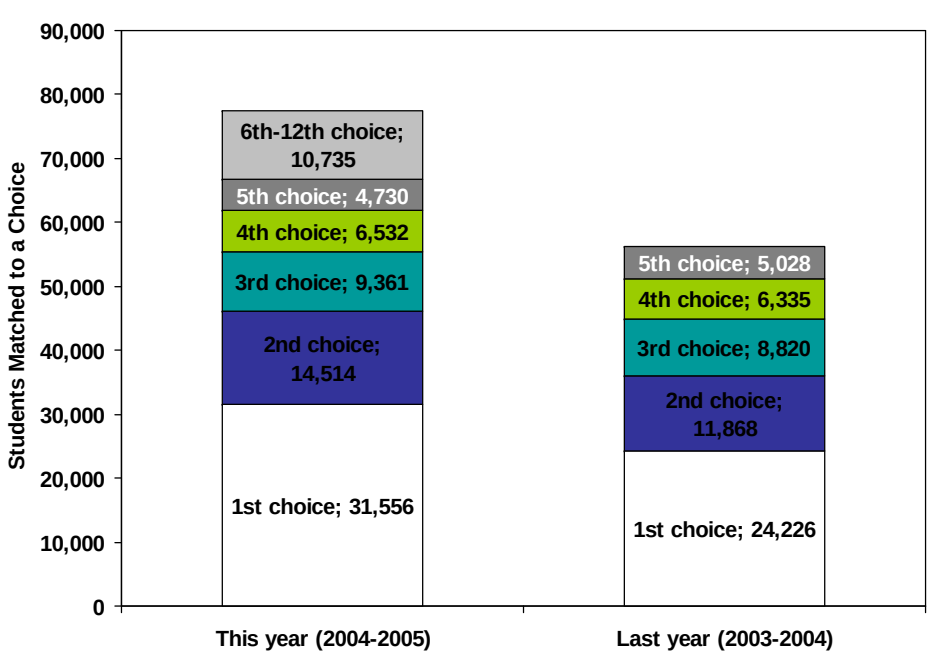
First year, cont

Much of the success is due to

- relieving congestion
  - Allowing many offers and acceptances to be made, instead of only 3
  - giving each student a single offer rather than multiple offers to some students
- allowing students to rank 12 instead of 5 choices
- But more than that is going on…

First year results:
More students get top choices
(this is a chart prepared by NYCDOE, comparing academic years 04-05 and 03-04)

Number of students matched at the end of Round II



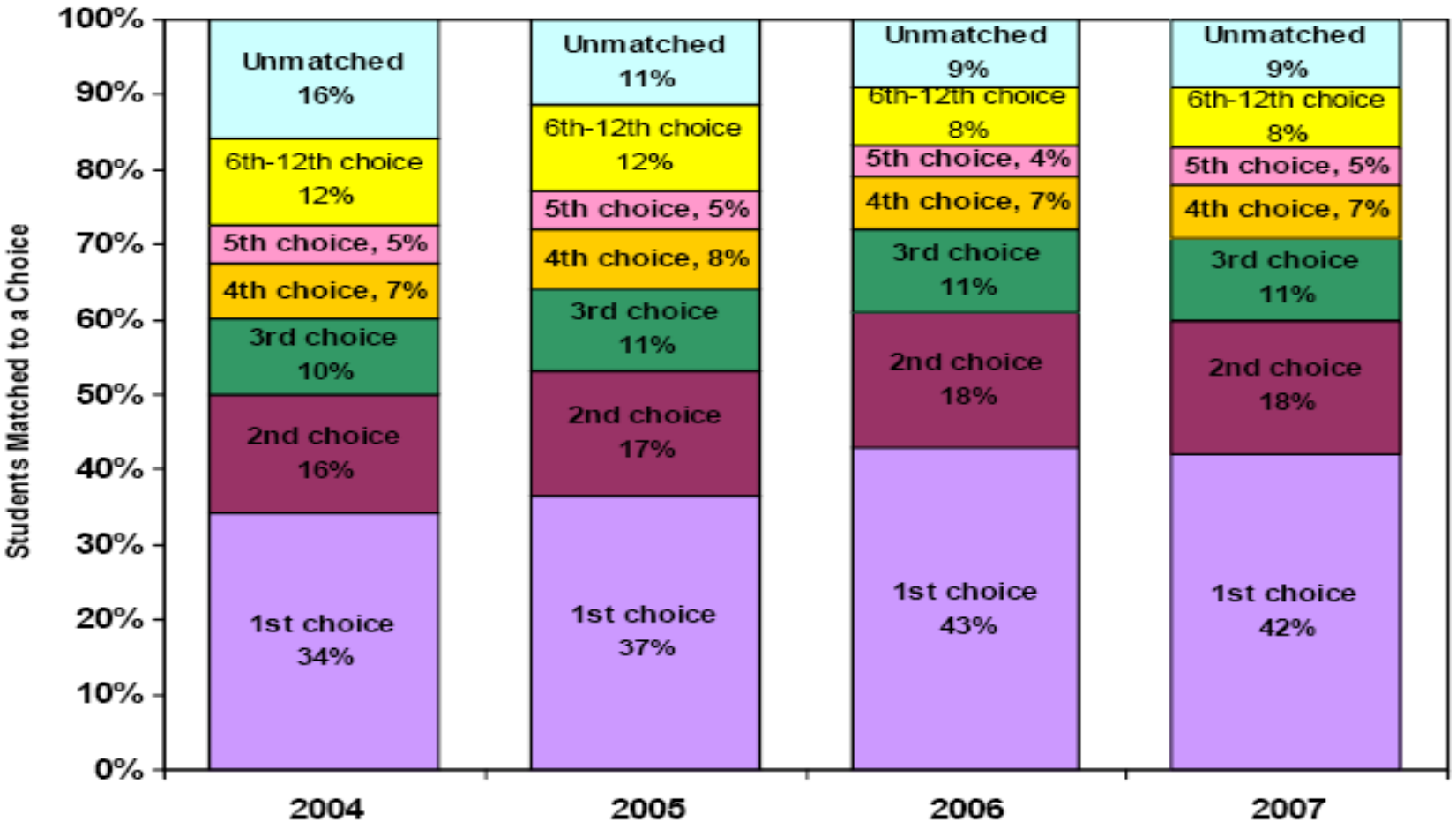
- **21,000** more students matched to a school of their choice
- **7,000** more students receiving their first choice
- **10,000** more students receiving one of their top 5 choices

The results show continued improvement from year to year

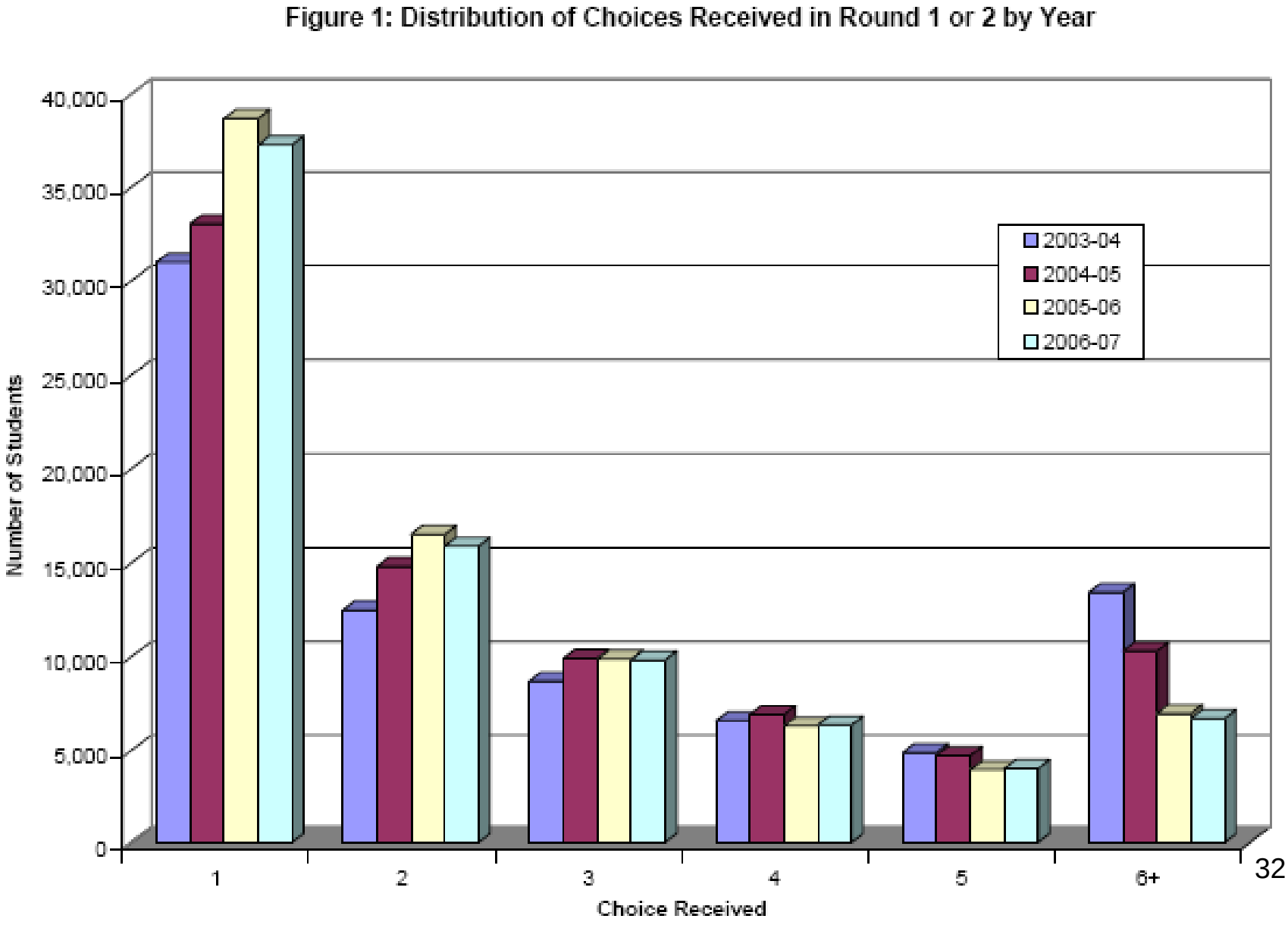
- Even though no further changes have been made in the algorithm…

First 4 years: March 23, 2007
Results at end of Round 2

(Schools have learned to change their reporting of capacities)



What happened in NYC after the algorithm was introduced in 2003-04?



What is going on?

- It appears that schools are no longer withholding capacity.
- Some high schools (even top high schools like Townsend Harris) have learned to rank substantially more than their capacity, because many of their admitted students go elsewhere (e.g. admissions to Townsend Harris provides good leverage for bargaining over financial aid with private schools).
- This allows more students to be accepted to their top choice, second choice, etc. during the formal match process.

Immediate Issue: Appeals

- Just over 5,100 students appealed in the first year
- Around 2,600 appeals were granted
- About 300 of the appeals were from students who received their first choice
- Designing an efficient appeals process—top trading cycles?
  - A dry run in year 2 showed that many students could be granted appeals without modifying school capacities.
    - One 40-student cycle…
- Lately (2006-08) TTC was used
  - One 26 student cycle

The old appeals system

- Administrative, child by child decisions…
- Changes in school capacities; i.e. schools were filled to over capacity…
- New approach: centralized clearinghouse for appeals…
  - Allows more appeals to be granted without violating the capacity constraints of schools.

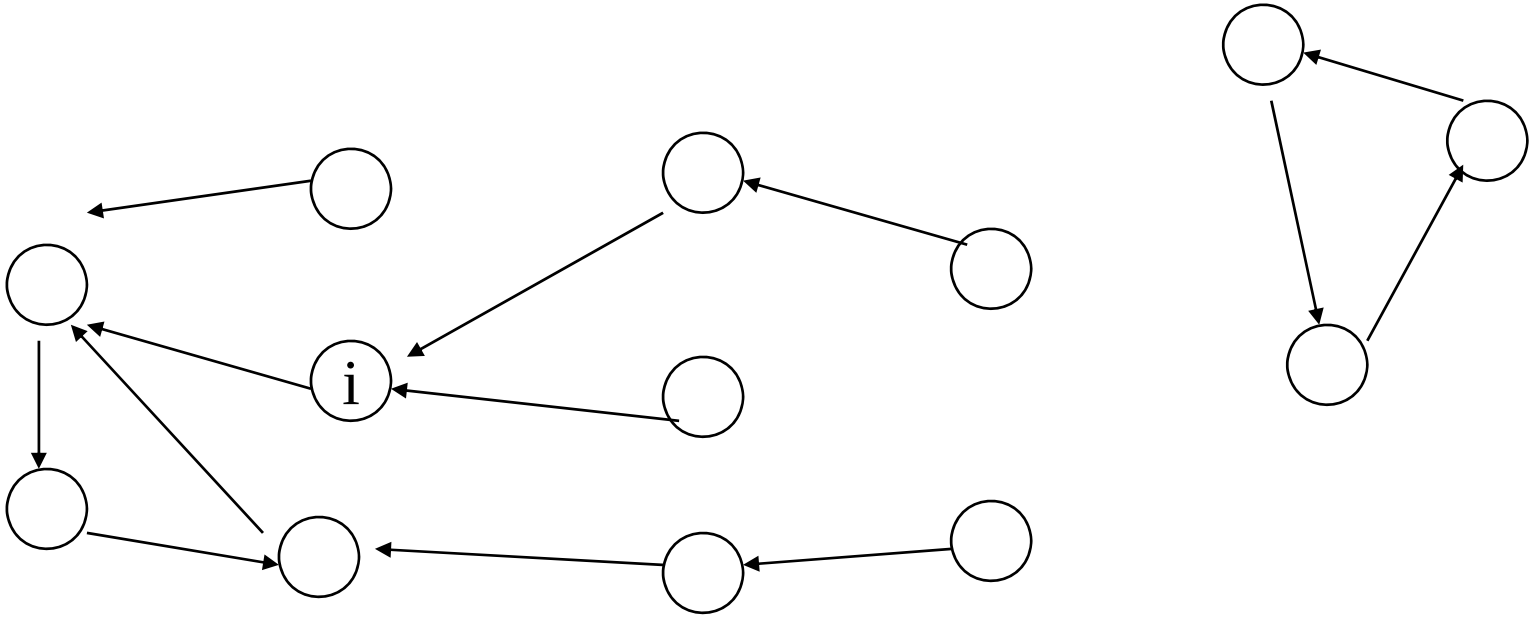
A slightly too simple 1-sided model:

- n students each with a currently assigned school place.
- Each student has preferences over schools.
- Gale's top trading cycles (TTC) algorithm: Each student points to her most preferred school (and each school place points to its current occupant). There is at least one cycle in the resulting directed graph (a cycle may consist of an agent pointing to her own place.) In each such cycle, the corresponding trades are carried out and these students are removed from the market together with their new assignments.
- The process continues (with each student pointing to her most preferred place that remains available) until no students and places remain.

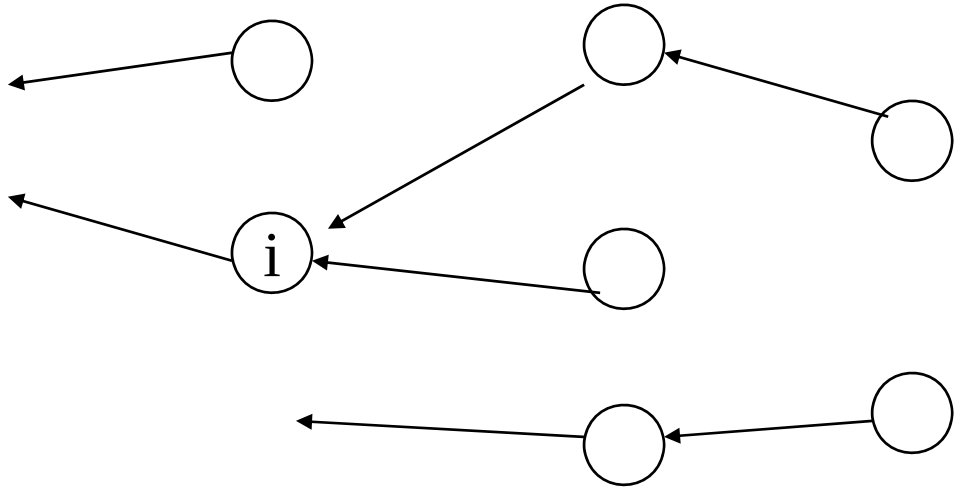
Theorem: if the top trading cycle procedure is used, it is a dominant strategy for every agent to state his true preferences.

- So this is a procedure that makes it safe and simple for students to participate
- The *idea* of the proof is simple, but it takes some work to make precise.

Cycles and chains



The cycles leave the system (regardless of where i points), but i's choice set (the chains pointing to i) remains, and can only grow



NYC--summary

- **Waiting lists** are a congested allocation mechanism—congestion leads to instabilities and strategic play.
- NYC high schools—only recently re-centralized—are active players in the system.
- Information about the mechanism is part of the mechanism.
  - Information dissemination within and about the mechanism is part of the design
- New mechanisms can have both immediate and gradual effects.
- Appeals may be a big deal
  - when the preferences are those of 13 and 14 year olds
  - When a nontrivial percentage of assigned places aren't taken up because of withdrawals from the public school system (moves, and private schools)
- Open question:
  - How best to design appeals, in light of changing preferences of 13 year olds, mobile school population, but to continue to give good incentives in the main match?

Matching mechanisms more generally

- While there are some general principles, local details matter.
- Different kinds of matching problems need different kinds of clearinghouses.

U.S. Medical Labor Market Clearinghouses

NRMP / SMS:

Medical Residencies in the U.S. (NRMP) (1952)
Abdominal Transplant Surgery (2005)
Child & Adolescent Psychiatry (1995)
Colon & Rectal Surgery (1984)
Combined Musculoskeletal Matching Program (CMMP)
- Hand Surgery (1990)

Medical Specialties Matching Program (MSMP)
- Cardiovascular Disease (1986)
- Gastroenterology (1986-1999; rejoined in 2006)
- Hematology (2006)
- Hematology/Oncology (2006)
- Infectious Disease (1986-1990; rejoined in 1994)
- Oncology (2006)
- Pulmonary and Critical Medicine (1986)
- Rheumatology (2005)

Minimally Invasive and Gastrointestinal Surgery (2003)
Obstetrics/Gynecology
- Reproductive Endocrinology (1991)
- Gynecologic Oncology (1993)
- Maternal-Fetal Medicine (1994)
- Female Pelvic Medicine & Reconstructive Surgery (2001)

Ophthalmic Plastic & Reconstructive Surgery (1991)
Pediatric Cardiology (1999)
Pediatric Critical Care Medicine (2000)
Pediatric Emergency Medicine (1994)
Pediatric Hematology/Oncology (2001)
Pediatric Rheumatology (2004)
Pediatric Surgery (1992)
Primary Care Sports Medicine (1994)
Radiology
- Interventional Radiology (2002)
- Neuroradiology (2001)
- Pediatric Radiology (2003)

Surgical Critical Care (2004)
Thoracic Surgery (1988)
Vascular Surgery (1988)

Postdoctoral Dental Residencies in the United States
- Oral and Maxillofacial Surgery (1985)
- General Practice Residency (1986)
- Advanced Education in General Dentistry (1986)
- Pediatric Dentistry (1989)
- Orthodontics (1996)

Psychology Internships in the U.S. and CA (1999)
Neuropsychology Residencies in the U.S. & CA (2001)
Osteopathic Internships in the U.S. (before 1995)
Pharmacy Practice Residencies in the U.S. (1994)
Articling Positions with Law Firms in Alberta, CA(1993)
Medical Residencies in CA (CaRMS) (before 1970)

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Matching students to schools: making it **safe to reveal preferences**

- Redesign of the Boston Public Schools choice mechanism
  - The old centralized assignment system tried to give as many people as possible their first choice: this made it unsafe to reveal true preferences.
    - Some parents acted on these strategic incentives, others did not (and suffered).
  - Replace the existing mechanism in 2006 (for entry into grades K, 6, 9) with a clearinghouse that lets parents safely list their true preferences .

Changing the **Boston** school match: A system with incentive problems (Abdulkadiroglu, Pathak, Roth and Sonmez)

- Students have priorities at schools set by central school system
- Students entering grades K, 6, and 9 submit (strict) preferences over schools.
- In priority order, everyone who can be assigned to his first choice is. Then 2nd choices, etc.
  - Priorities: sibling, walk zone, random tie-breaker
  - There are lots of people in each priority class (non-strict preferences)
- Unlike the case of NYC, in Boston, there weren't apparent problems with the system.

Incentives

- First choices are important: if you don't get your first choice, you might drop far down list (and your priority status may be lost: all 2nd choices are lower priority than all 1st...).
- Gaming of preferences?—the vast majority are assigned to their first choice
- Chen and Sonmez (2005): experimental evidence on preference manipulation under Boston mechanism

Advice from the West Zone Parent's Group: Introductory meeting minutes, 10/27/03

"One school choice strategy is to find a school you like that is undersubscribed and put it as a top choice, OR, find a school that you like that is popular and put it as a first choice and find a school that is less popular for a ''safe'' second choice."

Advice from Boston Public Schools

- BPS School Brochure (2004, p3)
  - “For a better chance of your `first choice’ school… consider choosing less popular schools.”

- Cambridge, MA:
  - “Nowadays, parents who might prefer Graham and Parks sometimes don’t choose it at all for fear of wasting their top choice.”
- St. Petersburg, FL:
  - “Make a realistic, informed selection as your first choice. It’s the cleanest shot you will get at a school, but if you aim to high you might miss. If the random computer rejects your first choice, your chances of getting your second choice are diminished… you can fall even farther behind as you get bumped down.”
- Similar stories in Denver, Seattle, Minneapolis

Detecting mistakes

- A school is **overdemanded** if the number of students who rank that school as their first choice is greater than the number of seats at the school.

- In the Boston mechanism, no one who lists an overdemanded school as a second choice will be assigned to it by the Boston mechanism, and listing an overdemanded school as a second choice can only reduce the probability of receiving schools ranked lower.

But not everyone knows

- Of the 15,135 students on whom we concentrate our analysis, 19% (2910) listed two overdemanded schools as their top two choices, and about 27% (782) of these ended up unassigned.

Costs of incentive problems

- Many preferences are “gamed,” and hence we don’t have the information needed to produce efficient allocations (and don’t know how many are really getting their first choice, etc.)
  - There are real costs to strategic behavior borne by parents—e.g. West Zone Parents group
  - BPS can’t do effective planning for changes.
- Those who don’t play strategically get hurt

Parent comments at public hearing

- “I find the current system of maximizing first choice to be insidious and destructive. … My wife and I take dozens of phone calls around choice time … and we have to tell people that it doesn’t make sense to choose our children’s elementary school. And that is absurd. And the people who get that advice get very angry. … So I have to say, don’t make your first choice your first choice. That’s enraging.

  It angers the parents who figure it out because they are told not to make their first choice the first one. And it hurts those who don’t figure it out because they choose a popular school and end up in the administrative assignment bin.”

Design issues for Boston Schools

- Is the market one-sided or two?
  - Unlike NYC, no gaming by schools (Boston school system has been centralized for a long time)
  - Are priorities intended to facilitate parent choice, or do they represent something important to the school system?
  - If one sided, “stable” matches wouldn’t be Pareto optimal: e.g. it would be Pareto improving to allow students to trade priorities—top trading cycles.
    - Other Pareto improvements may be possible
    - “Pareto” optimality involves decisions about who are the players…

Recommendations for BPS

- Switch to a strategy-proof mechanism.
- *We suggested two* choices:
  - Student Proposing Deferred Acceptance Algorithm (as in NYC)
    - Would produce “stable” assignments—no student is not assigned to a school he/she prefers unless that school is full to capacity with higher priority students
  - Top Trading Cycles
    - Would produce a Pareto efficient match.

Student Proposing Deferred Acceptance

- **Stable**: no student who loses a seat to a lower priority student and receives a less-preferred assignment
- **Incentives**: makes truthful representation a dominant strategy for each student
- Selects the stable matching that is preferred to any other stable matching by all students—no “justified envy” (when preferences are strict)

Top Trading Cycles

- If welfare considerations apply only to students, tension between stability and Pareto efficiency
- Might be possible to assign students to schools they prefer by allowing them to trade their priority at one school with a student who has priority at a school they prefer
- Students exchange their seats with each other based on their priorities
- Theorems:
  - makes truthful representation a dominant strategy for each student
  - Pareto efficient

Top trading cycles: psuedo-market

- Within a computer, at each school, all students are placed in a line based on their priority and random number.
  - Where they are placed in line **does not** depend on how they have ranked the school.

- Each student at the front of each school points to the school they want the most. A cycle must form where student 1 points to student 2 who points to … student N who points to student 1.

- Each student in a cycle is assigned to the school that they point to and they are removed from all of the lines they belong to.

- If a school has no more capacity to assign, then the lines at those schools no longer matter.

- The process repeats itself until there is no more capacity to assign, or every student has been assigned as part of a cycle.

The choice? Boston School Committee

- “Would anyone mind if two students who each preferred the schools in the other student’s walk zone were to trade their priorities and enroll in those schools?”
- YES: transportation costs, externalities when parents walk child to school, lawsuits when a child is excluded from a school while another with lower priority is admitted
  - DAA
- NO: efficiency of allocation is paramount
  - TTC

Explaining and defending

- In the final weeks before a decision was made, our BPS colleagues told us that their main concern was their ability to explain and defend the choice of (which) new algorithm to the public and to Boston politicians.

- We came up with some simpler descriptions of TTC in this process
  - i.e. lines in front of schools in priority order

Explaining and Defending: DA “FAQ”

Q: Why didn’t my child get assigned to his first choice, school X?
A: School X was filled with students who applied to it and who had a higher priority.

Q: Why did my child, who ranked school X first, not get assigned there, when some other child who ranked school X second did?

A: The other child had a higher priority at school X than your child did, and school X became that other child’s first choice when the school that he preferred became full. (Remember that this assignment procedure allows all children to rank schools in their true order of preference, without risk that this will give them a worse assignment than they might otherwise get.)

TTC “FAQ”

Q: Why didn’t my child get assigned to his first choice, school X?
A: School X was filled before your child’s priority (to be admitted to school X or to trade with someone who had priority at school X) was reached.

Q: Why did a child with lower priority at school X than my child get admitted to school X when my child did not?

A: Your child was not admitted to school X because there were more children with higher priority than yours than the school could accommodate. One of these children traded his priority with the child who had lower priority at school X.

The recommendation to the School Committee: School Superintendent Payzant Memorandum on 5/25/05 states:

"The most compelling argument for moving to a new algorithm is to enable families to list their true choices of schools without jeopardizing their chances of being assigned to any school by doing so."

"The system will be more fair since those who cannot strategize will not be penalized."

Fairness rationale for strategy-proof mechanisms

Further benefits of a strategy proof mechanism

"A resulting benefit for the system is that this alternative algorithm would provide the district with more credible data about school choices, or parent "demand" for particular schools. Using the current assignment algorithm, we cannot make assumptions about where families truly wish to enroll based on the choices they make, knowing many of those choices are strategic rather than reflective of actual preference."

BPS's Recommendation: Deferred Acceptance

- The Gale-Shapley *Deferred Acceptance Algorithm* will best serve Boston families, as a centralized procedure by which seats are assigned to students based on both student preferences and their sibling, walk zone and random number priorities.
- Students will receive their highest choice among their school choices for which they have high enough priority to be assigned. The final assignment has the property that a student is not assigned to a school that he would prefer **only** if every student who is assigned to that school has a higher priority at that school.
- Regardless of what other students do, this assignment procedure allows all students to rank schools in their true order of preference, without risk that this will give them a worse assignment than they might otherwise get.

Why not TTC?

“Another algorithm we have considered, Top Trading Cycles, presents the opportunity for the priority for one student at a given school to be "traded" for the priority of a student at another school, assuming each student has listed the other's school as a higher choice than the one to which he/she would have been assigned. **There may be advantages to this approach, particularly if two lesser choices can be "traded" for two higher choices. It may be argued, however, that certain priorities -- e.g., sibling priority -- apply only to students for particular schools and should not be traded away.**

Moreover, Top Trading Cycles is less transparent-- and therefore more difficult to explain to parents -- because of the trading feature executed by the algorithm, which may perpetuate the need or perceived need to "game the system."

The Vote

- The Boston School Committee decided to adopt a deferred acceptance algorithm
- It was implemented for use starting January 2006, for assignment of students to schools in September, 2006.

How is it doing?

- Anecdotal evidence of fewer complaints
- People are more expressive with their choices
  - Only 15% of families ranked 4 or more schools, now 28% do (at grade 6)
- Relatively small decrease in the number getting top choice: 74% to 70% (grade 6) but these are more likely true choices
- Deferred Acceptance procedure is close to efficient (less than 5% difference) – contrast with NYC

Boston: summary remarks

- Transparency is a virtue in a mechanism
  - Both when it is used and for it to be adopted
  - New mechanisms have to be explained and defended
- Strategy proofness can be understood in terms of fairness/equal access
- Efficient allocation based on personal preferences requires the preferences to be known

Belgian Schools will have special needs

- Some of their problems will resemble those of NYC and Boston
- But careful attention will need to be paid to the particular needs of Belgian schools.
- There are people in Belgium who knows the latest details of market design and who understands the local context.

School Assignment in the US

- Many aspects of school admissions involve complex trade-offs which economists are just beginning to study
  - How should schools and classrooms be organized?
  - How important are teachers, peers, resources educational backgrounds for student achievement?
  - How would changing walk zone boundaries affect where people live and the price of housing?
  - Do choice and competition benefit students?

- Our perspective is **practical** in nature: regardless of these other policies, students need to be assigned to schools, so the authorities should want to use the preference efficiently, and get decisions to families promptly in an uncongested way, and that's where market design can help.

Market design for school choice

- Thickness
  - In both NYC the market became thicker once schools no longer withheld some places.
- Congestion
  - In NYC, congestion was the most visible problem of the old system, which let to problems of safe participation (and thickness)
  - In Boston there was already a centralized mechanism in place
- Safety
  - In NYC, there were both participation problems and incentive problems about revealing preferences.
  - In Boston, the big problem was about revealing preferences

Background reading

- **New York City**
- Abdulkadiroglu, Atila , Parag A. Pathak, and Alvin E. Roth, "The New York City High School Match," *American Economic Review, Papers and Proceedings*, 95,2, May, 2005, 364-367.
- Abdulkadiroglu, Atila , Parag A. Pathak, and Alvin E. Roth, "Strategy-proofness versus Efficiency in Matching with Indifferences: Redesigning the NYC High School Match," revised, November, 2008, *American Economic Review*, forthcoming.
- **Boston**
- Abdulkadiroglu, Atila, Parag A. Pathak, Alvin E. Roth, and Tayfun Sonmez, The Boston Public School Match," *American Economic Review, Papers and Proceedings*, 95,2, May, 2005, 368-371.
- Abdulkadiroglu, Atila, Parag A. Pathak, Alvin E. Roth, and Tayfun Sonmez, "Changing the Boston School Choice Mechanism," May 2006.
- Pathak, Parag and Tayfun Sonmez, “Leveling the Playing Field: Sincere and Sophisticated Players in the Boston Mechanism”, September 2008, *American Economic Review.*
- **Market Design in general**
- Roth, Alvin E. "What have we learned from market design?" Hahn Lecture, Economic Journal, 118 (March), 2008, 285-310.