Sophistication and Cautiousness in College Applications

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Research Questions

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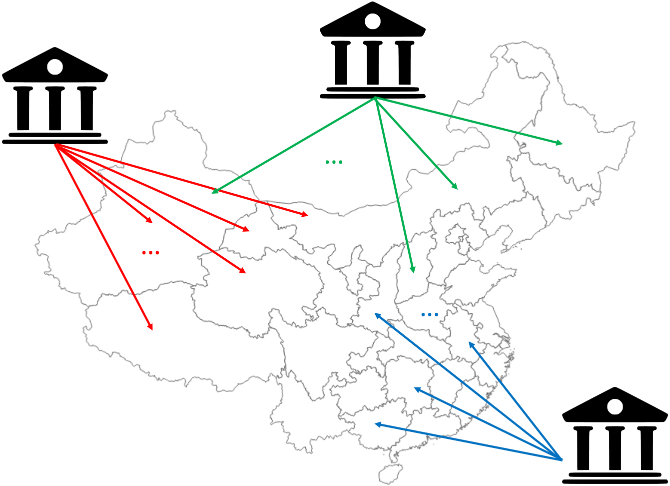
- We answer these in the context of Chinese college admission reforms.

College Admissions in China

- 3m seats in more than 1000 universities



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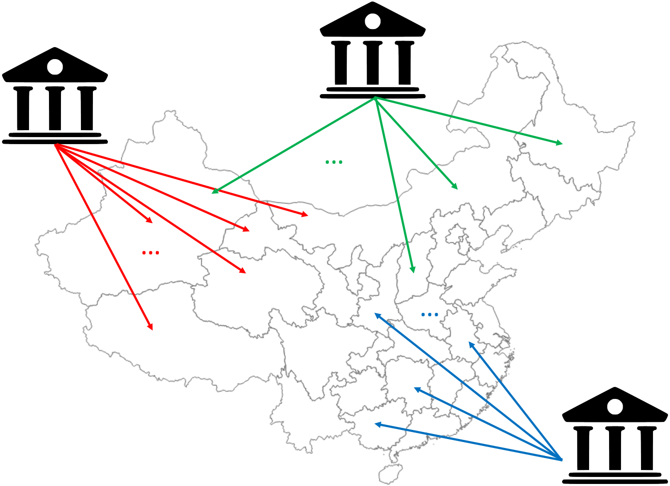

- Each university's seats are divided into 33 province-wide markets.

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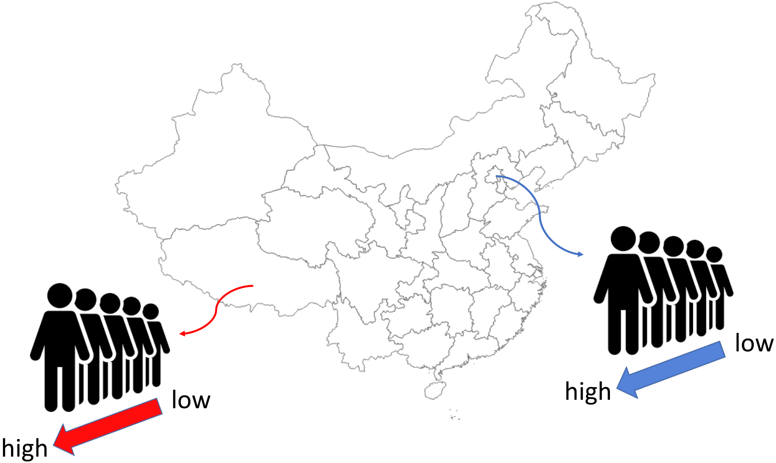

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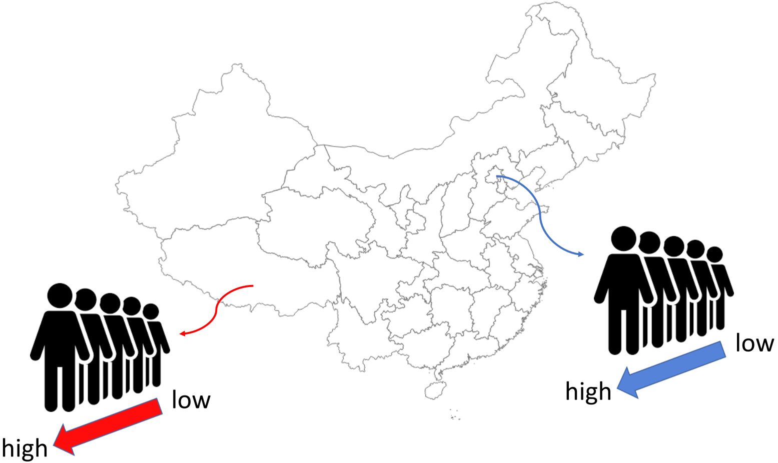

- Students participate in a centralized admission system in their home province.

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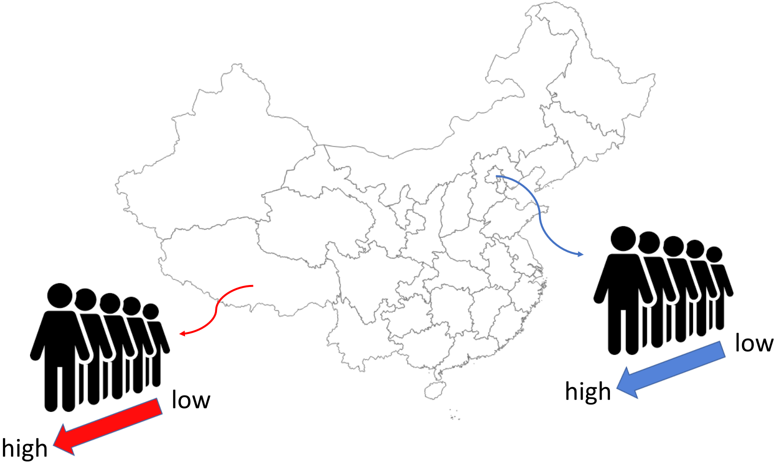

- Students participate in a centralized admission system in their home province.
- Single exam score is used as common priority in each province.

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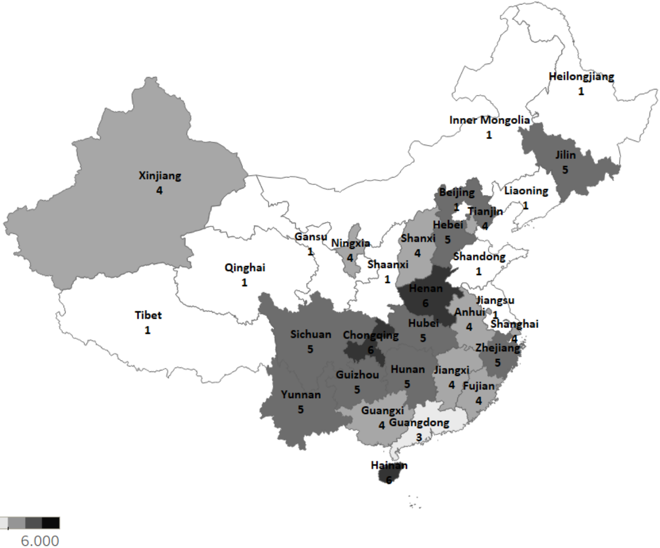
  - $e = 1$: IA (Immediate Acceptance) mechanism
  - $e = \infty$: DA mechanism

Chinese College Admission Reforms

- Between 2003-2018, all provinces shifted from IA to some parallel mechanism. In 2011:



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   ⇒ We reject this hypothesis by exploiting the policy variations. The matching became more assortative after the policy reforms.

2. To explain this, we consider sincere and cautious students, who may play suboptimally.

   ⇒ Structural estimation shows that both behavioral types are important. Students benefit from the reforms if their scores are high, and they are either sincere or cautious.

Related Literature

- Chinese college admissions:
  Chen and Kesten (2017; forthcoming), Wu and Zhong (2014), Lien, Zheng and Zhong (2017)
- Empirical school choice:
  - Submitted preference data:
    Ajayi (2013), Burgess et al. (2015), Akyol and Krishna (2017), Ajayi and Sidibé (2017), He (2017), Hwang (2017), Agarwal and Somaini (2018), Calsamiglia et al. (2018), Fack et al. (2018), Kapor et al. (2018), Luflade (2018)
  - Outcome data:
    Akyol and Krishna (2017), Fack et al. (2018)
- Deviations from equilibrium in school choice:
  Abdulkadiroğlu et al. (2006), Pathak and Sönmez (2008), He (2017), Kapor et al. (2018)

Plan of the Talk

Background of Chinese College Admissions

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- The matching mechanism is run sequentially from tier-1 to tier-3 colleges.
  - Focus on tier-1 admissions.
- Policy reforms between 2003 and 2018:
  1. the number of parallel options
  2. the timing of preference submission

  - Focus on 1 and use data from known-score submissions.

Parallel Mechanism: φ^1

Round 0: (a) Each student applies to her first choice.
(b) Each college accepts applicants following its priority order up to its capacity, and rejects all other students.

Round t: (a) Each remaining student applies to $t+1$-th choice.
(b) Each college accepts applicants following its priority order up to its remaining capacity, and rejects all other students.

- Called the Immediate Acceptance (IA) mechanism.

Parallel Mechanism: φ^e

Round 0: (a) If a student is unassigned and is yet to apply to her e-th choice, she applies to her most preferable college which has not rejected her.
(b) Each college tentatively accepts applicants following its priority order up to its capacity, and rejects all other students.
(c) The round terminates when each student is assigned or rejected by all first e choices. The assignments become final.

Round t: The same procedure for remaining students and their $te + 1$-th to $te + e$-th choices.

- φ^∞ is called the Deferred Acceptance (DA) mechanism.

Reforms and Implementation

change in e	1 to 3	1 to 4	1 to 5	1 to 6	3 to 5	4 to 6
# of provinces	2	8	6	2	2	1

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- Between 2005-2011, known-score submissions.
- Typically, the length of the preference lists is $2e$ or $3e$.
  - In the structural model, we assume that tier-one colleges are so competitive that all seats are filled in Round 0 in equilibrium.

Data Source

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   - includes each student's year, province, test score (ranking), assigned college

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    - includes each student's year, province, test score (ranking), assigned college
2. Policy data: the evolution of matching mechanisms in each province
3. Other data: external measure of school quality and the distance from the student's home county to each college

Model with a Continuum of Students

- A unit mass of students and a finite set C of colleges
  - As in Abdulkadiroğlu et al. (2015) and Azevedo and Leshno (2016).
  - $q_c > 0$: the capacity of c with $\sum_{c \in C} q_c < 1$

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- η: a probability measure over Θ
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- $\mu : C \cup \Theta \to 2^{\Theta} \cup C$: a matching
  - Assume standard technical conditions on μ.

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Df 1. σ is an *equilibrium under* φ^e if σ gives each student a highest possible expected payoff under φ^e when all other students also play σ.

Unique Equilibrium Outcome

Prop 1. For any $e \in \{1, \ldots, \infty\}$, there exists a unique equilibrium matching μ^e under the parallel mechanism φ^e. Moreover, $\mu^e = \mu^{e'}$ for any $e, e' \in \{1, \ldots, \infty\}$.

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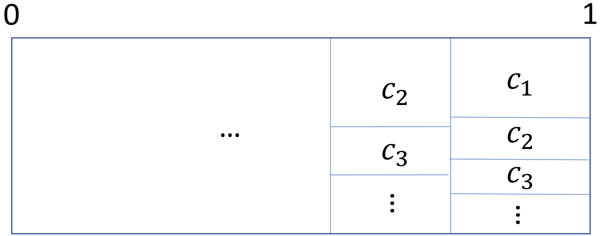

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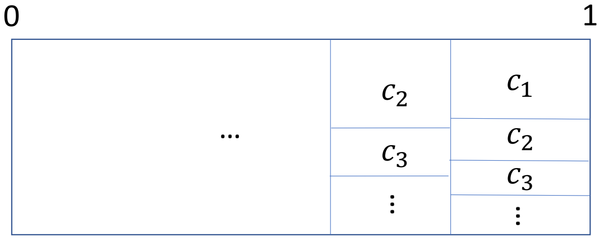

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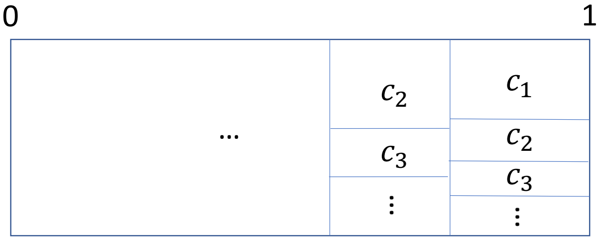

- Equilibrium strategies are different across φ^e's.
- The same result holds for finite markets with complete information.

Testing Prop 1

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  - Colleges: compare score range and variance of admitted students details
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     ⇒ control distance etc. by the provincial fixed effects
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  2. Quota changes:
     ⇒ look at students who have the same set of available colleges ex post

Students' Perspective

- Consider 10 college groups (CGs). definition
- Consider each students group (SG): those who could be admitted to the same set of colleges.

$$y_{ijt} = \xi_1 + \xi_2 r_{jt} + D_j + D_t + \epsilon_{ijt}$$

  - y_{ijt}: dummy variable of student i being matched to a given college group in province j and year t
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- If (i) the preferences are captured by two fixed effects and (ii) the students play the eq in Prop 1, ξ_2 must be zero.

Students in SG1 and SG2

- SG1: above all the cutoffs, SG2: just below CGs 1-2

	CG 1-2	CG 3-6	CG 7-10
SG1	0.0753***	-0.0549***	-0.0205**
	(0.0084)	(0.0096)	(0.0086)
Observations	33,660	33,660	33,660
R-squared	0.139	0.092	0.165
	CG 3-6	CG 7	CG 8-10
SG2	0.1680***	-0.0518***	-0.1130***
	(0.0119)	(0.0170)	(0.0149)
Observations	20,709	20,709	20,709
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- Shift from lower ranked colleges to higher ranked colleges.

Students in SG3 and SG4

- SG3: just below CGs 1-6, SG4: just below CGs 1-7

	CG 7	CG 8	CG 9-10
SG3	0.0725***	0.0744***	-0.146***
	(0.0011)	(0.0020)	(0.0021)
Observations	727,024	727,024	727,024
R-squared	0.084	0.043	0.062
	CG 8	CG 9	CG 10
SG4	0.0367***	0.1190***	-0.1540***
	(0.0030)	(0.0040)	(0.0044)
Observations	435,269	435,269	435,269
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- Consistent patterns: matchings became more assortative after the reforms.

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- A reduced form of the optimal portfolio choices under uncertainties (Chade and Smith, 2006; Shorrer, 2019)
  - Advantage: avoid huge computational burden while explaining the major patterns of the data.

Behavioral Types

strategies \ beliefs	neutral	pessimistic
sincere	Sincere	Sincere
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  ⇒ Takes the worst-case scenario out of all such beliefs:
  - everyone else is rational and
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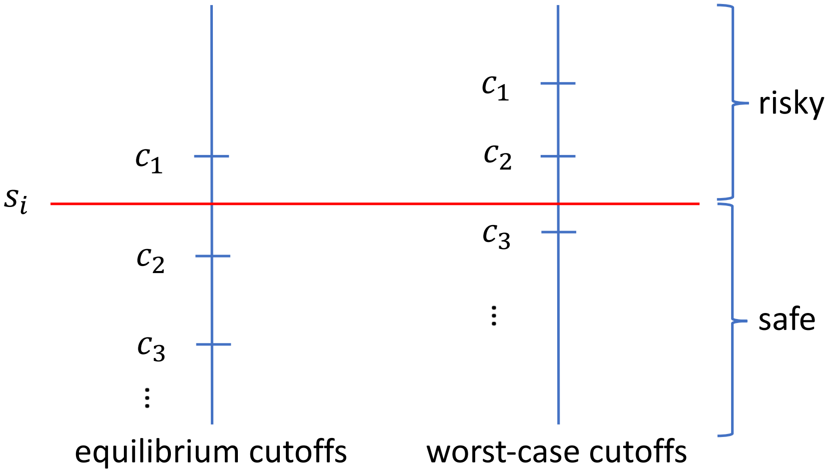
- Both dimensions can be generalized. general

Cutoff Scores for the Pessimistic Type



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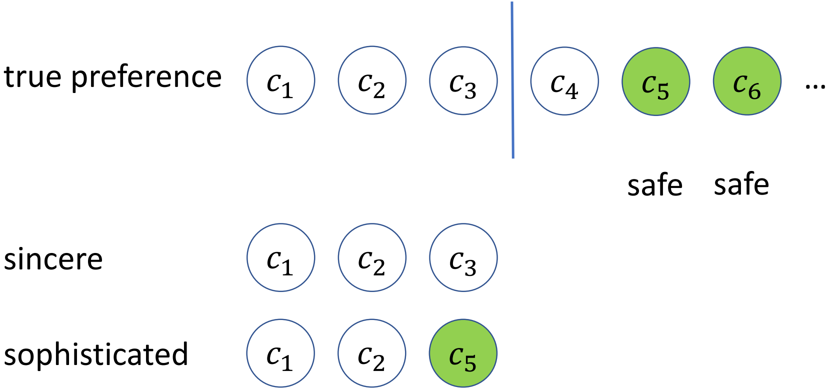
- A sophisticated student lists top e colleges as follows:
  (i) list truthful top e colleges; and
  (ii) if there is no safe college in the list, then drop the least preferable risky college and add the most preferable safe college that was not originally in the list

Example when $e = 3$



Assignment Probabilities

- Assume that the behavioral type is independent of other types.

strategies \ beliefs	neutral $(1-\beta)$	pessimistic (β)
sincere (α)	Sincere	Sincere
sophisticated $(1-\alpha)$	Rational	Cautious

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- The outcome is an equilibrium of φ^e given the behavioral-type restrictions, and varies across e's.
- The assignment probability is written in a closed form for $u_i(c) = v_i(c) + \epsilon_i$ with ϵ_i following type I extreme value distribution.

equation

Identification

- We emply the following assumption:

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Prop 5. Under Assumption I, utility parameters and behavioral type parameters are identified sepearately for each province and year.

Estimation

- For the ease of the estimation, specify the utility vector of province p as

$$v_p(c) = \gamma_1 Quality_c + \gamma_2 Distance_{cp}.$$

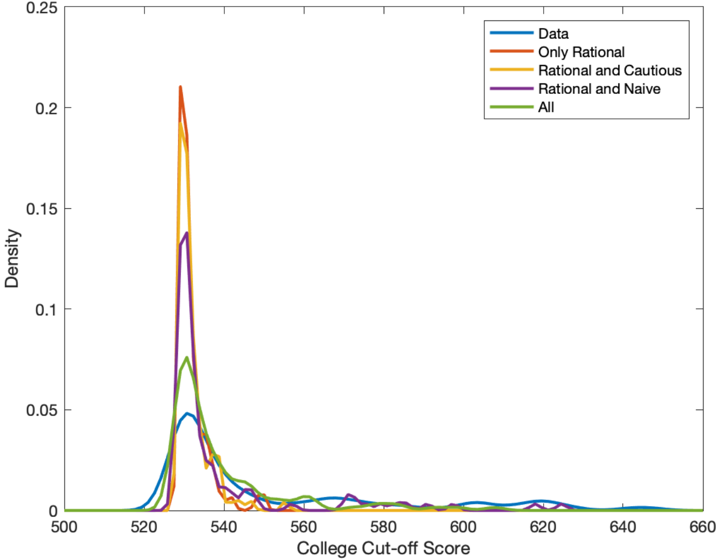
- In theory, this could be each college's fixed effect.

Estimation Results

Panel A: Sample province				
	School quality	Distance	α	β
Estimates	0.0570	-1.97E-03	0.2299	0.1212
s.e.	0.0011	1.73E-05	0.0056	0.0069
t-stat	53.9852	1.14E+2	40.8894	17.6036
Panel B: All estimates				
	School quality	Distance	α	β
Estimates	0.0507	-0.0013	0.5237	0.1198
s.e.	0.0236	0.0006	0.2835	0.1552
t-stat	2.1483	2.1667	1.8473	0.7719
Obs	65			

- In the sample province (Hebei Province in 2006, $e = 1$), 23% of students are sincere, and 9% are cautious.

Model Fit: Simulated Cutoff Scores



Three Welfare Measures

- Consider
  1. the expected utility (EU),
  2. the extensive margin ($\underline{P}$): the prob of being assigned to the outside option, and
  3. the intensive margin (CU): the utility conditional on being assigned to tier-one schools

  for each behavioral type (Rational, Sincere and Cautious).
- $A^e(s_i)$: the set of available colleges for a student i with score s_i under φ^e

Direct and General Equilibrium Effects

Prop 2. For any $e < e'$ and a student i with score s_i and $A^e(s_i) = A^{e'}(s_i)$,

1. $EU_R^e(s_i) = EU_R^{e'}(s_i)$, $EU_S^e(s_i) \leq EU_S^{e'}(s_i)$, and $EU_C^e(s_i) \leq EU_C^{e'}(s_i)$.
2. $\underline{P}_R^e(s_i) = \underline{P}_R^{e'}(s_i) = 0$, $\underline{P}_S^e(s_i) \geq \underline{P}_S^{e'}(s_i)$ and $\underline{P}_C^e(s_i) = \underline{P}_C^{e'}(s_i) = 0$.
3. $CU_R^e(s_i) = CU_R^{e'}(s_i)$, $CU_S^e(s_i) \geq CU_S^{e'}(s_i)$, and $CU_C^e(s_i) \leq CU_C^{e'}(s_i)$.

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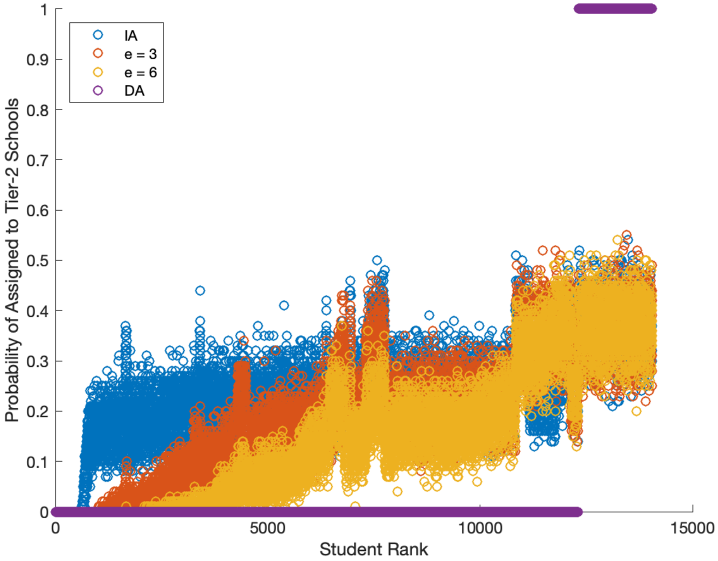
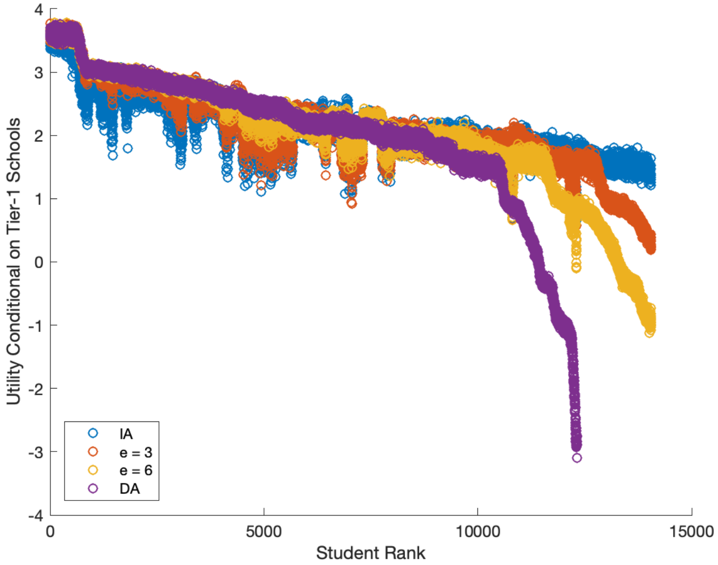
Prop 3. For any regular problem, any $e < e'$ and a student i with score s_i, $A^e(s_i) \supseteq A^{e'}(s_i)$ holds.

Simulation: Extensive Margin



Simulation: Intensive Margin



Simulation: by Behavioral Types

Panel A: Extensive margin			
e \ Behavioral types	Sincere	Rational	Cautious
1	0.87	0	0.2
3	0.64	0	0.27
6	0.49	0	0.25
DA	0.12	0.12	0.12

Panel B: Intensive margin			
e \ Behavioral types	Sincere	Rational	Cautious
1	3.31	2.39	0.48
3	3.01	2.23	1.18
6	2.82	2.04	1.84
DA	2.05	2.05	2.05

Summary

1. Prop 1 is rejected; higher e achieved a more assortative matching.
2. Both of sincere and cautious types are important in explaining the observations.
3. Students benefit from the reforms if their scores are high, and they are either cautious or sincere.

Thank you very much!

Colleges' Perspective

Dependent variable	Range		Variance	
OLS	(1)	(2)	(3)	(4)
Adopt parallel option (r_{jt})	-0.0832***	-0.0932***	-0.0323***	-0.0319***
	(0.0058)	(0.0046)	(0.0015)	(0.0013)
Mean Range / Variance	0.387		0.127	
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
College FE	No	Yes	No	Yes
Observations	35,439	35,439	31,531	31,531
R-squared	0.032	0.388	0.096	0.302

- Samples: all (tier-one) colleges from all markets
- Suggests that schools admit more similar scores of students.

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College Grouping

1. Peking University
2. Tsinghua University
3. University of Science and Techology China
4. Shanghai Jiaotong University
5. Fudan University
6. Zhejiang University
7. QS 2016 ranking above 450 (12 colleges)
8. QS ranking 450-600 or in Project 985 (55 colleges)
9. Project 211 (55 colleges)
10. Other tier-one universities (473 college)

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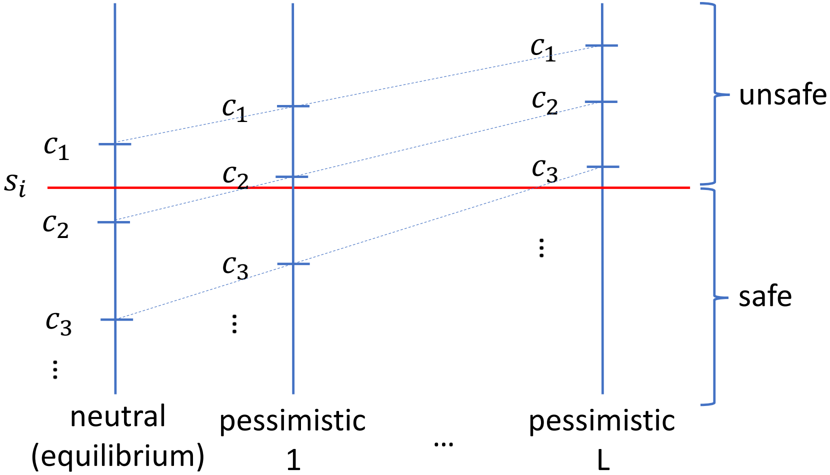
Behavioral Types

strategies \ beliefs	neutral	pessimistic 1	...	pessimistic L
sincere	Sincere	Sincere	...	Sincere
sophisticated 1	Rational	Cautious 11	...	Cautious 1L
⋮	⋮	⋮		⋮
sophisticated e	Rational	Cautious e1	...	Cautious eL

- neutral: has the correct belief over student (utility and behavioral) types
- pessimistic: has a set of beliefs that are consistent with the equilibrium ranking of colleges

  $\Rightarrow$ Pessimistic L takes the worst-case scenario out of all such beliefs:
  - everyone else is rational and
  - prefers colleges according to the equilibrium ranking.

Cutoff Scores for Pessimistic Types



Behavioral Types

strategies \ beliefs	neutral	pessimistic 1	...	pessimistic L
sincere	Sincere	Sincere	...	Sincere
sophisticated 1	Rational	Cautious 11	...	Cautious 1L
⋮	⋮	⋮		⋮
sophisticated e	Rational	Cautious e1	...	Cautious eL

- k: the degree of cautiousness
  - Student with degree k lists e colleges as follows:
    (i) list truthful top e colleges; and
    (ii) if there are $\kappa < k$ safe colleges in the list, then drop the least preferable $k - \kappa$ unsafe schools and add most preferable $k - \kappa$ safe colleges that were not originally in the list

Example when $e = 3$

Assignment Probabilities

- Assume that the behavioral type is independent of other types.

strategies $\setminus$ beliefs	neutral (β_0)	...	pessimistic L (β_L)
sincere (α_0)	Sincere	...	Sincere
sophisticated 1 (α_1)	Rational	...	Cautious $1L$
$\vdots$	$\vdots$		$\vdots$
sophisticated e (α_e)	Rational	...	Cautious eL

- The outcome is an equilibrium of φ^e given the behavioral-type restrictions, and varies across e's.
- The assignment probability is written in a closed form for $u_i(c) = v_i(c) + \epsilon_i$ with ϵ_i following type I extreme value distribution.

Assignment Probabilities

- The probability of student i with score s_i being assigned to an available tier-one college c:

$$
\begin{aligned}
&\beta_0 \sum_{k=1}^{e} \alpha_k \Big\{ \frac{\exp(v_i(c))}{\sum_{c' \in C_a(s_i)} \exp(v_i(c'))} \Big\} \\
&+\alpha_0 \Big\{ \frac{\exp(v_i(c))}{\sum_{c' \in C} \exp(v_i(c'))} \\
&\quad + \mathbb{1}_{\{e \geq 2\}} \sum_{m=1}^{e-1} \sum_{(c^{(1)},\dots,c^{(m)}) \in U_m(s_i)} \prod_{x=1}^{m} \frac{\exp(v_i(c^{(x)}))}{\sum_{c' \in C \setminus \{c^{(0)},\dots,c^{(x-1)}\}} \exp(v_i(c'))} \frac{\exp(v_i(c))}{\sum_{c' \in C \setminus \{c^{(1)},\dots,c^{(m)}\}} \exp(v_i(c'))} \Big\} \\
&+ \sum_{l=1}^{L} \beta_l \sum_{k=1}^{e} \alpha_k \Big\{ \mathbb{1}_{\{e-\tilde{k} \geq 1\}} \frac{\exp(v_i(c))}{\sum_{c' \in C} \exp(v_i(c'))} \\
&\quad + \mathbb{1}_{\{e-\tilde{k} \geq 2\}} \sum_{m=1}^{e-\tilde{k}-1} \sum_{(c^{(1)},\dots,c^{(m)}) \in U_m(s_i)} \prod_{x=1}^{m} \frac{\exp(v_i(c^{(x)}))}{\sum_{c' \in C \setminus \{c^{(0)},\dots,c^{(x-1)}\}} \exp(v_i(c'))} \frac{\exp(v_i(c))}{\sum_{c' \in C \setminus \{c^{(1)},\dots,c^{(m)}\}} \exp(v_i(c'))} \\
&\quad + \mathbb{1}_{\{c \in C_s^l(s_i)\}} \frac{\exp(v_i(c))}{\sum_{c' \in C_s^l(s_i)} \exp(v_i(c'))} \\
&\quad \Big(\mathbb{1}_{\{\tilde{k} \geq e\}} + \mathbb{1}_{\{e-\tilde{k} \geq 1\}} \sum_{(c^{(1)},\dots,c^{(e-\tilde{k})}) \in U_{e-\tilde{k}}(s_i)} \prod_{x=1}^{e-\tilde{k}} \frac{\exp(v_i(c^{(x)}))}{\sum_{c' \in C \setminus \{c^{(0)},\dots,c^{(x-1)}\}} \exp(v_i(c'))} \Big) \Big\}.
\end{aligned}
$$

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Identification

- We emply the following assumption:

Assumption I. For each province and year, the utility vector u_i and the score s_i are independently distributed.

Prop 5. Under Assumption I, utility parameters and behavioral type parameters are identified sepearately for each province and year.

Proof Idea of Prop 3

- Consider $e = 3$ and $L = 2$.

strategies \ beliefs	neutral (β_0)	pessimistic 1 (β_1)	pessimistic 2 (β_2)
sincere (α_0)	Sincere	Sincere	Sincere
sophisticated 1 (α_1)	Rational	Cautious 11	Cautious 12
sophisticated 2 (α_2)	Rational	Cautious 21	Cautious 22
sophisticated 3 (α_3)	Rational	Cautious 31	Cautious 32

- $v(c)$ and five parameters need to be identified.

Proof Idea of Prop 3

- C_a: the set of available colleges (safe colleges under the neutral belief)
- C_s^I: the set of safe colleges for pessimistic I

$C = C_a = C_s$	$v(c)$ identified
$C = C_a = C_s^1 \neq C_s^2$	$\alpha_3\beta_2$ identified
$C = C_a \neq C_s^1$	$\alpha_3\beta_1$ identified
$\lvert C_a \rvert = \lvert C \rvert - 1$	α_2/α_3 identified
$\lvert C_a \rvert = \lvert C \rvert - 2$	$\alpha_1/(\alpha_2+\alpha_3)$ identified
$\lvert C_a \rvert = \lvert C \rvert - 3$	$\alpha_0/(\alpha_1+\alpha_2+\alpha_3)$ identified

students by scores

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