Limiting Applications in College Admissions

Wei-Cheng Chen

Department of Economics, National Chung Cheng University

Yi-Cheng Kao

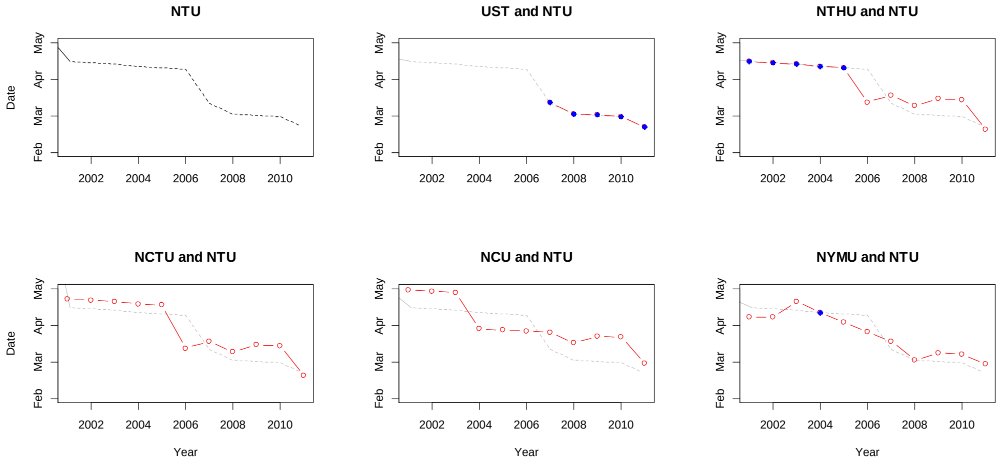
Department of Business Administration, Chung Yuan Christian University

November 17, 2015

Outline

- **What is the strategy of limiting applications**
- A Simple Model with Uncertainty (Chen and Kao, 2014)
- A General Model with Incomplete Information
- Empirical Results
- Conclusion and Future Work

Examination dates of NTU and UST



Limiting Applications in Various Ways

- In Taiwan and many Asia countries, exams are commonly used to screen students. Setting the entrance examination on the same day restricts students to attend only one of the exams.
- In the United States, an “Early Decision” program requires a student to commit to attend the school if an admission is offered. Thus, a student cannot apply to two schools via the early decision channel.
- In both cases, schools could restrict students' application portfolio as a tool to acquire students’ private information in order to enroll desired students.

College Admissions: A Decentralized Two-Sided Matching with Uncertainty

- School's screening devices, such as exams and interviews, are inherently imperfect. Thus uncertainty is a crucial factor in a college admissions process.
- Limiting applications, while restricts some students from applying to others, also changes the composition of applicants.
- Students, facing such limitations, may choose to apply to a less desired school when the uncertainty is high, and the opportunity cost is low.

Past Studies and Empirical Findings

- Early decisions are typically adopted by lower ranked (but still selective) colleges (Avery, Fairbanks, and Zeckhauser, 2003).
- Avery and Levin (2010) show that when schools care about students' ability and preference among schools, a relatively lower ranked college may enroll desired students who are uncertain about their abilities in the early decision program (the competitive effect).
- Other potential explanations for early decision programs that have been discussed in the literature, such as jumping winner's curse (Lee, 2009), or financial need (Kim, 2010).
- However, the competitive effect is not supported by previous empirical studies (Jensen and Wu, 2010; Chapman and Dickert-Conlin, 2012).

Our Explanation and New Finding

- We argue that none of the above reasons are required to adopt strategies to limit application portfolios. Uncertainty about the application outcome alone could justify such strategies.
- We show that a less prestigious school could gain from using such strategies (the Competitive Effect) when uncertainty is high, and the prestige of the school is close to the better one.
- Indeed, by using a natural experiment in Taiwan, we are able to control the school's prestige, and for the first time confirm the competitive effect in the context of conflicting examinations.

Outline

- What is the strategy of limiting applications
- **A Simple Model with Uncertainty (Chen and Kao, 2014)**
- A General Model with Incomplete Information
- Empirical Results
- Conclusion and Future Work

Players and Preferences

- There are 2 schools and 3 students in the model.
- The set of students is $S=\{s_i : i=1,2,3\}$, where i is the unobservable type (**quality**) and only the student s_i know its own type i.
- The set of schools is $G=\{A,B\}$, and, for simplicity, each of them only admits one student.
- Schools have the same preference over student's quality:

$$v_j(s_i)=v_i \text{, where } v_1 > v_2 > v_3 > 0 \text{ for } j=A,B;$$

i.e., $s_1 \succ_j s_2 \succ_j s_3$ for $j=A,B$.
(Henceforth Good, Normal, Bad students)

- Students also have the same utility function representing $A \succsim_i B$:
(Henceforth A is the Best and B is the Second Best School)

$$u_i = \begin{cases} a & \text{if } s_i \text{ is enrolled by } A \\ b & \text{if } s_i \text{ is enrolled by } B \\ 0 & \text{if } s_i \text{ is not enrolled} \end{cases}, \text{ where } a > b > 0 \text{ for } i = 1,2,3.$$

- a, b are called the **prestige** of the Best and the Second Best School, respectively.

Entrance examination

- Exam is an imperfect screening device: students of higher quality perform better in an exam statistically, but not for sure.

- To model this, let an exam be a random mapping from students to the pseudo types (exam rankings), i.e., $S \rightarrow T = \{t_k : k = 1,2,3\}$ such that

$$(s_1, s_2, s_3) \rightarrow (t_1, t_2, t_3) \text{ with probability } 1/3;$$
$$(s_1, s_2, s_3) \rightarrow (t_2, t_1, t_3) \text{ with probability } 1/3;$$
$$(s_1, s_2, s_3) \rightarrow (t_1, t_3, t_2) \text{ with probability } 1/3.$$

- Once an examination is implemented, the common realization of t_k, the exam ranking, is observed by both schools.

Strategies of Schools and Students

- School A first announces the "date" of its examination; school B then decides whether to have the same date as school A's exam date or not.
- When the schools implement exams in the same date, students simultaneously take exams from either A or B. When the exam dates are different, students can take exams from A, B, or Both.
- We focus on the Subgame Perfect Nash Equilibrium (SPNE) in the first two stages. The choices after the exam result reveals are straightforward.

Equilibrium Analysis: the Second Stage

- *When* A *and* B *have different examination dates, all students will apply for both schools.*
- *When* A *and* B *have the same examination date, depending on the value of* b*, the equilibrium strategy profiles for students could be* $(\tilde{s}_1, \tilde{s}_2, \tilde{s}_3) = (A, A, B)$*,* $(\tilde{s}_1, \tilde{s}_2, \tilde{s}_3) = (A, B, B)$ *, or* $(\tilde{s}_1, \tilde{s}_2, \tilde{s}_3) = (B, A, A)$*. In particular,* $(\tilde{s}_1, \tilde{s}_2, \tilde{s}_3) = (B, A, A)$ *is possible only if* $b \in [2a/3, \text{ a}]$*. But* $(\tilde{s}_1, \tilde{s}_2, \tilde{s}_3) = (A, B, B)$ *is also possible when b is in that range.*

Equilibrium Analysis: the First Stage

- In the first stage, the two schools simply compare their expect utility of using a conflicting strategy with that of using an avoiding strategy.
- When the two schools have different exam dates, the expected utilities for A and B are

$$E[v_A \mid \tilde{d}_A \neq \tilde{d}_B] = \frac{2}{3} \times v_1 + \frac{1}{3} \times v_2,$$

$$E[v_B \mid \tilde{d}_A \neq \tilde{d}_B] = \frac{1}{3} \times v_1 + \frac{1}{3} \times v_2 + \frac{1}{3} \times v_3$$

Equilibrium Analysis

- When the two schools have the same exam dates, the expected utilities for A and B are summarized in the following table:

	$(\tilde{s}_1, \tilde{s}_2, \tilde{s}_3)$	$E[v_A \mid (\tilde{s}_1, \tilde{s}_2, \tilde{s}_3)]$	$E[v_B \mid (\tilde{s}_1, \tilde{s}_2, \tilde{s}_3)]$
$b \in (0,\ a/2)$	(A,A,B)	$\frac{2}{3}v_1 + \frac{1}{3}v_2$	v_3
$b \in (a/2,\ 2a/3)$	(A,B,B)	v_1	$\frac{2}{3}v_2 + \frac{1}{3}v_3$
$b \in (2a/3,\ a)$	(A,B,B)	v_1	$\frac{2}{3}v_2 + \frac{1}{3}v_3$
	(B,A,A)	$\frac{2}{3}v_2 + \frac{1}{3}v_3$	v_1

Main Result

When the two schools have similar prestige such that $b > b^*$ *, where* $b^* \in (2a/3,\ a)$ *,* B *have an incentive to conflict with* A *on the examination date because the expected quality of enrolled students will be higher. In other cases of* $b < b^*$ *,* B *will never conflict with* A *.*

Alvin Roth's comment on our paper:

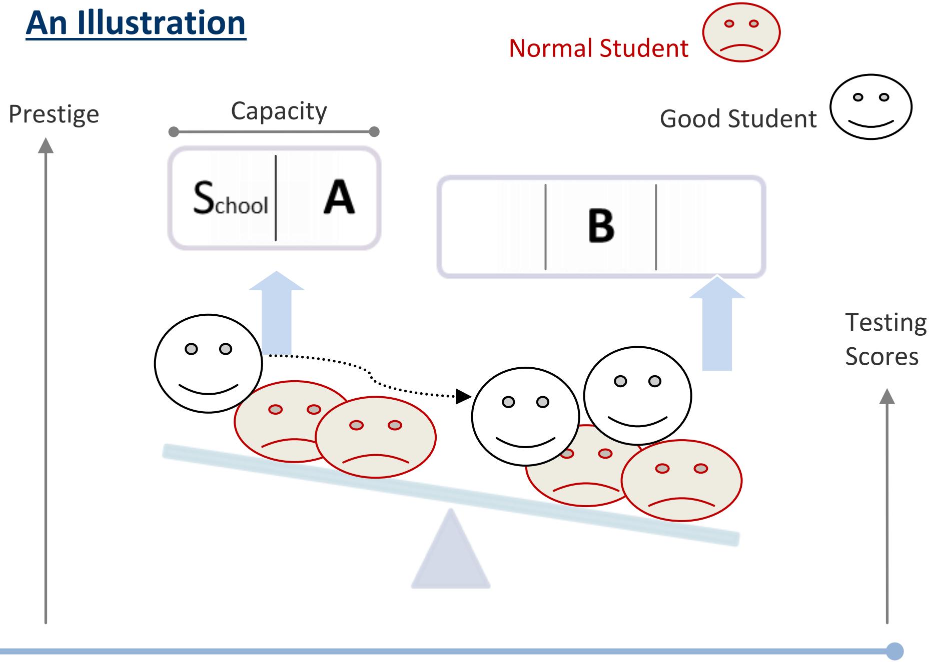
"Wei-Cheng Chen and Yi-Cheng Kao have a paper on college admissions that focuses on the practice of universities in a number of Asian countries of scheduling their admissions exams on the same day, so that students must choose which school to apply to among those whose exam is on the same day."

http://marketdesigner.blogspot.tw/2014/02/competition-between-colleges.html

Outline

- What is the strategy of limiting applications
- A Simple Model with Uncertainty (Chen and Kao, 2014)
- **A General Model with Incomplete Information**
- Empirical Results
- Conclusion and Future Work

An Illustration



Players and Preferences (1)

- There are 2 schools and a unit measure of a continuum of students.
- Good students have measure μ and normal ones have $1-\mu$.
- School A has enrollment capacity of k_A (and school B has k_B), and wants to maximize the enrollment of good students.
- Each Student has a taste $y \sim F(y)$ with the support of $[-\delta,\ \delta]$, and y is independent of student's type and only observed by students.
- Student's utility of attending school A is $a+y$ (and $b-y$ for B).
- Note that a student strictly prefers school A to B if and only if $a+y>b-y$, i.e., $y>c=(b-a)\,/\,2$. For $y<c$, he strictly prefers B to A.

Players and Preferences (2)

- We assume that school A is the best school and school B the second best; specifically, we restrict attention to

$$0 < k_A < k_B ,$$
$$\mu < k_A + k_B < 1;$$
$$F(0) < 0.5 ,$$
$$\delta < b < a .$$

- If $b \to a$, we say that B has similar prestige to A.

Information Structure and Entrance examinations

- To model uncertainty of exams, we assume that entrance exams reveal student's type perfectly, but students only have partial knowledge about their types before taking exams.

- Moreover, good students always obtain signal h and normal students obtain signal h or l with probability of p and $1-p$, respectively.

- Hence for $p=1$, students have no information about their types at all; for $p=0$, students completely know their types.

Strategies of Schools and Students

- We focus on the Subgame Perfect Nash Equilibrium (SPNE) in the first two stages.
- In the first stage, both schools decide whether to set a conflict exam date.
- In the second stage, if both schools choose not to conflict with each other ("avoiding strategy"), then students can take exams from A, B, or Both. If one of the schools (or both) chooses to conflict with another school ("conflicting strategy"), then students can only take exams from either A or B.

Main Result

- The second best school gains from using the conflicting strategy if its prestige is close to that of the best school, i.e., b is close to a, given that the uncertainty, p, is sufficiently large and μ is sufficiently small.

Uncertainty is Essential

- Notice that for the special case $p = 0$, we have the following result.
- If students are fully aware of the examination result, then the second best school is strictly worse to adopt the conflicting strategy when the prestige difference is large, and is indifferent if the prestige difference is small.

Outline

- What is the strategy of limiting applications
- A Simple Model with Uncertainty (Chen and Kao, 2014)
- A General Model with Incomplete Information
- **Empirical Results**
- Conclusion and Future Work

Competition among Top Universities in Taiwan

- National Taiwan University (NTU) is generally considered as the best university in Taiwan in almost every discipline.
- In 2008, 4 other top-ranked universities jointed an alliance called the University System of Taiwan (UST). Since then, UST has always chosen to have exam dates that conflict with NTU. However, UST also gives its departments the option to set their own exam dates.
- This provides a unique opportunity to test our model implications, because prior to 2008, some schools of UST had chosen to conflict with NTU, in which case all of their departments had to hold exams in the same date, even though each department had different prestige.

Retardation Rate as a Proxy for Student Quality

- The retardation rate of students is the ratio of students who study for more than the regular (two) years.
- We assume that others being equal, student quality in a department is negatively correlated to its retardation rate.
- We use a fixed-effect model to control for department-specific endogenity, such as quality of departments, department's standard for graduation, and so on.

Effects on the Departments with Similar Prestige

- UST departments in the fields of Electrical Engineering and Computer Science have higher rankings than other departments at UST, and almost tie with corresponding departments at NTU.
- According to the model’s prediction, we should expect that conflicting strategies should have better effects on students’ quality for Electrical Engineering and Computer Science departments than other departments.
- Data suggests that conflicting with NTU significantly reduces the retardation rates in these departments, whereas overall it has the opposite effect.

UST Electrical Engineering and Computer Science Departments

Independent variables	Retardation rate models		
	Model 1	Model 2	Model 3
Conflicting with NTU	- 6.99* (4.16)	- 7.60* (4.16)	- 7.15* (4.10)
Conflicting with other Tops		2.12 (1.50)	2.06 (1.47)
UST dummy (2008)			- 6.81* (3.44)
Number of faculty	0.51*** (0.18)	0.51*** (0.18)	0.43** (0.18)
Time Trend	1.17*** (0.41)	1.23*** (0.41)	1.82*** (0.50)
Unemployment rate	2.47 (1.68)	2.13 (1.69)	1.45 (1.70)
Observations	98	98	98
Adjusted R^2	0.371	0.378	0.395

Competitive effect on the quality of students at UST, Overall

Independent variables	Retardation rate models		
	Model 1	Model 2	Model 3
Conflicting with NTU	4.05** (2.03)	4.05** (2.03)	4.01** (2.00)
Conflicting with other Tops		0.15 (1.19)	0.46 (1.18)
UST dummy (2008)			- 8.39*** (2.10)
Number of faculty	0.26 (0.16)	0.26 (0.16)	0.25 (0.16)
Time Trend	1.05*** (0.19)	1.06*** (0.19)	1.67*** (0.24)
Unemployment rate	3.66*** (1.04)	3.65*** (1.05)	2.45** (1.08)
Observations	657	657	657
Adjusted R^2	0.06	0.06	0.09

Do Departments Gain from Choosing the Exam Dates?

- After 2008, the departments in UST have the freedom to choose whether to conflict with NTU or not.
- According to the model, departments should respond differently according to their prestige compared to that of the corresponding departments of NTU. A “revealed preference” argument suggests for those departments that changed their choices, the quality of enrolled students should improve.
- Using their performance after 2008 as a baseline, we are able to calculate the gain from adopting the optimal strategies.

Gain from Adopting the Optimal Strategies

	Retardation rate models		
Independent variables	Model 1	Model 2	Model 3
Optimal	-7.13*** (2.00)	-7.37*** (2.02)	-5.44*** (2.07)
Conflicting with other tops		0.77 (0.85)	0.76 (0.84)
UST dummy			-7.12*** (1.87)
Number of faculty	0.33** (0.13)	0.32** (0.13)	0.32** (0.13)
Time trend	0.60 (1.10)	0.63 (1.10)	0.62 (1.09)
Unemployment rate	2.49*** (0.69)	2.52*** (0.69)	1.79** (0.71)
Observations	1050	1050	1050
Adjusted R2	0.122	0.141	0.134

Prestige Differences and Conflicting Strategy

- We find a proxy based on standardized test scores of college enrollment in order to measure the prestige differences between NTU and UST departments. According to the CEEC statistics, the original percentile rank (PR) of the lowest score of enrolled students for every departments is also public available.
- We use the method proposed by Zen, Chen, and Lin (2008) to construct a comparable PR among departments. We use such PR as a measure of prestige and then define the PR difference by subtracting a UST department's PR from its corresponding NTU one.
- We define a binary variable which equals one when a department adopts the conflicting strategy and equals zero otherwise. The probit and logit models are employed to estimate the probability of adopting the conflicting strategy for UST departments.

Conflicting Strategy and the PR Differences

Independent variables	Probit		Logit	
	Model 1	Model 2	Model 1	Model 2
PR differences	-0.09** (0.03)	-0.08** (0.03)	-0.16** (0.06)	-0.16** (0.06)
Conflicting tops		0.16 (0.42)		0.28 (0.72)
Faculty	0.02 (0.01)	0.02 (0.01)	0.03 (0.03)	0.03 (0.03)
Unemploymen	-0.44 (0.64)	-0.36 (0.67)	-0.52 (1.10)	-0.40 (1.15)
Observations	90	90	90	90
AIC	99.97	101.83	99.72	101.57

Outline

- What is the strategy of limiting applications
- A Simple Model with Uncertainty (Chen and Kao, 2014)
- A General Model with Incomplete Information
- Empirical Results
- **Conclusion and Related Work**

Findings

- We develop a decentralized two-sided matching model with an imperfect screening device to analyze the school conflict problem, and test the model with a data set in Taiwan.
- Our empirical result suggests that only the departments in the second best school that have similar rankings with the best school (i.e EE and CS) can benefit from using a conflicting strategy, which is consistent with the model's prediction.
- Moreover, when schools set up the exam date at the departmental level, we show that departments' choices are consistent with the model of maximizing student quality.
- Finally, we measure prestige differences and show that a department with close prestige to the best one tends to adopt the conflicting strategy.

Some Limitations

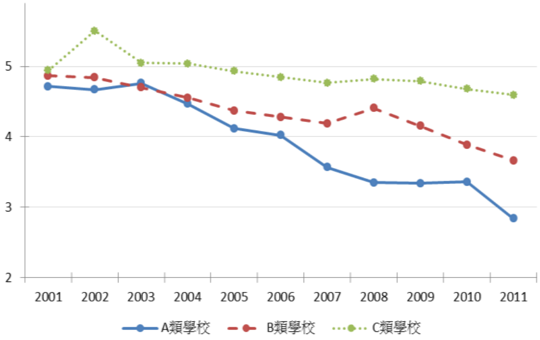
- Measures of student's "quality"; other characteristics that schools may desire.
- Our model and empirical results focus on the benefit of enrolling better students for the second best school on using the conflicting strategy.
- However, we do not exclude other potential explanations for limiting applications that have been discussed in the literature.

Related Research

- Avery, Roth, and Lee (2014, *NBER Working Paper,* No. 20774) study the college admissions in Korea and show a similar result as Chen and Kao (2014) that schools with high enough prestige have incentive to conflict with the best one on entrance examination dates.
- Chen, Chen, Kao (2015) conduct an experimental study to test the model of Chen and Kao (2014).
- Kao and Lin (2015, TER, forthcoming) also explain the phenomenon of diverging dates of top, middle, and lower universities over time based on the model of Chen and Kao (2014).

Related Research

- Kao and Lin (2015) find that top, middle, and lower universities cluster their examinations during February, March, and April, respectively.



Related Research

- Kao and Lin (2015) developed a model to explain such phenomenon of diverging dates.
- The model shows that when the examination exhibits measurement error, i.e., the best (worst) student may not have the highest (lowest) testing scores, the phenomenon is an equilibrium among universities in competing for better students.
- Specifically, as the measure error increases over time, a top university will have an early examination to decrease the error and then raise the probability of enrolling best students.

Thank you!

Key Assumption of Kao and Lin (2015)

- 各校可在考試日期集合 $D=\{D_t:t=1,2,\cdots,T\}$ 中，選擇任一時間點 D_t 舉行考試。考試分數之集合 $G=\{g_k:k=1,2,3\}$ 為學生素質的隨機映射且 $g_1>g_2>g_3$ ，而 $S\rightarrow G$ 的可能結果與對應機率為:

$$p\left[(s_1,s_2,s_3)\rightarrow(g_1,g_2,g_3)\right]=\frac{3-2e(t)}{3};$$

$$p\left[(s_1,s_2,s_3)\rightarrow(g_2,g_1,g_3)\right]=\frac{e(t)}{3};$$

$$p\left[(s_1,s_2,s_3)\rightarrow(g_1,g_3,g_2)\right]=\frac{e(t)}{3};$$

- 其中 $e(t)\in(0,1)$ 是考試的衡量誤差且 $\Delta e(t)/\Delta t>0$。
- 教育心理學者 Cassady and Johnson (2002)及 Cassady (2004)的研究，考試壓力之累積會影響大學生的考試表現，故衡量誤差會隨時間遞增。