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ABSTRACT

This paper examines non-price competition among colleges to attract highly qualified students, exploiting the South Korean setting where the national government sets rules governing applications. We identify some basic facts about the behavior of colleges before and after a 1994 policy change that changed the timing of the national college entrance exam and introduced early admissions, and propose a game-theoretic model that matches those facts. When applications reveal information about students that is of common interest to all colleges, lower-ranked colleges can gain in competition with higher-ranked colleges by limiting the number of possible applications.

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I. Introduction

College admissions is a matching market, in which applicants cannot simply choose what college to attend, even if they can afford it, but in which they must also be admitted. That is, prices are not used to equate supply and demand: selective colleges are priced to attract many more students than they can admit, and admissions policies thus serve to clear the market. Compared to the immense interest in college admissions in the press, relatively little academic research on this topic has been conducted in the field of economics. One reason may be that while college admissions processes are complex, only partial information is available for analysis.

This paper utilizes a setting with a well-defined set of strategies for colleges and where relevant information is available, namely South Korea, where the central government determines the total number of seats a college can fill in an incoming cohort and the methods by which a college can evaluate its applicants. These centralized rules governing the admissions process allow us to model and analyze the strategic decisions of South Korean colleges more precisely than would be possible in the decentralized environment in which American colleges operate.

We focus on recent changes in the rules and timing for college admissions in South Korea, and in particular, on a set of reforms that introduced early applications in 1994.[1] Between 1982 and 1993, the national exam required for college admission in South Korea was only offered on two dates each year, and students were allowed to apply for only one college per exam date.[2] Thus, there was a structural limitation of at most two applications per student. In addition, many of the most selective colleges, including all of the top nine by a common reputational ranking (see Table 1), chose to fill their classes on the first exam date. That is, students were able to apply to at most one very selective college, since those colleges all held their examinations on the same day and since a student could only apply to a college where he or she took the exam.

Limitations on the ability of students and colleges to explore possible matches typically lead to inefficiencies characteristic of "congested" markets, when participants

[1] By 1994, we mean the policy change applied to the cohort who entered colleges from the 1994 academic year (March 1994).

[2] We refer to a 4-year post secondary institute as a college except when it is part of the proper name of an institution. Such a college is typically referred to as a university in South Korea.

are unable to "consider enough alternative possible transactions to arrive at satisfactory ones" (Roth, 2008). Congestion frequently leads to unstable matches and subsequent pressure to change the rules of the matching system (see for example Roth and Xing, 1997). In South Korea, it became common for students who were not admitted to their first-choice colleges to wait another year and participate in the next admissions cycle rather than to enroll immediately at a second (or worse) choice college.

Partly to address this obvious inefficiency, the South Korean government changed the admission rules in 1994 to allow multiple applications, including a first phase officially designated as an early application period. This reform also introduced a centralized date for the national examination during the early application period, thereby allowing colleges to create and offer idiosyncratic and specialized examinations during the regular application period. That is, after the reform the national exam was administered to all students before the start of [early] applications, thereby allowing colleges to develop additional individualized exams to further differentiate applicants during the regular admissions process.

In this paper, we develop a model to study the incentives for colleges under these two regimes and compare the predictions of the model to stylized facts about the behavior of South Korean colleges given each set of rules. We then assess the success of the reform using aggregated data on the number of re-applicants before and after these changes to admissions rules.

Our analysis is related to several papers in the economics literatures on matching and college admissions. Chen and Kao (2014a, 2014b) develop related models of graduate school admissions in Taiwan to make the point that a second-ranked college can gain from a "single application rule" if that would enable it to draw applicants away from a top-ranked college. This result is quite similar in nature to Proposition 2 in this paper, though our model is more general than that of Chen and Kao. Che and Koh (2014) study the relationship between competition and coordination in admission policies of competing colleges who are especially concerned about over-enrollment or under-enrollment, finding that colleges have incentives to develop negatively correlated admissions practices. Though they do not emphasize this point, the Che and Koh model suggests that colleges might opt for a single application rule in order to reduce uncertainty about total enrollment.[3] The competitive advantage gained by the less preferred college in a single application system is reminiscent of strategic gains to lower ranked colleges from early application programs in the United States (Avery and Levin (2010), Avery, Fairbanks, and Zeckhauser (2003)). Hafalir et al. (2014) compare centralized admissions, by exam, in which students effectively can apply to all colleges, with an alternative regime in which each student is restricted to apply to only one college. They show that when students must decide how much costly effort to commit to the admissions process, higher ability students prefer centralized admissions in this model.

Our model is also quite related in structure to the model of Chade, Lewis, and Smith (2014) (we refer to this paper below as CLS), who study the application choices of students considering two colleges, where one college is universally agreed to be preferable to the other. The primary difference between our paper and CLS is in focus. CLS is oriented towards "application portfolios", especially the value of applying to both colleges rather than just one of them. By contrast, we are interested in the current paper about the strategic choices of the *colleges* to expand or contract application options for students. That is, we consider the situation facing colleges whose strategies interact to determine both the timing of applications and the number of applications that a student can submit.

The paper proceeds as follows. Section II provides additional background on the nature and history of South Korean college admissions. Section III describes the theoretical model. Section IV reports the results of equilibrium analysis and suggests a series of empirical hypotheses to test. Section V concludes.

[3] This was precisely the motivation for an earlier reform in 1982 in South Korea that limited students to no more than two applications under the rules described above. Prior to 1982, South Korean students could apply to an unlimited number of colleges, but it was felt that colleges faced burdensome administrative costs for keeping track of their waiting lists under those rules. (see Hwang, 1994)

II. Background on South Korean College Admissions

Graduating from a prestigious college is an effective and popular way for a South Korean to improve his/her status (Sorensen 1994, and Lee 2007).[4] Competition among students is intense to gain admission to a prestigious college, and many high school graduates are willing to spend an extra year in prep school in order to get an extra chance to apply to a highly ranked college. Perhaps because of this intense social interest in college choice, the South Korean government has been deeply involved in designing college admissions systems and regulating the admissions policies of both public and private colleges.

College rankings are fairly well-agreed upon among South Koreans and stable across time, which can be shown from the quality of applicants to each college and from evaluation by third party agencies similar to the US News and World Report annual rankings. Seoul National University (herein, Seoul National) is considered the best, followed by the second group of colleges, which includes Yonsei, Korea, KAIST, and Postech. The third group of colleges, considered to rank right below these four colleges, includes Sogang, Hanyang, Seongkyunkwan, Ewha, Pusan, Kyungbook, Hankook Foreign Language, Joongang, and Kyunghee universities.[5] See Online Appendix 1.1 for details.

From 1982 to 1993, the South Korean government conducted national exams twice a year and required all colleges to make admissions decisions according to a composite index based on the nationwide exam score and high school performance.[6] After some year-to-year modifications from 1982 to 1987, the Korean government settled on a stable set of rules that were in place from 1988 to 1993, as shown in Panel A of Figure 1.

In this system, the South Korean government announced the two exam dates (typically one in January, the other in February) and then colleges announced how they

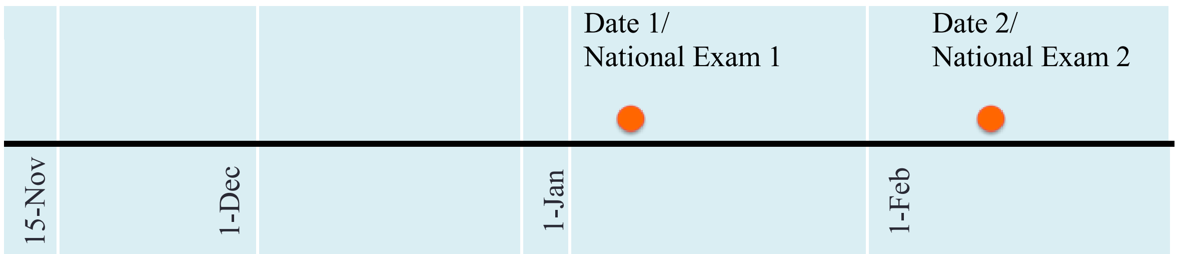
[4] Lee (2007) reports that in 2003, 48 percent of the CEOs of the Hankyung's top 81 South Korean firms had been undergraduates at Seoul National University (which accounts for only 0.4 percent of South Korean college graduates) and that an additional 26 percent of CEOs of these firms were undergraduates at Yonsei or Korea University. By contrast, he finds that in 2004, 17 percent of CEOs of S&P 500 firms were graduates of the top ten ranked colleges in the United States.

[5] These rankings refer only to the main campuses of these colleges. Several of these top 13 ranked colleges have additional affiliated campuses that typically operate independently and have much lower prestige.

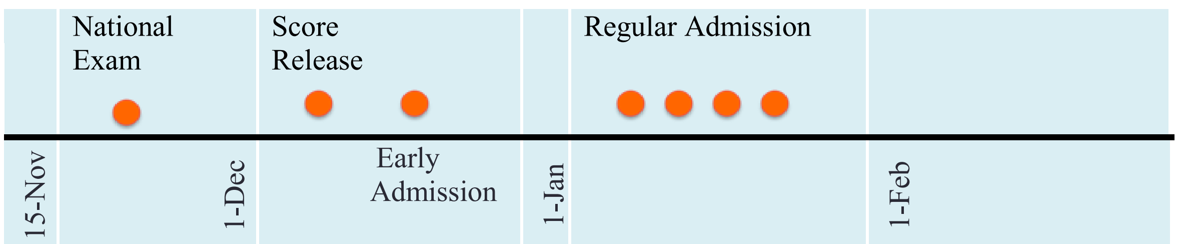
[6] In theory, colleges were allowed to conduct interviews and to include the results as up to 10 percent of the composite index. In practice, however, such interviews had little effect on admission decisions (Hwang, 1994).

Figure 1 Time Line

Panel A: 1988 to 1993 Academic Year



Panel B: 1994 to 2001 Academic Year



would allocate their seats between the two exam dates at the beginning of the academic year. Each student was restricted to a maximum of two applications, one per national examination date. Each application specified a single program of study at a particular college and the candidate was required to take the exam at that particular college as part of the application. In practice, Date 1 (early January) had the flavor of "early decision" in the United States system, because students were required to enroll if admitted in that round, while Date 2 (February) had the flavor of a last-chance "scramble." Since most high-ranked colleges allocated all of their seats to Date 1, in essence, students could only apply to a single program at a high-ranked college.[7]

In 1994 the South Korean government introduced a series of reforms for applications. These reforms had three major goals: (1) changing the format of the national exam to emphasize complex reasoning skills rather than memorization; (2) promoting the autonomy of individual colleges in admissions decisions by allowing

[7] Similarly, in the United Kingdom, applicants are restricted to a single application to either Cambridge or Oxford University. Further, this application must specify a particular college (one of the more than 60 colleges at the two universities) and a particular program of study at that college. http://www.ucas.com/how-it-all-works/undergraduate/filling-your-application

institution-specific examinations in part of the admissions process; (3) providing more application options for students to reduce the number of students enrolling in prep school and applying again the following year.[8]

These new rules changed the timing and location of the national exam, introduced a system of early admissions, expanded the number of possible regular admission dates from two to four, and allowed each college to administer a specialized exam as part of a regular application. Under the rules of the revised system, students first took the nationwide exam at a neighborhood public school in mid-November and learned their scores prior to submitting an application to any college. As in the previous system, each application was to a single program of study at a particular college. Colleges specified how many seats in the entering class to allocate to early admission (it was possible to choose not to participate in early admissions by allocating zero seats to it) and then allocated all remaining seats across the four regular application dates.

Panel B of Figure 1 shows the timeline that was in place after the introduction of early applications in 1994. Once a student received his/her test score on the nationwide exam, he/she decided whether to submit an early application (in mid-December) to a college that offered early admission. Early admission was binding in that a student could apply early to only one school, and was required to enroll if admitted. A student participating in regular admissions could apply to up to four schools (one school per regular admission date) and could choose from among those that admitted him/her.[9] One important difference between early and regular admission was that students took a specialized exam at each college to which they applied as regular applicants, whereas early admission was based only on high school grades and scores on the national exam.

[8] The original documents are in Korean and are available at the national archive of official government documents at http://contents.archives.go.kr. We also consulted a 1998 technical report from the South Korean Ministry of Education, "50 Years of Korean Education Policies". Weidman and Park (2000) for an overview of the South Korean college admission system written in English.

[9] There were policy debates over providing students even more opportunities for college applications instead of giving them up to 5 chances (early admission and four applications in regular admission). However, there was major resistance from colleges, based on several concerns, including the possibility of "losing face," "congestion," and lack of applications to low-ranked colleges. (http://magazine.kcue.or.kr/last/popup.html?vol=99&no=476 http://www.snujn.com/site/art_view.html?id=878) There may also have been some institutional memory of the problems with the system prior to 1982, when students were allowed to apply to an unlimited number of colleges.

In part for this reason, a student who applied but was not admitted to a particular program as an early applicant could apply again to that same program in regular admissions.

In 2002, the government changed the application system in an attempt to promote diversity in enrollment. Early applications were limited to students who met particular eligibility criteria, such as qualifying for the Math Olympiad or residing in an underrepresented rural area. Although it was not stated explicitly, it seems plausible that this reform was intended to limit the importance of early applications. However, since the criteria for eligibility were set individually by each college, the program quickly expanded to include a wide range of applicants, as we discuss below. The rules for regular admissions have been largely unchanged from 1994 to the present, though today there are three rather than four possible dates for regular applications.

This paper focuses on the admission policies of 13 elite colleges between 1993 and 2001. While we do not study the policies of these colleges in detail beyond 2001, we view the evolution of their strategies between 2002 and the present as largely consistent with the results for the system between 1993 and 2001, as we describe in the discussion of Tables 2, 3, and 4 below.

We collected the information released by the Korean Council for University Education (KCUE) and by Seoul National and all colleges in Groups 2 and 3, excluding KAIST.[10] We omit KAIST because it is exempt from the government's college admission policy in that in addition to high school seniors (12th graders), it can accept 11th graders enrolled in science high schools without a nationwide test score.

[10] For each admission cycle, we collected press releases by those colleges every year, reported in 5 major South Korean newspapers. Such press releases include the information of the total seats, and the allocation of seats across exam dates and early application. For each college and year, we crosscheck the accuracy of the information by checking two to three different major newspapers.

II.A Stylized Facts

This information suggests the following stylized facts.

(F1) Prior to the policy change in 1994, almost all elite colleges chose the same date (Date 1) for the national exam and admissions.

Table 1 shows the number of seats each college can fill up to and the fraction of seats allocated between Dates 1 and 2 in 1993. For example, Seoul National, Korea, Yonsei, and Postech selected their students entirely from Date 1, as did the majority of the group 3 colleges. Although several colleges selected students from both Dates 1 and 2, they still filled the majority of their seats on Date 1.

Table 1 Distribution of Seats Before the Policy Change (1993)

Group	College	Seats	Date 1	Date 2
1	Seoul National	4,905	100%	0%
2	Korea	3,930	100%	0%
	Yonsei	3,930	100%	0%
	Postech	300	100%	0%
3	Sogang	1,700	100%	0%
	Ewha women's	3,670	100%	0%
	Pusan	4,370	100%	0%
	Kyungbook	4,370	100%	0%
	Joongang	2,315	100%	0%
	Hanyang	3,320	79%	21%
	Kyunghee	2,000	77%	23%
	Seongkyunkwan	3,850	69%	31%
	Hankook	1,730	50%	50%

(F2) After the policy change in 1994, schools just below the very top chose a different (regular) admissions date than the date chosen by the top-ranked school, Seoul National.

Although the government specified four separate possible dates for regular admissions, most of the top-ranked colleges chose a single date for regular admissions in each year during this time period. For example, in 1994 and 1995, all 13 colleges conducted regular admissions on just a single date, though not all chose the same date. Similarly, in 2000 and 2001, 10 of these 13 colleges conducted regular admissions on just a single date and two of the others offered a clear majority (between 70 and 100 percent) of their regular admissions seats on a single date.

Table 2 identifies the date for which each of these 13 colleges offered the majority of its regular admissions seats from 1994 to 2001. (See Online Appendix 1.2 for the exact percentages of seats offered by each college in each year.) In the first two years after the policy change, 10 of these 13 colleges continued their pre-existing practice of emphasizing "Date A", the regular admissions date chosen by Seoul National.[11] However, in 1996, the third year after the reform, seven of these colleges switched from "Date A" to "Date B". From that point on, none of the Group 2 colleges and at most 3 of the 9 Group 3 colleges offered "Date A" as its primary date for regular admissions. Despite the small sample size, this reduction from 75% in 1995 to 25% in 2001 of Group 2 and Group 3 colleges offering "Date A" as the primary regular admissions date is statistically significant at the 5% level in a simple two-sample Binomial comparison.

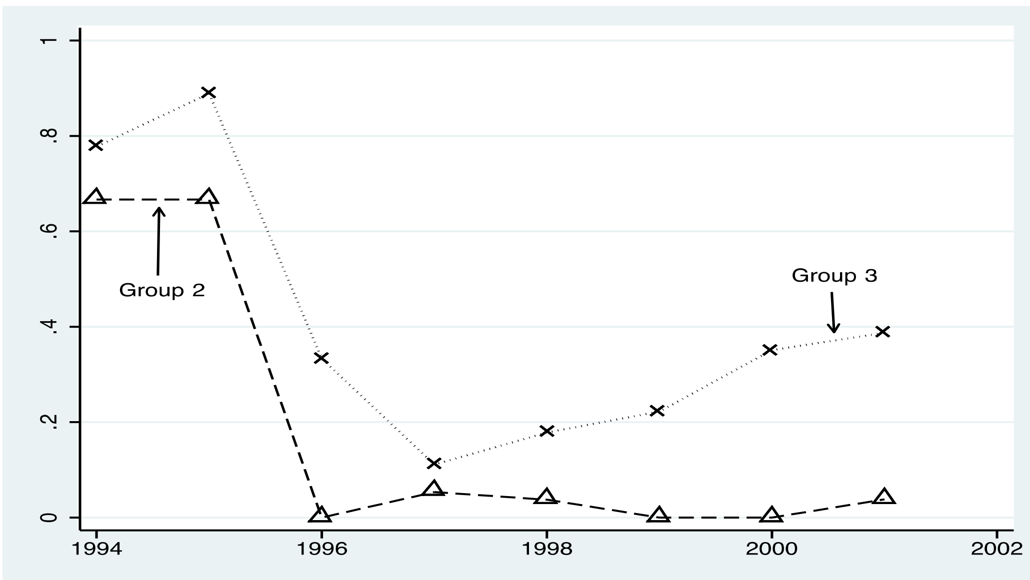
Table 2 Choice of Regular Exam Dates since 1994

		1994			1995			1996			1997			1998			1999			2000			2001		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	Seoul National	*			*			*			*			*			*			*			*		
2	Korea	*			*				*			*			*			*			*			*	
	Yonsei	*			*				*			*			*			*			*			*	
	Postech		*			*			*			*			*			*			*			*	
3	Sogang	*			*				*			*		*			*			*			*		
	Ewha women's	*			*				*			*			*			*			*			*	
	Pusan	*			*				*			*			*			*			*			*	
	Kyungbook	*			*				*				*		*			*			*			*	
	Joongang	*			*			*			*			*			*			*			*		
	Hanyang	*			*				*			*			*			*			*			*	
	Kyunghee	*			*			*				*			*			*			*			*	
	Seongkyunkwan			*	*			*				*			*			*			*			*	
	Hankook			*			*			*			*			*			*	*			*		

[11] For simplicity in presentation, we define "Date A" as the regular admissions date chosen by Seoul National University, "Date B" as the regular admissions date chosen by Postech, and "Date C" as a combination of the remaining two regular admissions dates specified by the government.

Figure 2 plots the average percentages of regular admissions seats allocated to Date A in each group and year, weighting each college equally.[12] From 1996 to 2001, a negligible fraction of regular admission seats were allocated to Date A in Group 2. For Group 3, the average fraction of regular admissions seats allocated to Date A decreased from over 80 percent to less than 40 percent in 1996 and then settled around 30 percent.

Figure 2 Regular Admission: Fraction of Seats Allocated to Date A (Seoul National)



(F3) Early applications gained steadily in importance from 1994 to 2001. Seoul National, the top-ranked college, was among the last colleges to adopt early admissions.

Table 3 presents the share of seats each college allocated to early admission in each year from 1994 to 2001. Although 10 of the 12 competitors to Seoul National adopted early admissions immediately after the reform in 1994, they initially offered proportionally few seats to early applicants, and only one of them, Postech, enrolled 40 percent of its entering class early that year. All twelve of these colleges increased their use of early admissions over time, and by 2001, Hanyang was the only one that enrolled less than 40 percent of its entering class early. As a group, these 12 colleges almost tripled their use of early admissions between 1994 and 2001, offering an average of 16.8% of their seats

[12] The results are similar if we use a weighted average based on the number of seats offered by each college.

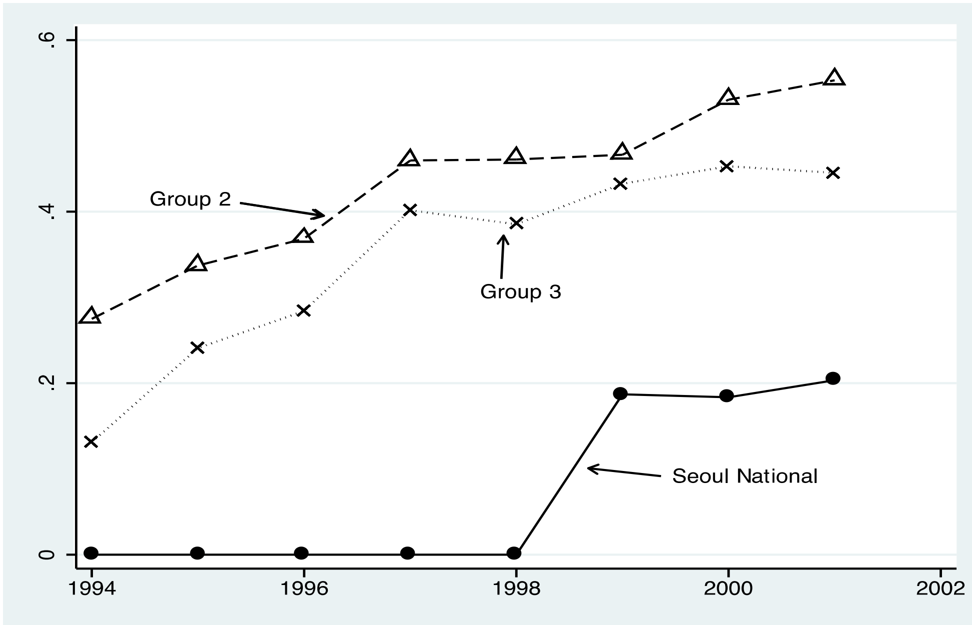
Table 3 Percent of Seats Allocated to Early Admission since 1994

		1994	1995	1996	1997	1998	1999	2000	2001
1	Seoul National	0	0	0	0	0	19	18	20
2	Korea	24	24	30	37	46	41	49	54
	Yonsei	19	37	41	50	53	59	60	57
	Postech	40	40	40	51	40	40	50	56
3	Sogang	25	30	40	49	35	41	44	46
	Ewha women's	12	32	33	44	44	49	48	48
	Pusan	0	0	6	27	43	43	47	43
	Kyungbook	0	9	27	48	50	50	49	53
	Joongang	9	35	34	45	31	33	44	46
	Hanyang	18	26	35	41	45	43	42	37
	Kyunghee	22	13	13	38	38	46	44	41
	Seongkyunkwan	13	32	38	41	36	45	44	47
	Hankook	20	39	30	28	24	39	46	40

Figure 3 graphs the fraction of seats allocated to early admission by group and year. The percentage of seats offered to early applicants by both Group 2 and Group 3 colleges increased fairly steadily over time, and by 1999 colleges in both groups were offering an average of more than 40 percent of their seats to early applicants. Interestingly, Seoul National began offering early admissions only in 1999, after its primary competitors were already emphasizing early admissions to a considerable degree. This choice mirrors changes in early admission practice in the United States, where Harvard and Princeton eliminated their early application programs in 2006, but then reinstated them in 2011. Administrators from both these colleges explained a primary reason for this change in 2011 was that not offering early applications was putting their institutions at a competitive disadvantage. For example, Michael Smith, Dean of the Faculty of Arts and Sciences at Harvard, commented: "We looked carefully at trends in Harvard admissions these past years and saw that many highly talented students, including some of the best-prepared low-income and underrepresented minority students, were choosing programs with an early-action option, and therefore were missing out on the opportunity to consider Harvard".[13]

[13] "Early Action Returns," Harvard Gazette, February 24, 2011, http://news.harvard.edu/gazette/story/2011/02/early-action-returns/. See also "Princeton to Reinstate Early Admissions Program," Feburary 24, 2011, http://www.princeton.edu/main/news/archive/S29/85/15K32/

Figure 3 Percentage of Seats Offered Through Early Admission



Although we do not have direct evidence about the decision of Seoul National to offer early admissions for the first time in 1999, the circumstantial evidence suggests that it did so in response to competitive pressure. Interestingly, it appears that its competitors responded by emphasizing early admission to an even greater degree. The three Group 2 competitors to Seoul National offered an average of 46 percent of seats to early applicants in 1997, 1998, and 1999, but then increased this percentage to 53 and 56 percent in 2000 and 2001, the two years after Seoul National first offered early admissions.

(F4) The rule change in 2002 had little effect on the prevailing trends in admission practice. Early admissions has continued to grow in importance to the present, while schools just below the very top continue to choose a different (regular) admissions date than the date chosen by the top-ranked school, Seoul National.

Table 4 presents the share of seats each college allocated to early admission and to each of the regular admission dates in 2014 and 2015. Whereas these colleges allocated an average of 45 percent of seats to early applicants in 2000 and 2001, they now allocate an average of 68 percent of seats to early applicants today. In addition, the second-tier colleges, Korea and Yonsei continue to choose a different regular admission date than the top ranked college, Seoul National.

Table 4 Percent of Seats Allocated to Admission/Exam Days: 2014 and 2015

		2014				2015			
		Early	Regular			Early	Regular		
			A	B	C		A	B	C
1	Seoul National	82	18	0	0	75	25	0	0
2	Korea	69	0	31	0	71	0	29	0
	Yonsei	55	0	45	0	64	0	36	0
	Postech	100	0	0	0	100	0	0	0
3	Sogang	69	31	0	0	62	38	0	0
	Ewha women's	64	0	36	0	62	38	0	0
	Pusan	61	20	19	0	55	23	23	0
	Kyungbook	62	19	20	0	57	21	22	0
	Joongang	72	14	12	3	69	18	12	2
	Hanyang	71	9	20	0	78	6	15	0
	Kyunghee	56	25	14	6	61	19	20	0
	Seongkyunkwan	69	12	18	0	76	10	14	0
	Hankook	60	14	8	17	54	9	23	13

(F5) The 1994 reform somewhat reduced, but by no means eliminated the phenomenon of repeat applications.

Table 5 lists the number of high school seniors and repeat applicants to (all) four-year colleges in South Korea from 1990 to 2001. An average of 318,543 students – more than half of the high school seniors from the prior year[14]- were repeat applicants each year in the four years prior to the reform. In 1994, the first year after the reform, there was an immediate drop of about 25% in the number of repeat applicants, but some potential repeat applicants may have been discouraged by the change in format of the national exam that went along with the reform. After excluding 1994, there were an average of 260,288 repeat applicants per year from 1995 to 2001, or about an 18 percentage point decline per year from the four years just prior to the reform. Despite the small sample

[14] This computation assumes that students reapply at most once, which is not necessarily the case.

size, this decline in the absolute number of repeat applicants on average per year before and after the 1994 reform is significant at the 1% level in a two sample t-test.

Table 5 Fraction of Repeat Applicants

Year	No. High School Seniors	No. Repeat Applicants	Total Seats in College Admission	Overall Competition [(1)+(2)]/(3)	% of Repeat Applicants (2)/[(1)+(2)]	% of Repeat relative to previous year's non-admits $(2)_t/[(1)+(2)-(3)]_{t-1}$
	(1)	(2)	(3)	(4)	(5)	(6)
1990	597,456	283,890	199,380	4.420	32.2	-
1991	610,586	331,212	204,995	4.594	35.2	48.6
1992	594,500	336,861	215,565	4.321	36.2	45.7
1993	602,144	322,208	224,159	4.124	34.9	45.0
1994	526,703	248,102	236,653	3.274	32.0	35.4
1995	492,471	276,262	257,859	2.981	35.9	51.3
1996	528,690	300,546	271,015	3.060	36.2	58.8
1997	546,172	265,817	298,328	2.722	32.7	47.6
1998	612,379	245,791	304,265	2.820	28.6	47.9
1999	622,964	231,072	311,590	2.741	27.1	41.7
2000	632,171	248,930	337,721	2.609	28.3	45.9
2001	603,224	253,601	339,209	2.526	29.6	46.7

Two demographic changes complicate the analysis of pre- and post-reform data. First, Table 5 indicates a conspicuous decline in the number of high school seniors from 1993 to 1994-1997, the first four years after the reform. It would be predictable, presumably with a one-year lag, to find fewer repeat applicants in this period when there were fewer new applicants than the pre-reform period. The decline in the number of high school seniors eventually reversed, however, and there were even more high school seniors in each year from 1998 to 2000 (and almost as many in 2001) as in any year from 1990 to 1993. Further, there were even fewer repeat applicants in this period from 1998 to 2001 than in the first four years after the reform.[15]

Second, Table 5 indicates that the total admission seats available increased every year during the sample period, resulting in an increase in more than 50% in available places from 1990 to 2001. Presumably, this expansion of admission seats would yield a

[15] Restricting the post-reform sample to 1998 to 2001, with or without incorporating a one year lag for repeat applicants to appear in the data, we still find a significant decline in the absolute number of repeat applicants per year by comparison to the pre-reform years of 1990 to 1993.

result where more students would be placed in desirable college seats each year – if so, it would be predictable to find fewer repeat applicants in subsequent years as a result. One straightforward approach to account for the expansion of admission seats is to find the ratio of repeat applicants in one year to the number of applicants who applied the previous year but did not enroll (the difference between total number of applicants and total number of seats).[16] By this approach, we find only a very small (and clearly insignificant) change as a result of the reform: 46.4 percent of unmatched students in 1990 to 1992 and 44.7 percent of unmatched students in 1998 to 2000 returned as repeat applicants the following year. At the same time, this approach presumably overstates the importance of the expansion of seats, for it is likely that the new seats were disproportionately placed at low-ranked colleges and that many of them were not filled.

Taking these observations together, we find little evidence that the reduction in the number of repeat applicants after the 1993 reform could be explained by changes in the number of high school seniors each year, but it is possible that the expansion of the number of places in colleges could explain at least some of this reduction.

III. The Model

Suppose that there are two colleges and a continuum of ex ante identical students. All students have identical preferences with utility $\mathbf{u_1}$ = 1 for attending College 1 and utility $\mathbf{u_2}$ for attending College 2, where 0 < $\mathbf{u_2}$ < 1. Each college wishes to enroll the same proportion $\mathbf{K}$ < ½ of all students. Applications are costless, so if possible, each student applies to both colleges.

At the start of the application process, the only information differentiating one student from another is high school grade point average, which we denote by $\mathbf{x_i}$ for student **i**. During the application process, each student takes the national college entrance exam and we denote student **i**'s score on this exam by $\mathbf{s_i}$. We assume further that colleges agree on a subsequent ranking of students based on an index, $\mathbf{y_i} = \mathbf{y}(\mathbf{x_i}, \mathbf{s_i})$, which summarizes the information contained in high school grades and the national exam score, with all values $\mathbf{x_i}$, $\mathbf{s_i}$, $\mathbf{y_i}$ scaled to range from 0 to 1.

Student **i** provides utility **v**ij to the college by enrolling at college **j**, where **v**ij

[16] This computation assumes that all available seats are filled in a given year by applicants from that year.

ranges from 0 to 1 . We assume that a student's grades, $\mathbf{x_i}$, national exam score $\mathbf{s_i}$, and specialized exam score $\mathbf{s_{ij}}$ at college $\mathbf{j}$ (if available) $\mathbf{s_{ij}}$ combine to identify $\mathbf{v_{ij}} = \mathbf{z(y_i, s_{ij})}$, where $\mathbf{z}$ is continuous, differentiable and strictly increasing in each argument, while $\mathbf{s_{i1}}$ and $\mathbf{s_{i2}}$ are identically distributed and conditionally independent given $\mathbf{x_i}$ and $\mathbf{s_i}$.[17] We further assume that there is a joint distribution of values $\mathbf{f(x_i, s_i, v_{ij})}$ such that the conditional distributions $\mathbf{g(y_i \mid x_i)}$ and $\mathbf{h(v_{ij} \mid y_i)}$ satisfy the strict monotone likelihood ratio property: for $\mathbf{y_i} < \mathbf{y_i'}$ and $\mathbf{v_{ij}} > \mathbf{v_{ij}'}$

$$\mathbf{h}(\mathbf{v_{ij}} \mid \mathbf{y_i}) / \mathbf{h}(\mathbf{v_{ij}'} \mid \mathbf{y_i}) \quad > \quad \mathbf{h}(\mathbf{v_{ij}} \mid \mathbf{y_i'}) / \mathbf{h}(\mathbf{v_{ij}'} \mid \mathbf{y_i'}).$$

Similarly, for $\mathbf{x_i} > \mathbf{x_i'}$, $\mathbf{y_i} > \mathbf{y_i'}$,

$$\mathbf{g}(\mathbf{y_i} \mid \mathbf{x_i}) / \mathbf{g}(\mathbf{y_i'} \mid \mathbf{x_i}) \quad > \quad \mathbf{g}(\mathbf{y_i} \mid \mathbf{x_i'}) / \mathbf{g}(\mathbf{y_i'} \mid \mathbf{x_i'}).$$

To rule out boundary issues, we assume that all possible pairwise combinations of GPA and national test score, national test score and specialized exam score take strictly positive densities: $\mathbf{f(x_i, s_i, s_{ij})} > \boldsymbol{\varepsilon}$ for each $(\mathbf{x_i, s_i, s_{ij}})$ and similarly $\mathbf{g(y_i \mid x_i)} > \boldsymbol{\varepsilon}$ for each $(\mathbf{x_i, y_i})$; $\mathbf{h(v_{ij} \mid y_i)} > \boldsymbol{\varepsilon}$ for each $(\mathbf{y_i, v_{ij}})$, where $\boldsymbol{\varepsilon}$ is a known positive constant.

We use this general framework to study the incentives for colleges and students using equilibrium analysis for each of two different sets of rules. We label the initial set of rules, which were in place until 1994, as "Regime 1". In Regime 1, we assume that student $\mathbf{i}$ knows $\mathbf{x_i}$ at the start of the admissions process, prior to submitting any applications, and that admissions decisions at each college are based on $\mathbf{y_i}$ values. College 1 moves first and announces which one of the two possible dates it will offer. Then College 2 responds by announcing its choice of the two possible admission dates. Once the colleges have announced their admission timetables, students decide which college to apply to on the first date and the admissions process moves along accordingly from there. Any student admitted on Date 1 must attend the college where he/she applied; a student who was not admitted on Date 1 can apply again on Day 2. We prove

[17] The assumption that $\mathbf{s_{i1}}$ and $\mathbf{s_{i2}}$ are conditionally independent given $\mathbf{x_i}$ and $\mathbf{s_i}$ essentially means that the specialized exam score at one college is not relevant to the student's likely performance at the other college. We make this extreme assumption to emphasize the differential implications of (1) common information about a student's underlying academic preparation and (2) idiosyncratic information about the value of a student-college match for the strategies selected by colleges.

in Online Appendix 3 that Proposition 2, the key result for Regime 1, also holds in the case where each college can admit some students on each date.[18]

We label the new system, which was put in place in 1994 as "Regime 2". In Regime 2, we assume that student **i** knows $\mathbf{y_i}$ at the start of the admissions process, prior to submitting any applications, that early admissions decisions at each college are based on $\mathbf{y_i}$ and that regular admissions decisions at college **j** are based on $\mathbf{v_{ij}}$ values (as revealed by specialized exams at each college). College 1 moves first and announces both the number of students it will admit early and the regular admissions date it will use to fill the remainder of its entering class, then College 2 responds by announcing its allocation of seats to early and regular admissions along with its regular admissions date. Once these admission schedules are announced, students decide whether to apply early to one college and the admissions process moves along accordingly from there. In this regime, early application is binding, so that any student admitted early must attend the college where he/she applied early, but regular admission is not binding. A regular admit to one college can still apply to the other college if it still has admission dates/seats available; a student who is admitted in regular admissions to both colleges can choose between them (and will choose College 1, since we assume $\mathbf{u_1} > \mathbf{u_2}$ for all students).

We focus on equilibrium in the timetables announced by the two colleges under each regime, along with the resulting allocation of students to colleges in those equilibria. We use subgame perfect equilibrium as our equilibrium concept throughout the paper for competition between College 1 and College 2 since we assume that College 1 moves first and that College 2 observes College 1's choices and then moves second.

[18] Under the rules for Regimes 1 and 2, colleges were allowed to allocate seats for admission on multiple regular admission dates, but in practice, as shown in Table 2 and Online Appendix Table A.1, the 13 highest-ranked colleges almost always allocated seats to just one regular admissions date.

IV. Equilibrium Analysis

A. Information Structure and the Monotone Likelihood Ratio Property

We record several properties of the relationship between $\mathbf{x_i}$ and $\mathbf{y_i}$ – all related to the Monotone Likelihood Ratio Property – that are fundamental to our equilibrium analysis. These properties, especially Properties 1 and 2 are standard,[19] but we include them with proofs in Online Appendix 2 for the sake of being comprehensive. Since both ($\mathbf{x_i}$, $\mathbf{y_i}$) and ($\mathbf{y_i}$, $\mathbf{v_{ij}}$) satisfy the strict Monotone Likelihood Ratio Property, these four properties apply to both pairs of variables.

Property 1: The distribution of application quality ($\mathbf{y}$) given high school grades ($\mathbf{x}$) First Order Stochastically Dominates the distribution of application quality ($\mathbf{y}$) given test score $\mathbf{x'}$ if $\mathbf{x} > \mathbf{x'}$.

Property 2: $\mathbf{E(y \mid x) \geq E(y \mid x')}$ if $\mathbf{x > x'}$.

Property 3: $\mathbf{E}(\mathbf{y} \mid \mathbf{x}, \mathbf{y} < \mathbf{r})$ is increasing in $\mathbf{x}$ for any constant $\mathbf{r}$.

Property 4: For $\mathbf{r_1} > \mathbf{r_2}$, the ratio $\mathbf{P_x(y > r_1) / P_x(y > r_2)}$ is increasing in $\mathbf{x}$.

B. Equilibrium Analysis without Early Applications

In Regime 1, the colleges agree on a common ranking of all students based on $\mathbf{y_i}$-values, though these values are not revealed to students until after they receive admission decisions. Denote $\mathbf{y_{(M)}}$ to the denote a threshold value that is implicitly defined by the equation $\mathbf{F(y_{(M)})} = \mathbf{M}$. If College 1 chooses Date 1 and College 2 chooses Date 2, then all students apply to College 1 first, the top $\mathbf{K}$ (those with $\mathbf{y_i} \geq \mathbf{y_{(K)}}$) are admitted and enroll at College 1, and the next $\mathbf{K}$ students (those with those with $\mathbf{y_{(2K)}} \leq \mathbf{y_i} < \mathbf{y_{(K)}}$) enroll subsequently at College 2.[20]

[19] In fact, MLRP Property 1 was documented in Proposition 1 of Milgrom's (1981) seminal paper, while MLRP Properties 2 and 3 are closely related to Proposition 4 in that same paper.

[20] Here, the top $\mathbf{K}$ students are those with values above threshold $\mathbf{y_{(K)}}$ which is implicitly defined by $\mathbf{F_y(y_{(K)})}$ = 1-$\mathbf{K}$ and similarly, the top 2$\mathbf{K}$ students are those with values above threshold $\mathbf{y_{(2K)}}$ which is implicitly defined by $\mathbf{F_y(y_{(2K)})}$ = 1-2$\mathbf{K}$.

If instead, both College 1 and College 2 choose to admit all students on Date 1, then the admissions process amounts to a "Single Application Game", where each student can apply to at most one of the two colleges. Proposition 1 shows that the equilibrium of the Single Application Game in Regime 1 takes a natural monotonic form described by Chade, Lewis, and Smith as a "robust sorting equilibrium", where both colleges use threshold admission rules and the most promising students apply to College 1.[21] A similar result applies in Regime 2 when student **i** knows $\mathbf{y_i}$ at the time of application and an application reveals the value of $\mathbf{v_{ij}}$ to College **j**.

Proposition 1: Suppose that student **i** knows $\mathbf{x_i}$ at the time of application and that $\mathbf{y_i}$ will be revealed by that student's application. If students are limited to a single application, there is a unique admissions equilibrium with thresholds $\mathbf{x^*}$, $\mathbf{y^*_{C1}}$, $\mathbf{y^*_{C2}}$, where students with $\mathbf{x_i \geq x^*}$ apply to College 1, students with $\mathbf{x_i < x^*}$ apply to College 2, College 1 admits students with $\mathbf{y_i \geq y^*_{C1}}$ and College 2 admits students with $\mathbf{y_i \geq y^*_{C2}}$.

Proof: See Appendix.

To attract applicants, College 2 must adopt a lower admissions threshold than College 1 in equilibrium of the Single Application Game. Thus, since the colleges enroll a total of 2K students, College 1 adopts a threshold above and College 2 adopts a threshold below $\mathbf{y_{(2K)}}$ in any equilibrium of the Single Application Game.[22] Thus, the equilibrium allocation of students to colleges in the Single Application Game is not efficient, as some students with $\mathbf{y_i < y_{(2K)}}$ enroll at College 2 and some students with $\mathbf{y_i > y_{(2K)}}$ do not enroll at either college (this second group of students all apply to College 1 and are rejected).[23]

Given the choice of admission dates in Regime 1 (where there is no possibility of early application), College 2 faces a tradeoff. If it opts for the Single Application Game

[21] In fact, our Proposition 1 mirrors Proposition 1 of Chade, Lewis, and Smith, though in a different context, as their model assumes costly applications and endogenous choices of the number of applications submitted by each student.

[22] If both colleges adopt admission thresholds above $\mathbf{y_{(2K)}}$, they combine to admit strictly fewer than 2K students, and similarly if both colleges adopt admission thresholds below $\mathbf{y_{(2K)}}$, they combine to admit strictly fewer than 2K students. We assume that $\mathbf{u_2}$ is sufficiently large that College 2 is able to fill its class in equilibrium of the Single Application Game.

[23] Here, we assume that assortative matching of students to colleges is socially desirable.

by choosing the same admissions date as College 1, it will only attract applicants with low grades (i.e. students with $\mathbf{x_i}$ values below some cutoff $\mathbf{x^*}$). This yields one source of gains and a separate source of losses to College 2. By comparison to its ordinary allocation of students with $\mathbf{y_{(2K)}} \leq \mathbf{y_i} < \mathbf{y_{(K)}}$ when all students apply to both colleges, College 2 enrolls additional students with low grades and high test scores ($\mathbf{x_i} < \mathbf{x^*}$ and $\mathbf{y_i} > \mathbf{y_{(K)}}$), but loses some appealing students who would ordinarily enroll at College 2, but do not apply to College 2 in equilibrium of the Single Application Game ($\mathbf{x_i} > \mathbf{x^*}$, $\mathbf{y_{(K)}} > \mathbf{y_i} > \mathbf{y_{(2K)}}$). Proposition 2 shows that this tradeoff for College 2 between these gains and losses turns on the value of $\mathbf{u_2}$. If $\mathbf{u_2}$ is sufficiently large, then College 2 gains by choosing the same admissions date as College 1 in Regime 1, but otherwise, College 2 prefers to choose a different admissions date than College 1.[24]

Intuitively, when $\mathbf{u_2}$ is relatively small, College 2 attracts few applicants in the Single Application Game and must relax its admissions threshold considerably to fill its entering class. But at the other extreme, when $\mathbf{u_2}$ is close to $\mathbf{u_1}$, College 2 can compete successfully for applicants in the Single Application Game in Regime 1 and does not need to relax its admissions threshold very much from $\mathbf{y_{(2K)}}$ when it offers the same admissions date as College 1.

Proposition 2: In Regime 1, if each college must choose either Date 1 or Date 2 to admit all students, then there is a threshold value $\mathbf{u^*}$ such that College 2 will choose the same admissions date as College 1 if $\mathbf{u_2} > \mathbf{u^*}$ and will choose a different admissions date than College 1 if $\mathbf{u_2} < \mathbf{u^*}$.

Proof: Assume that College 1 chooses Date 1. If College 2 chooses Date 2, then students apply to both colleges and College 1 takes those with the highest $\mathbf{y_i}$ values. The admission cutoffs for the colleges are implicitly defined by the equations $F(\mathbf{y_{(K)}}) = 1\text{-}\mathbf{K}$ and $F(\mathbf{y_{(2K)}}) = 1\text{-}2\mathbf{K}$, so that College 2 enrolls students with $\mathbf{y}$-values between $\mathbf{y_{(2K)}}$ and $\mathbf{y_{(K)}}$, while College 1 enrolls students with $\mathbf{y}$-values between $\mathbf{y_{(K)}}$ and 1.

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[24] This result matches the qualitative results of Chen and Kao (2013, 2014) but with continuous distributions of both applicant signals ($\mathbf{x_i}$) and assessments of applicant ability ($\mathbf{y_i}$) by schools as opposed to binary distributions .

If both colleges choose Date 1, then as shown in Proposition 1, there is a robust sorting equilibrium where the threshold (in an interior equilibrium) value $\mathbf{x}$ for students to apply to College 1 is implicitly defined by the equation

$$P(\mathbf{y_i} \geq \mathbf{y_{C1}} \mid \mathbf{x_i} = \mathbf{x^*}) / P(\mathbf{y_i} \geq \mathbf{y_{C2}} \mid \mathbf{x_i} = \mathbf{x^*}) \quad = \quad \mathbf{u_2}.$$

We observed in the proof of Proposition 1 that $\mathbf{x^*}$ is strictly increasing in $\mathbf{u_2}$, so College 2 strictly gains applicants and thus strictly gains in utility in equilibrium as $\mathbf{u_2}$ increases. As College 2 approaches College 1 in utility (i.e. $\mathbf{u_2} \to 1$), (1) the cutoffs for admission must become approximately equal so that some students are willing to apply to each college and (2) both admission thresholds must tend to $\mathbf{y_{(2K)}}$ to ensure that a total of 2$\mathbf{K}$ students are admitted overall. That is, $\mathbf{y_{C1}}(\mathbf{x})$ and $\mathbf{y_{C2}}(\mathbf{x}) \to \mathbf{y_{(2K)}}$ as $\mathbf{u_2} \to 1$, so the set of students admitted to at least one of College 1 or College 2 is exactly the same as in the case above where the colleges offer different application dates.[25] But College 2 gets the lesser half of the group of admitted students with different application dates, but enrolls at least some of the top half of admitted students (given the assumption that $\mathbf{f}(\mathbf{x_i}, \mathbf{y_i})$ is strictly positive) in the limiting equilibrium when both colleges offer the same application date with $\mathbf{u_2} \to 1$. Thus College 2 prefers to choose the same application date as College 1 in the limit as $\mathbf{u_2} \to 1$. Further, since College 2 has strictly increasing utility in $\mathbf{u_2}$, there must be some cutoff $\mathbf{u_2^*}$ such that College 2 prefers to choose the same application date as College 1 iff $\mathbf{u_2} > \mathbf{u_2^*}$. END OF PROOF

One critical difference between Regime 1 and Regime 2 is that students take the national exam and learn their $\mathbf{y_i}$ values prior to application date 1. Under these conditions, College 2 prefers to choose a different admissions date than College 1 in order to avoid the "Single Application Game" in Regime 2.

Proposition 3: If there is no early application program in Regime 2, then College 2 prefers to choose a different regular application date than College 1 for all values of $\mathbf{u_2}$.

[25] Apart from the limit as $\mathbf{u_2} \to \mathbf{u_1}$, $\mathbf{y_{C2}} < \mathbf{y_{C1}}$ and so it must be that $\mathbf{y_{C2}} < \mathbf{y_{(2K)}} < \mathbf{y_{C1}}$, meaning that some students with $\mathbf{y} < \mathbf{y_{(2K)}}$ enroll at College 2, but some students with $\mathbf{y} > \mathbf{y_{(2K)}}$ apply to College 1 and are not admitted in a single application equilibrium.

Proof: If Colleges 1 and 2 both choose Date 1, the students with the highest $\mathbf{s_i}$ values apply to College 1 and fewer than 1-**K** students apply to College 2. If College 1 chooses Date 1 and College 2 chooses Date 2, then College 2 gets more applications than before (from the 1-**K** students with $\mathbf{v_{i1}}$ values below College 1's cutoff) and also a better selection of applicants (those with lowest values of $\mathbf{v_{i1}}$ rather than $\mathbf{s_i}$). So College 2 unambiguously gains by choosing a different date than College 1. END OF PROOF

Without early applications, Regimes 1 and 2 are superficially similar; in each case, students possess some information about themselves beforehand, and reveal additional information to the colleges with their applications. The distinction is that in Regime 1, each application reveals information of common interest to the colleges ($\mathbf{y_i}$), whereas in Regime 2, it reveals information of idiosyncratic interest ($\mathbf{v_{i1}}$ and $\mathbf{v_{i2}}$) to the colleges.

College 2 is operating at a competitive disadvantage, so it will always suffer from negative selection in the application process. In Regime 2, it has the option of negative selection based on $\mathbf{y_i}$ if it chooses Date 1 and competes directly with College 1 for applicants, or negative selection based on $\mathbf{v_{i1}}$ if it chooses Date 2 and only attracts applicants who were not previously admitted to College 1. From the perspective of College 2, however, $\mathbf{v_{i1}}$ is simply a noisy version of $\mathbf{y_i}$, since it depends on the specialized exam score at College 1, which is assumed not to be relevant to the student's performance at College 2. So College 2 prefers negative selection of applicants based on $\mathbf{v_{i1}}$ rather than $\mathbf{y_i}$. Further, College 2 gets a larger proportion of applicants by choosing a different admissions date than by choosing the same admissions date as College 1. So College 2 gets a larger volume of applicants and a preferable sorting of applicants in Regime 2 by choosing Date 2 rather than competing directly with College 1 on Date 1. (By contrast, as described above, College 2 faces a tradeoff between larger volume of applicants on Date 2 but preferable sorting of applicants on Date 1 in Regime 1.) So both incentives induce College 2 to choose a different regular admissions date than College 1 in Regime 2.

One interesting example to consider is the extreme case where almost all of a student's value to a college is revealed by grades and the national exam score so that $\mathbf{v_{ij}} \approx \mathbf{y_i}$. Then admission decisions in Regimes 1 and 2 are based on essentially the same information about applicants. However, given the difference in timing of the national exam in the two regimes, applicants would still have much more information at the time of application in Regime 2 than in Regime 1, and that change of information causes College 2 to wish to choose a different regular admissions date than College 1. In the limiting case in this example where $\mathbf{v_{ij}} \rightarrow \mathbf{y_i}$, College 2 would not receive any applications from students with $\mathbf{y_i} > \mathbf{y_{(K)}}$ if it chooses the same date for regular admissions as College 1 in Regime 2, and so it could still do better by choosing a different admissions date than that of College 1.

C. Equilibrium Analysis with Early Applications

We now extend the model to allow for early applications. The early application system in Korea is unusual because most of the components of admission decisions are numerical and are known to students at the time of application.

To simplify analysis, we assume that $\mathbf{u_2}$ is sufficiently large that all students would accept an early offer of admission to College 2 (even if $\mathbf{y_i} = 1$, the maximum value for a student's observed credentials at the deadline for early application) rather than attempting to gain admission to College 1 as a regular applicant. This assumption may not be too far from the situation that caused College 1, Seoul National to belatedly adopt early admissions and gradually expand the number of students it admitted early in response to the growing emphasis on early applications by its competitors, who were able to enroll through early admissions students who Seoul wished to attract.

We consider the following early application game. First, College 1 chooses a regular admissions date, then College 2 decides whether to offer the same regular admissions date or a different one. Once these regular admissions dates are set, the colleges announce their thresholds for early and regular admission and then students make their application decisions.[26] Thus, we can summarize any equilibrium by the four-tuple ($\mathbf{e_1}$, $\mathbf{r_1}$, $\mathbf{e_2}$, $\mathbf{r_2}$) where $\mathbf{e_j}$ represents the threshold value of $\mathbf{y_i}$ for early admission to college $\mathbf{j}$ and $\mathbf{r_j}$ represents the threshold value of $\mathbf{v_{ij}}$ for regular admission to college $\mathbf{j}$.

[26] We assume that both colleges offer early application programs but also allow for the possibility that each may decide not to admit any early applicants. /

We identify properties of the early application equilibria under both Regime **2S**, where College 2 chooses the same regular application date as College 1 so that only a "Single" regular application per student is possible, and under Regime **2M**, where College 2 chooses a different regular application date than College 1 so that "Multiple" regular applications per student are possible. We then compare the results for College 2 in equilibrium under these separate regimes in order to determine whether it would choose the same regular application date or a different regular application date from that of College 1.

We prove equilibrium existence for the separate subgames corresponding to Regimes **2M** and **2S** in Online Appendix 4. Though we only prove the existence of a unique equilibrium in Regime **2S** (when the colleges have set the same date for regular admission), we are still able to provide sharp comparative static comparisons between that equilibrium and all equilibria in Regime **2M** (when the colleges have set different dates for regular admission).

In Proposition 4, we use a revealed preference argument to show that College 2 can guarantee at least the same utility in Regime **2M** as it achieves in the unique equilibrium in Regime **2S** by simply choosing to admit the same number of early applicants in Regime **2M** as it does in the unique equilibrium of Regime **2S**. With this strategy, College 2 gets a better distribution of early admits in Regime **2M** (because $\mathbf{e_{1M}} > \mathbf{e_{1S}}$, i.e. College 1 is more selective in its early admits) and does at least as well in regular admissions in Regime **2M** as in Regime **2S**. By revealed preference, College 2 prefers its outcome in Regime **2M** than in Regime **2S** and will choose a different regular admissions date than College 1 in Regime 2.

Proposition 4: College 2 gets a higher payoff in any early application equilibrium in Regime **2M** than in the unique early application equilibrium in Regime **2S**, so will choose a different regular admissions date than College 1.

Proof: See Appendix.

Stylized Fact 3 observes that Seoul National (which corresponds to College 1 in the model) did not adopt early admissions until after its rival colleges expanded early admissions considerably. We do not attempt to provide a description of any dynamic process resulting in equilibrium in our model, so cannot address this fact directly, but can demonstrate that this stylized fact is consistent with College 1's best response function in the model. In Regime **2M**, when the colleges choose different dates for regular admissions, College 1 knows that it can enroll any applicant it wishes to admit in early admissions and also that it can enroll any remaining applicant (i.e. anyone not admitted early to College 2) it wishes to admit in regular admissions. So its best response to College 2's admissions standards depends only on College 2's early threshold. In particular, as shown in Proposition 5, College 1's best response function calls for more aggressive use of early applications (through lower threshold for early admission) when other colleges are more aggressive in their use of early applications.

Proposition 5: College 1's best response function for the early application threshold $\mathbf{e_{1M}}(\mathbf{e_{2M}})$ is increasing in $\mathbf{e_{2M}}$ and is strictly increasing whenever $\mathbf{e_{1M}}(\mathbf{e_{2M}}) < 1$.

Proof: Suppose that ($\mathbf{e_1}$, $\mathbf{r_1}$) is the best response for College 1 to some early application threshold $\mathbf{e_2}$ for College 2, so that $E(\mathbf{v_{i1}} \mid \mathbf{y_1} = \mathbf{e_1}) = \mathbf{r_1}$. Then if College 2 chooses $\mathbf{e_2'} < \mathbf{e_2}$, College 1 faces a smaller pool of regular applicants than before and would not fill its class with admission cutoffs ($\mathbf{e_1}$, $\mathbf{r_1}$). So College 1 would have to relax its admissions cutoffs to maintain its enrollment and would have to reduce both $\mathbf{e_1}$ and $\mathbf{r_1}$ in order to maintain its indifference between marginal early admits and marginal regular admits. Thus since $\mathbf{e_1}$ must decrease when $\mathbf{e_2}$ is reduced, $\mathbf{e_{1M}}(\mathbf{e_{2M}})$ is strictly increasing whenever $\mathbf{e_{1M}}(\mathbf{e_{2M}}) < 1$ (so that $\mathbf{e_{1M}}$ can be increased). END OF PROOF

D. Allocational Comparisons across Regimes

The 1994 admissions reforms provide additional information to students (who now know their $\mathbf{y_i}$ values at the time of application) and colleges (which can now observe $\mathbf{v_{ij}}$ values for regular applicants) and also ensure that students can apply to both colleges in equilibrium. These features of the new admission system induce a more efficient equilibrium allocation of students to colleges in Regime 2 than in Regime 1.

Proposition 6: College 1 achieves a higher payoff in equilibrium in Regime 2 than it does in equilibrium of Regime 1. The average of the payoffs to the two colleges is greater in equilibrium in Regime 2 than in equilibrium of Regime 1.

Proof: College 1 achieves maximum payoff in Regime 1 if it admits students on Date 1 and College 2 admits students only on Date 2. In this case, College 1 enrolls students with the highest y-values, specifically those with $\mathbf{y_i} \geq \mathbf{y_{(K)}}$. In Regime 2, College 1 can replicate this outcome by setting a threshold of $\mathbf{y_{(K)}}$ for early admission. It can improve on this outcome by setting a threshold for early admission arbitrarily close to, but just above $\mathbf{y_{(K)}}$. Regardless of the early admission threshold set by College 2, College 1 can anticipate that it will enroll a small number of regular applicants with unexpectedly high values of $\mathbf{v_{i1}}$ given $\mathbf{y_i}$ -- in particular with $\mathbf{v_{i1}} > E(\mathbf{v_{i1}} \mid \mathbf{y_i} = \mathbf{y_{(K)}})$.[27] Thus, since College 1 has an admissions strategy available that does better than any equilibrium payoff in Regime 1, it must do better in equilibrium in Regime 2 than in equilibrium in Regime 1.

To compare the average payoffs to the two colleges in Regime 1 and Regime 2, first note that in Regime 1, students are admitted on the basis of $\mathbf{y_i}$ values, with maximum average value per student of $E(\mathbf{v_{ij}} \mid \mathbf{y_i} \geq \mathbf{y_{(2K)}})$. Suppose that College 2 uses a regular admission threshold based on $\mathbf{y_i}$ rather than on $\mathbf{v_{i2}}$ in Regime 2. Since College 1 admits some students in regular admissions in Regime 2 with $\mathbf{y_i} < \mathbf{y_{(2K)}}$, College 2 could set this regular admission threshold above $\mathbf{y_{(2K)}}$ and still fill its class. Then the set of students enrolling at the two colleges combined in Regime 2 would match the set of students enrolling in Regime 1, except that College 1 enrolls some students in Regime 2 who are preferred (according to their $\mathbf{y_{i1}}$ values) to the students they replace from Regime 1. This implies that the average values of all students enrolling at College 1 and College 2 to those colleges is higher in Regime 2 than in Regime 1. END OF PROOF

[27] This follows from the assumption that all values of $\mathbf{y_i}$ and $\mathbf{v_{i1}}$ have strictly positive densities.

The economic intuition underlying Proposition 6 is straightforward. The rule changes in Regime 2 restore College 1's dominance in the admission process in two ways. First, the introduction of specialized examinations induce College 2 to choose a different date for regular admission than College 1, thereby ensuring that all regular applicants can apply to both colleges, and thus that College 1 has its pick of them. Second, since students know $\mathbf{y_i}$ prior to the early admissions stage and since early admission decisions are entirely based on $\mathbf{y_i}$ values, any applicants that College 1 wishes to attract to apply early will do so.

The rule changes in Regime 2 have countervailing effects on the results for College 2. On the one hand, the introduction of early admissions and revelation of national exam scores to students prior to the application process both serve to reduce College 2's ability to compete with College 1 for applicants. On the other hand, the introduction of specialized examinations enables the college to differentiate their admissions decisions, identifying applicants who are particularly attractive to one college and not the other. Thus, if there is relatively little new information in $\mathbf{v_{ij}}$ relative to $\mathbf{y_i}$, College 2 will tend to do better in the equilibrium of Regime 1 than in the equilibrium of Regime 2, but if the reverse is true and there is a great deal of new information in $\mathbf{v_{ij}}$ relative to $\mathbf{y_i}$, then College 2 will tend to do better in the equilibrium of Regime 2.

E. Predictions of the Model about Repeat Applications

We now expand the model to allow for the possibility of repeat applications. Suppose that there is some cost (incorporating the cost of time and effort required to participate in another cycle of the application process) to become a repeat applicant and further that this cost is sufficient to discourage anyone who is admitted to College 2 from turning down that offer of admission for another opportunity to apply to College 1. Any student **i** who applies and is not admitted (1) observes national exam score $\mathbf{x_i}$ in Regime 1 and (2) observes college specific values $\mathbf{y_{i1}}$ and $\mathbf{y_{i2}}$ in Regime **2M**.

The incentive to return as a repeat applicant depends crucially on the relationship between one's admission values ($\mathbf{x_i}$, $\mathbf{y_{i1}}$, $\mathbf{y_{12}}$) from one year to ($\mathbf{x_i}$', $\mathbf{y_{i1}}$', $\mathbf{y_{i2}}$') the next year. We consider two illustrative cases to highlight the dynamics of the model in this context.

Case 1: All applicants retain exactly the same qualifications from year to year: $\mathbf{x_i}' = \mathbf{x_i}$, $\mathbf{y_{i1}} = \mathbf{y_{i1}}'$, and $\mathbf{y_{12}}' = \mathbf{y_{12}}$.

Case 2: All applicants get a completely new draw of qualifications, ($\mathbf{x_i}'$, $\mathbf{y_{i1}}'$, $\mathbf{y_{12}}'$) if they return as repeat applicants.

Proposition 7: Assume that the distribution of new applicants is stationary from year to year. In Case 1 some applicants would wish to return to the admission pool the next year in Regime 1, but in Regime 2, no applicants would wish to do so. In Case 2, there would be equal incentive in Regimes 1 and 2 for applicants who were not admitted in one year to return to the admission pool the following year.

Proof: (1) In equilibrium in Regime 2, students who are not admitted early have the opportunity to apply to both colleges as regular applicants. Given a stationary distribution of new applicants each year, then the colleges will use the same admission thresholds each year, and thus under the assumptions of Case 1, an applicant who is not admitted to either college in one year would also not be admitted to either college in any subsequent year. By contrast, in an equilibrium in Regime 1 where both colleges choose the same admissions date, some students who apply and are rejected by College 1 with $\mathbf{y_{C2}} \leq \mathbf{y_i} < \mathbf{y_{C1}}$ would have an incentive to return the next year, expecting to gain admission to College 2 under the assumptions of Case 1.

(2) Once again, given a stationary distribution of new applicants each year, then the colleges will use the same admission thresholds each year, and thus under the assumptions of Case 2, a repeat applicant would have the same unconditional probability of admission to either college as the average new applicant (who does not yet know $\mathbf{x_i}$ or $\mathbf{y_i}$). Since each college will ultimately enroll **K** students, these unconditional probabilities of enrolling at College 1 and separately at College 2 are the same for repeat applicants in Regime 1 and in Regime 2, so their incentives to reapply are the same in the two regimes. END OF PROOF

Part 1 of Proposition 7 provides theoretical justification for one official explanation for the 1994 reform – that it was designed to reduce the number of repeat applicants. The earlier system systematically resulted in congestion and strategic choice of the limited number of applications available to students. In the language of the model, since students have to target their applications on the basis of known $\mathbf{x_i}$ values, but admission decisions were based on $\mathbf{y_i}$ values (incorporating student **i**'s score on the national exam) in Regime 1, in equilibrium, some students apply to College 2 even though they would have been admitted by College 1. These students are presumably stuck at College 2, apart from the possibility of transfer. But more conspicuously, some students who are rejected by College 1 may discover after the fact that their $\mathbf{y_i}$ values would have been sufficient for admission by College 2; Proposition 7 indicates that these students would stand to gain in a stationary world by returning to the applicant pool the next year.

Part 2 of Proposition 7 highlights a different motivation for repeat applications, namely that students hope to improve their national exam score sufficiently to gain admission to a college that was previously out of reach under any admissions regime. Under the assumptions of Case 2, all reapplicants have equivalent chances of admission, independent of the choice of regime.

Case 1 and Case 2 both represent extreme and unrealistic assumptions, for in practice, there would always be some variation and also some consistency in exam performance from year to year. Proposition 8 highlights the tension between these two elements of performance, suggesting that the logic underlying the 1994 reforms was premised, at least to some degree, on an assumption of consistent performance from year to year.

But under the assumption of completely consistent performance, Proposition 8 also points out that congestion only limits the placement of a subset of applicants in Regime 1 – those who apply only to College 1 and then subsequently discover that they have sufficient qualifications for admission to College 2 but not to College 1. Yet, the impact of this form of congestion is also limited by the endogenous choice of application date by College 2. If College 2 is not very competitive with College 1, then there would be a large gap in their admission cutoffs, but then College 2 would choose to offer a different admissions date than College 1 in Regime 1, thereby making it possible for applicants to apply to both colleges (and eliminating the possibility of congestion). Since the closest competitors to Seoul National chose the same admissions date as Seoul National in Regime 1, we conjecture that they were relatively competitive to Seoul National, and thus that not that many applicants would have been affected by congestion in Regime 1. In sum, this logic suggests that the 1993 reform may have only addressed the more minor motivation for repeat applications – consistent with the finding that such a large number of students returned as repeat applicants even after the reform.

V. Conclusion

The rules governing the application choices of students are paramount in college admissions. The rules themselves are data, which allow the strategic game to be modeled and studied. Further, the evolution of these rules over time can be viewed as a different kind of data, as each rule change provides suggestive evidence of prior behavior by students and colleges that prompted that rule change. The South Korean college admissions system is especially conducive to this approach because the national government sets the rules in centralized fashion and because it has made several discrete and substantive changes in the rules in recent years.

Given near-universal agreement on college rankings in South Korea, the default outcome of the admissions process is for Seoul National to enroll almost all of the applicants with the most outstanding credentials. Thus, competitors to Seoul National have a strong motivation to try to undermine this outcome, in particular by adopting policies that induce very good students to commit not to apply to Seoul National. The results of our theoretical model are consistent with Stylized Facts #1 and #3, which indicate that the next ranked competitors to Seoul National adopted different timing strategies in Regimes 1 and 2. Specifically, these colleges chose the same application date as Seoul National in Regime 1 (through 1993), then switched to aggressive use of early application programs while choosing a different application date than Seoul National for regular admissions in Regime 2 (1994 to 2001) and beyond,

In this regard, early application programs in South Korea and the United States are similar in two ways. First, they serve as a vehicle for lower-ranked colleges to try to attract talented students away from higher-ranked colleges. Second, though top-ranked colleges such as Harvard, Princeton and Seoul National have attempted to opt out of early admissions, competitive pressures have induced them to reconsider and ultimately to admit substantial proportions of their entering classes through early admission programs.

One unique aspect of the history of early admissions in Korea is that regular applications include a potentially important source of information – the idiosyncratic exam given by each college – beyond the information available in an early application. This highlights a paradoxical element of early admissions in the United States, namely that "early" applications are not submitted at a markedly earlier time than regular applications to most colleges, and so there is little if any difference in the content of early and regular applications.

The introduction of early admissions in South Korea coincided with the change in the timing of the national examination, which changed the information environment from Regime 1 to Regime 2 in two ways. Given knowledge of their national exam score before submitting applications in Regime 2, students can better predict whether they would be admitted to Seoul National, limiting opportunities for other colleges to gain by competing with Seoul National on the first date of regular applications. Perhaps even more importantly, the introduction of idiosyncratic admissions exams attuned to each college's preferences reduced the adverse selection associated with multiple applications.

In Regime 1, a rejected application signals a poor score on the national exam, thereby making that candidate much less attractive to other colleges. But in Regime 2, a rejected application in regular admissions signals only a poor score on one college's idiosyncratic exam, which may have limited effect on the attractiveness of that candidate to other colleges. Thus consistent with Stylized Fact 2, our theoretical results suggest that these changes in information structure provided incentives for other colleges to choose a different date for regular admissions than Seoul National, thereby allowing students to apply to both colleges as regular applicants.

In sum, the 1994 South Korean college admission reforms can be seen as increasing the efficiency of the assignment process in two ways. First, these reforms reduced congestion, ensuring that all students could apply to at least three highly-ranked colleges (once in early admissions and then on two different dates in regular admissions). Second, this reform provided new information to colleges, enabling them to promote specialized matches in their regular admission decisions. Nevertheless, the reforms had little effect on the prevalence of repeat applications, suggesting that students were primarily motivated by take a year off in order to apply to colleges all over again because they were disappointment with the national exam results, not because they were frustrated by the inefficiencies of a congested market. In addition, although the 1994 reforms opened up opportunities for students as regular applicants, they also opened another channel – early admissions – that other colleges have used progressively more aggressively over time to compete with Seoul National for applicants.

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Appendix

Proof of Proposition 1:

In equilibrium, each college $\mathbf{j}$ receives applications from some set of students, and observes the $\mathbf{y_i}$ values but not the $\mathbf{v_{ij}}$ values for those applicants. Given this information, it maximizes the quality of the entering class conditional on this applicant pool by admitting applicants with the highest $\mathbf{y_i}$ values until filling its class with $\mathbf{K}$ admitted students (or admitting all applicants if it receives fewer than K applications). That is, in any equilibrium, each college must use a threshold rule for admission, where College 1 admits applicants with $\mathbf{y_i \geq y_{C1}}$ and College 2 admits applicants with $\mathbf{y_i \geq y_{C2}}$. Further, it must be that $\mathbf{y_{C1}} > \mathbf{y_{C2}}$, as otherwise, all students will apply to College 1 and not to College 2, which would be a contradiction because College 2 should set $\mathbf{y_{C2}} = 0$ (admitting all applicants) if it receives fewer than $\mathbf{K}$ applications.

Given fixed admission thresholds $\mathbf{y_{C1}}$, $\mathbf{y_{C2}}$, student $\mathbf{i}$ applies to College 1 rather than College 2 if

$$\mathbf{u_1\, P(y_i \geq y_{C1} \mid x_i = x)} \quad \geq \quad \mathbf{u_2\, P(y_i \geq y_{C2} \mid x_i = x)}$$

OR $$\mathbf{P(y_i \geq y_{C1} \mid x_i = x) / P(y_i \geq y_{C2} \mid x_i = x)} \quad \geq \quad \mathbf{u_2}.$$

By MLRP Property 4, the ratio $\mathbf{P(y_i \geq y_{C1} \mid x_i = x) / P_x(y_i \geq y_{C2} \mid x_i = x)}$ is increasing in $\mathbf{x}$ for fixed admission thresholds $\mathbf{y_{C1}}$ and $\mathbf{y_{C2}}$ with $\mathbf{y_{C1}} > \mathbf{y_{C2}}$. Thus, only students with the highest national exam scores would choose to apply to College 1 when it is only possible to apply to a single college. This shows that any equilibrium must involve thresholds and monotonic applications / admissions decisions for both students and colleges, but does not prove the existence of an equilibrium.

Define functions $\mathbf{y_{C1}(x)}$ and $\mathbf{y_{C2}(x)}$ to be the threshold values for Colleges 1 and 2 to fill their classes when students apply to College 1 iff $\mathbf{x_i} > \mathbf{x}$. (To complete this definition, we set $\mathbf{y}_{\mathrm{Cj}}(\mathbf{x})$ to 0 if a threshold value of $\mathbf{x}$ for applications causes college $\mathbf{j}$ to receive less than $\mathbf{K}$ applications, in which case it admits all applicants). Then an increase in $\mathbf{x}$ shifts some applicants from College 1 to College 2, so $\mathbf{y_{C1}(x)}$ is decreasing in $\mathbf{x}$ while $\mathbf{y_{C2}(x)}$ is increasing in $\mathbf{x}$, and both functions are strictly monotonic except for values of $\mathbf{x}$ where a given college admits all applicants.

Now consider two potential threshold values in $\mathbf{x}$, $\mathbf{x^*}$ and $\mathbf{x^{**}}$, where $\mathbf{x^{**}} > \mathbf{x^*}$. By MLRP Property 4, given fixed thresholds $\mathbf{y_{C1}(x^*)}$ and $\mathbf{y_{C2}(x^*)}$, we know that

$$\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = x^{**}) / P(y_i \geq y_{C2}(x^*) \mid x_i = x^{**})}$$
$$\geq \quad \mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = x^*) / P(y_i \geq y_{C2}(x^*) \mid x_i = x^*)}. \qquad (1)$$

Further, since $\mathbf{y_{C1}(x)}$ is decreasing in $\mathbf{x}$, $\mathbf{P(y_i \geq y_{C1}(x^{**}) \mid x_i = x^{**})) > P(y_i \geq y_{C1}(x^*) \mid x_i = x^{**}))}$, and since $\mathbf{y_{C2}(x)}$ is decreasing in $\mathbf{x}$, $\mathbf{P(y_i \leq y_{C2}(x^{**}) \mid x_i = x^{**}))}$. Substituting these relationships in (1) gives

$$\mathbf{P(y_i \geq y_{C1}(x^{**}) \mid x_i = x^{**}) / P(y_i \geq y_{C2}(x^{**}) \mid x_i = x^{**})}$$
$$\geq \quad \mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = x^*) / P(y_i \geq y_{C2}(x^*) \mid x_i = x^*)}. \qquad (2)$$

This shows that the ratio $\mathbf{P(y_i \geq y_{C1}(x) \mid x_i = x) / P(y_i \geq y_{C2}(x) \mid x_i = x)}$ is strictly increasing in $\mathbf{x}$. The condition for a equilibrium with application threshold $\mathbf{x^*}$ is

$$\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = x^*) / P(y_i \geq y_{C2}(x^*) \mid x_i = x^*)} \quad = \quad \mathbf{u_2}. \qquad (3)$$

Since the left-hand side of (3) is strictly increasing in $\mathbf{x^*}$, there can be at most one such equilibrium.

If $\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = 0) / P(y_i \geq y_{C2}(x^*) \mid x_i = 0) \geq u_2}$, then condition (3) can never be satisfied for any value of $\mathbf{x^*} > 0$ and there is a unique equilibrium where all students apply to College 1 despite the fact that College 2 will admit anyone who applies.

So assume instead that $\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = 0) / P(y_i \geq y_{C2}(x^*) \mid x_i = 0) < u_2}$. If all applicants apply to College 2, then College 2 must set admission threshold below 1, whereas College 1 will set admission threshold equal to zero and admit all applicants. Thus,

$$\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = 1) / P(y_i \geq y_{C2}(x^*) \mid x_i = 1) > 1 > u_2}.$$

Since $\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = x) / P(y_i \geq y_{C2}(x^*) \mid x_i = x)}$ starts off below $\mathbf{u_2}$ at $\mathbf{x} = 0$, ends up above $\mathbf{u_2}$ at $\mathbf{x} = 1$, and is continuous and strictly increasing in $\mathbf{x}$, there must be a unique value $x = x^*$ between 0 and 1 such that $\mathbf{P(y_i \geq y_{C1}(x^*) \mid x_i = x^*) / P(y_i \geq y_{C2}(x^*) \mid x_i = x^*) = u_2}$. This value x^* is the unique equilibrium threshold for applications. Thus, we can view the application threshold $\mathbf{x^*}$ as an implicit function of $\mathbf{u_2}$, and further we can view the admission thresholds $\mathbf{y_{C1}(x^*)}$ and $\mathbf{y_{C2}(x^*)}$ as implicit functions of $\mathbf{u_2}$ as well.

Proof of Proposition 4:

The proof relies on an additional Lemma, which shows that both colleges adopt lower thresholds for early admission in Regime **2S** than in Regime **2M**, thereby competing more aggressively in the early admission phase of Regime **2S** than **2M**. The intuition for Lemma 4 is straightforward: since the colleges both achieve higher utility in Regime 2M than Regime **2S** in a world without early admissions, they have less incentive to admit any particular early applicant in Regime **2M**.

Lemma 4: Comparing any equilibrium ($\mathbf{e_{1M}}$, $\mathbf{r_{1M}}$, $\mathbf{e_{2M}}$, $\mathbf{r_{2M}}$) in Regime 2M to the unique equilibrium ($\mathbf{e_{1S}}$, $\mathbf{r_{1S}}$, $\mathbf{e_{2S}}$, $\mathbf{r_{2S}}$) in Regime 2S, we have $\mathbf{e_{1M}} > \mathbf{e_{1S}}$ and $\mathbf{e_{2M}} > \mathbf{e_{2S}}$.

Proof: First suppose $\mathbf{e_{1S}} \geq \mathbf{e_{1M}}$. Since $\mathbf{r_1} = \mathbf{E(v_{i1} \mid s = e_1)}$ for each admission rule, then $\mathbf{r_{1S}} \geq \mathbf{r_{1M}}$. If $\mathbf{e_{2M}} \geq \mathbf{e_{2S}}$, then college 1 would admit more early applicants with rule **M**, receive and admit more regular applicants with rule **M** than rule **S**, so would overenroll with rule **M**. So it must be that $\mathbf{e_{2M}} < \mathbf{e_{2S}}$ and in turn $\mathbf{r_{2M}} < \mathbf{r_{2S}}$, since college 2 adjusts its regular threshold down as a result of adverse selection with the Multiple Application rule, but does not do so for the Single Application rule. So in this case $\mathbf{e_{1S}} \geq \mathbf{e_{1M}}$, $\mathbf{r_{1S}} \geq \mathbf{r_{1M}}$, $\mathbf{e_{2S}} > \mathbf{e_{2M}}$ and $\mathbf{r_{2S}} > \mathbf{r_{2M}}$, i.e. the colleges use weaker thresholds for admission throughout with rule M than with rule S. But the regular applicants get to apply to both colleges with rule M and only to one college with rule S, so this means that the colleges must overenroll with rule M. So this is not possible. By similar reasoning, we can rule out the possibility that $\mathbf{e_{2S}} \geq \mathbf{e_{2M}}$. END OF PROOF OF LEMMA

Suppose that in Regime 2**M**, College 1 follows equilibrium strategy ($\mathbf{e_{1M}}$, $\mathbf{r_{1M}}$). In response, College 2 could choose an admission rule to admit the same number of early applicants that it would admit in the unique equilibrium in Regime **2S**. That is, it could choose early admission threshold $\mathbf{e'_{2M}}$ where $\mathbf{e'_{2M}}$ is defined implicitly by the equation

$$\mathbf{P(s > e_{1M}) - P(s > e'_{2M}) \quad = \quad P(s > e_{1S}) - P(s > e_{2S})}$$

By Lemma 5, $\mathbf{e_{1M}} > \mathbf{e_{1S}}$ and $\mathbf{e'_{2M}} > \mathbf{e_{2S}}$. So by construction, College 2 admits the same number of early applicants in each case, but gets a higher average payoff from them in regime **2M** than in regime **2S**. Further, in regime **2M**, College 1 admits measure **K** of applicants from two groups of students:

(1) those with $\mathbf{y_i} > \mathbf{e_{1M}}$;

(2) students with the highest $\mathbf{v_{i2}}$-values among those with $\mathbf{y_i} < \mathbf{e'_{2M}}$

Similarly, in Regime **2S**, College 1 admits measure **K** of applicants from two groups of students:

(1) those with $\mathbf{y_i} > \mathbf{e_{1S}}$;

(2) students with the highest $\mathbf{v_{i1}}$-values among those with $\mathbf{y_i} < \mathbf{e'_{2S}}$

College 2 only cares about the $\mathbf{y_i}$-values of its regular applicants, not their $\mathbf{v_{i1}}$ values once $\mathbf{y_i}$ values are known. The worst case scenario for College 2 in Regime 2**M** is that College 1 fills its class with the regular applicants with highest $\mathbf{y_i}$-values, so that College 2 has a regular pool with students who have $\mathbf{y_i}$-values between 0 and $\mathbf{e_{2M}}$. By contrast, in Regime 2**S**, the regular applicants with the highest values of $\mathbf{y_i}$ apply to College 1, while the others apply to College 2. The best case scenario for College 2 in Regime **S** is then that College 1 receives just enough applicants in regular admissions to fill its class. Then once again College 2 has a regular pool with students who have $\mathbf{y_i}$-values between 0 and $\mathbf{e_{2M}}$.

In sum, if College 2 simply chooses to admit the same number of early applicants in Regime **2M** as it does in the unique equilibrium of Regime **2S**, it gets a better distribution of early admits in Regime **2M** (because $\mathbf{e_{1M}} > \mathbf{e_{1S}}$, i.e. College 1 is more selective in its early admits**)** and does at least as well in regular admissions in Regime **2M** as in Regime **2S**. By revealed preference, College 2 prefers its outcome in Regime **2M** than in Regime **2S** and will choose a different regular admissions date than College 1 in Regime 2. END OF PROOF