Admission Standards and Tuition in The Market for Professional Graduate Education*

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Abstract

We analyze competitive graduate education, such as MBA programs, assuming that potential employers use the minimum admission requirements (such as GMAT scores) as a signal for the productivity of their graduates. Professional graduate schools are free to set tuition levels as well as minimum admission standards. If tuition is not regulated, the market would be split. Some graduate schools would set a very high tuition level and admit a small number of highly qualified students. Other competing schools would specialize in less qualified students and capture a larger market share. Both competitors set admission requirements higher than the optimal level. A regulator can influence the market-determined admission requirements by instituting a nationwide tuition level. However, the first best admission criteria can not be achieved by mandating the uniform admission level.

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1. Introduction

At the prevailing tuition level there is a large excess demand for higher education. Universities use a highly competitive examination system in order to ration study places at all levels of university degree programs. In fact, entry exams are used as a selection device in the higher education system. This is particularly true for professional graduate schools such as business schools or law schools that offer a professional second degree to students who already have a first academic degree. Most of the students in such graduate programs expect to enter the labor market upon graduation. At the admission stage, professional school usually uses both tuition and fees (prices) and the results of entry exams as a selection mechanism.

Combining exams with tuition into a selection mechanism is often justified because higher education in general is considered to be a special type of service. Hence, as we demonstrate below, a strict price mechanism may be insufficient for optimal allocations of students to schools. There are two common arguments against strict reliance on prices by academic degree granting institutions. The first argument relies on the existence of significant positive externalities on the consumption side. The second argument regards higher education as a "special service", not because of the existence of social externalities, but rather because each student may have positive or negative externalities (known as "peer effect"), in the production process of education itself, for other students.

As a matter of practice, most goods and services are allocated by price mechanism only. Economists believe that in a competitive industry, prices convey all the information by producers and consumers regarding the actual value of the good. In the acquisition of academic degrees, prices are not the sole allocation mechanism. Here we observe two-tiered arrangements to academic institutions and to schools within universities. The price (tuition) plays the standard economic role. In addition, grades in past studies and entry examination results play an important role in determining admission policies.

The two-tiered allocation, by price and test scores, impacts the nature of competition in the academic professional education market. In this paper, we investigate the possible interaction between tuition and test scores. We emphasize some observed features of graduate business schools that provide an MBA degree. We believe, however, that markets for other professional academic degrees, such as law, dentistry, and social work, behave in a similar way. The key economic observation in the "production" of MBA degrees is that different education quality is produced by different institutions at different costs. The "output" is then sold, at different prices, to students with different input characteristics.

We examine the admission policy of schools that provide a second academic degree, such as an MBA, in an environment where students are heterogynous with respect to their academic ability. We assume that professional school exercise control, over student's quality. By setting standards the graduate school controls the quality of the graduates that they are providing. The quality of the school, in tern, is linked to the future earnings of its graduates. Articles such as Behrman, Rosenzweig, and Taubman (1996), and Eide, Brewer and Ehrenberg (1998) confirm the positive correlation between "University quality" and life-time earnings in the U.S. Cohn and Addison (1998) provide a detailed summary about other countries. Because graduate schools control their quality they are able to charge different prices. However, by setting the quality of the student's body they also restrict the market share that they can get.

This paper aims to develop a model of professional graduate schools in the higher education sector.[1] The model will describe optimal level of tuition and admission standards when students have different abilities and schools have some discretion over the two selection variables. The driving force are the *employers who are assumed to know only the schools' admission standards*. Admission criteria become the signal of worker's quality. Different market structures are then considered and their impact on the level of tuition and admission standards is explored.

We develop a simple model with two competing business schools that provide an MBA degree. Each can freely set its tuition level and its minimum admission standards. On the other side of the market there are potential students who are heterogeneous with respect to their academic ability. We assume that the academic ability of each student is reflected by a single parameter,

[1]In this study, we use the terms graduate school, professional school, institution of higher education, and university interchangeably.

which we call "test score." The test score can be viewed as the score of the GMAT exam required by most business schools.

Graduates of professional schools are faced by potential employers who are unable to extract any information concerning the exact productivity of the graduates as workers. Therefore, employers use the admission criteria of the graduate school as a signal of the average productivity of the worker and pay a competitive wage accordingly.[2] Using this labor market, students are willing to pay more in order to study at a school that sets a stricter admission standard. This means that the degree providers are vertically differentiated when they set different admission standards.

In this environment, if there are two competing schools, one will set a very high admission standard and admit a small number of highly-qualified students. The competing graduate school will respond by specializing in less-qualified students, thereby capturing a larger market share. In an unregulated environment, students with low ability will not be admitted to any school, even if schools have unlimited capacity. For this market, we demonstrate that the equilibrium admission requirements exceed the optimal level.

Finally, we look at quasi-regulatory regime where a regulator sets a uniform tuition level, but leaves to business schools the freedom to choose their admission standards. We demonstrate that the regulator can increase or decrease the equilibrium admission levels by raising or lowering the mandated (uniform) tuition level. However, the regulator cannot achieve the socially optimal admissions levels by adjusting only the uniform tuition level.

Based on this approach, we make two main contributions to the analysis of admissions policies in the professional graduate education sector. First, we analyze rational students' choice between graduate programs that compete on both the number and quality of students. We find that in an unregulated duopoly market, one school will set a high admission standard and admit a small number of highly-qualified students. The competing school will respond by specializing in less-

[2]Tracy and Waldfogel (1997) regressed starting salaries on measures of MBA student quality and interpreted the salary residual as a measure of program value added. They found that four out of five top programs are indeed associated with higher value added.

qualified students and as result would capture a larger market share. Second, we use the model to explore the effects of regulating tuition on admission standards. We find that when tuition is regulated both schools set the admission standards such that they admit the same number of students.

The paper is organized as follows. The following section contains a brief literature review on admission policies. Section 3 analyzes individuals' decisions whether and where to obtain a professional academic degree by linking these decisions to the post-graduate labor market. Section 4 analyzes how a single profit-maximizing graduate school determines its minimum admission requirements and its tuition level. Section 5 extends the model to two competing schools where both tuition and admission standards are used as strategic variables. Section 6 analyzes socially optimal minimum admission requirement levels. Section 7 introduces a regulator who mandates a uniform tuition level, but leaves schools the freedom to choose their own admission standards. Section 8 concludes with further discussion.

2. The Pricing of Higher Education: Literature Review

The economic literature on the educational market can be classified into four branches: The competitive nature of the market, the implications of having two screening variables, the link between school qualities and future income and the implications of entry exams on the behavior of the producer of educational services. In this section, a brief review of each is provided.

The quality of the student body maybe considered as an important input in the education process. There is a growing literature on peer-effects and most of it is concerned with primary and secondary education. Authors such as Zimmer and Toma (2000) and Hoxby (2000) provide evidence on the positive impact of peer effects on educational success. The empirical test show how an achievement variable such as test score is affected by the student's peers.

A model that is based on the heterogeneity of students is analyzed by Epple and Romano (1998). They analyze a school system where free public schools and tuition charging school coexist. They analyze the general school systems where free public schools and tuition charging private schools coexist. They have a model of the educational process that incorporates two elements: First, students have different abilities and higher ability increase both, the student's achievements and the achievement of here peers. Second, students differ in their income and higher income is linked to a higher demand to educational achievement. The school quality, in their model, is determined by the average ability of the student- body. The model is used to characterize the distribution of kids across public and private schools. In equilibrium public schools will have the lower ability students. Essentially there is a partition of the ability-income combination. Private schools attract high-ability, low income students by offering them tuition discounts .At the same time tuition-free public schools do not price the peer group externality . Therefore equilibrium with only public schools is inefficient. In their model, public and private schools are equally effective producers of education.

Epple, Figlio and Romano (2004) test some of the equilibrium predictions of Epple and Romano (1998). Their model stresses differences in income and in students abilities and considers the impact of peer quality on educational achievements. They show that the propensity to attend private schools increases with both income and ability. Both prices and exams play an important role in determining the allocation of students to graduate schools. Prices can influence allocations directly via tuition and fees. As implied by Page and West (1969) and noted by Comay, Melnik and Pollatschek (1973) they also can influence the allocation of students indirectly by affecting the length of studies and the level of the degrees attained. Related works consider the efficiency of exams for screening purposes. It may be argued that exams are not necessarily perfect indicators of ability. They are influenced by previous expenditures that, to some extent, actually augment human capital and to some extent merely enhance test performance. In such a case, the competition for higher test scores, runs into the same borrowing constraint problems as under strict market tuition. Wealthy individuals can outspend poorer ones in their drive to obtain higher exams' scores.

However, exams can still provide an efficient screening mechanism even if they cannot distinguish between ability and previous expenditures. In fact, Freeman (1996) found that exams may improve efficiency in a model with identical agents and borrowing constraints. In his model, exams serve also as a mechanism that allows agents to specialize. Specialization, in turn, permits students to take advantage of increasing returns to scale in education by sorting candidates to fewer subjects.

A second literature strand examines the role of school quality. Regardless of what measure of educational quality is used, there is an almost universal agreement that the link between it and future success in the labor market is positive. In general, high quality educational institutions produce graduates who are likely to earn higher income. This tendency is noted, with respect to general university education, by Clotfelter (1996). Ehrenberg (1989) and Rosen (1992) find a positive link between quality and earnings in the market for the graduates of law schools. Wise (1975), Fay, Feraara, and Stryker (1993), and Montgomery (2002) find it to hold with respect to new MBA graduates.

The fact that more selective graduate programs are associated with eventual higher earnings, impacts the demand for graduate education. As noted by Dichev (1999) the ranking of graduate business programs in the US influences business applicants, alumni, and employers. It is clear that potential student demand is apparently sensitive to the quality of the existing student population. Various media publications such as Business Week, US News & World Report, Wall Street Journal and Financial Times, publish rankings of graduate business schools and other professional programs. Such publications inform potential students and future employers. In the context of our model, it is important to note that a major determinant of all the rankings is the minimum test scores of the admission exams.[3]

Service quality is reflected by the intensity of the selection process which is measured either by the ratio of applicants to admissions, or by threshold test scores such as the minimum GMAT score that schools may require. In any case, the caliber of students that a professional graduate school attracts, can be measured properly by the average standardized score of the entry class.[4]

[3]Tracy and Waldfogel (1997) also investigate the quality of existing business schools ranking. They find that the ranking system does not take sufficiently into account the quality of incoming students as measured by their GMAT test scores. It does not measure at all the labor market experience prior to entering the MBA program, which also impact their starting salaries after graduation.

[4]The road from schooling to gainful employment is often long and uncertain. This is true even for many university graduates. The period between the end of formal education and the acquisition of full-time stable

Graduate business schools also play a certification role. They provide their graduates with a signal that is valued by potential employers. Evidence from the United States suggests that, allowing for unobserved selection processes, a graduate business degree is indeed associated with a higher pay. This is in line with the signaling idea of Arrow (1973) and Spence (1974).

Another research track considers the industry itself. There are only a few theoretical studies of the pricing of university educational services. Rothschild and White (1995) model a competitive industry where firms use technologies that depend on customer inputs, and use higher education as a prime example. In their model, two prices are determined in the market for higher education. One is the standard market clearing price for the "product". The other is the market-clearing price for each customer's input. In this market students are indifferent as to where they study. They are expected to get the same benefit per dollar spent on educational product and they pay the same market-clearing price for it. Essentially, strong students pay a lower net tuition than weak ones because they contribute more on the margins to the educational activities of the university. Colleges are indifferent among students since they pay competitive "wage" for each unit of student quality.

The industrial organization literature did not consider a policy which combines pricing and admission policies in the formulation of a competitive strategy. There are however, works such as Hansmann (1990), that deal with the role of endowments as a competitive tool. Danziger (1990) analyzes the effects of endowment on subsidizing enrolment. He demonstrates that it is not always true that a university with larger endowment admits more applicants and charges lower tuition. It is quite possible that a wealthier university would be more selective and admit only better qualified applicants.

employment may be long. Business schools may improve the chances of university graduates in the labor market. Graduate professional schools become more important during periods when the employment options of university graduates deteriorate. Graduate business degrees play an important role of matching young people to jobs faster.

3. Students' Behavior

The high tuition levels of professional graduate education at top universities are well documented.[5] At the same time, other universities charge low tuition and admit seemingly less-qualified students. Our purpose is to analyze the market for higher eduction paying close attention to the competitive forces that create "differentiated" tuition. Following the literature, we assume that both the returns and the tuition of top programs are strongly related to future occupational status and income.

The theoretical framework of our model traces the impact of college education on occupational choice while taking into account the unobserved heterogeneity of students. We accept the fact that individual outcome of the education process is highly uncertain. We incorporate it via an asymmetric information model that considers the minimum admission requirement of universities rather than the individual ability of a given university graduate.

3.1 Students, universities' tuition, and admission criteria

There is a continuum of n applicants who are indexed by an ability (quality) parameter $s \in [0, 1]$ with a uniform density. The index number of a given student, s, reflects his or her academic promise as measured by an admission test. Such a test could be interpreted as the GMAT score (which for our purpose is normalized to be between zero and one), or other tests given by universities and national institutions. We assume that this test score, s, truly reflects a student's ability as perceived by universities, students, and potential employers. Thus, potential applicants indexed by a low (high) test score s reflect a low (high) academic ability, respectively.[6]

For simplicity we sort all professional schools into two groups. Each group is represented by a single institution. Therefore, we analyze two academic programs in this economy. Each professional school i, $i = A, B$, sets two variables: Tuition, denoted by t_i, and its minimum

[5]Further evidence regarding the correspondence between top programs and high tuition levels is given in Ehrenberg (1989), and Rosen (1992).

[6]Clearly in practice, test scores rarely form a uniform distribution which is assumed here. Assuming a non-uniform distribution of abilities would require numerical simulations instead of obtaining closed-form solutions.

admission standard, denoted by s_i. Thus if, for example, school i sets its minimum admission standard to $s_i = 0.75$, it is ready to admit all applicants who score in the range $0.75 \leq s \leq 1.00$, and will reject applications from any applicant who is indexed by $0.00 \leq s < 0.75$.

3.2 The gain from a professional education

The productivity of each student is affected by the student's ability parameter, s. Following Spence (1974), we assume that potential employers are unable to observe the quality of a job applicant, and therefore must rely on a signal provided by the minimum admission requirement set by the school attended by the job candidate.[7] Formally, we assume that employers expect that the revenue generated by employing a worker with ability s ($s \in [0, 1]$) to be $R(s) = \alpha s$, where $\alpha > 0$ is the common productivity parameter.

Following the arguments made in the signaling literature, students register at business and law schools to signal their quality. Therefore, potential employers compare universities' minimum admission requirements since this is the only information that is available to them.[8] In practice, school quality is difficult to measure. Different universities have different reputations for their quality of the education they provide. Quality may be measured in various tangible ways. Selective universities may have better maintained infrastructure, more influential faculty members, good career counseling services, less crowded dormitories, smaller class size, etc. In the present paper we do not model the production of educational services. Therefore, for simplicity we use the quality of the students' peer group as a measure of educational quality.

We now calculate the competitive wage to be paid to a worker holding a diploma from school i that admits all students with abilities between $s_i \leq s \leq 1$, assuming that there are two schools labeled by $i = A, B$. Since there is more than one school we assume that potential

[7] Clearly, an alternative assumption would be that employers pay according to the average ability of students attending a particular university. However, the present assumption is more realistic since universities rarely reveal the information concerning the test scores of their top students, hence averages cannot be computed by potential employers. However, universities always announce their minimum admission requirement.

[8] In job advertising columns many firms specifically list the quality of the job candidates' school as a prerequisite. These advertisements use terms such as "the successful candidate will have an MBA degree from a leading university" or "a graduate business degree from a reputable university is required."

employers are unable to compute the exact allocation of students among the academic programs and will therefore adjust their wages proportionally to the minimum admission requirement of the graduate's university. Hence, a competitive employer will pay a wage of $w_i = \alpha s_i$ to a graduate of university i. Thus, the net gain (utility) from a university education for each individual is given by

$$U = \begin{cases} \beta + \alpha\, s_A - t_A & \text{if she graduates from school } A \\ \beta + \alpha\, s_B - t_B & \text{if she graduates from school } B \\ 0 & \text{if she does not study,} \end{cases} \quad \text{where} \quad 0 < \beta < \frac{3\alpha}{5}. \tag{1}$$

The parameter β measures the *basic* utility derived from higher education. The upper bound on β given in (1) ensures internal solutions for the model. α is the productivity parameter defined earlier.[9] This measure is then translated into wages after graduation. Thus, if α is very small, students (and later, potential employers) do not care much about the academic level of their graduate school and therefore the school's admission standard. In contrast, high values of α reflect a situation where students' utility is strongly enhanced with an increase of the academic quality of their graduate school as reflected by its minimum admission requirement, which is then translated to wages and salaries.[10] Finally, readers who are interested in further exploration of student utility functions (1) are referred to Appendix A.

3.3 Students' choice of enrollment

All the n potential students share the same preferences towards all professional schools, given in (1). That is, despite the fact that students differ in their academic abilities (score differently on the relevant admission test), they have identical preferences with respect to each university (as

[9]The parameter α could also capture the "peer-group effect" as it defines the average quality of fellow students. Potential students' demand is apparently sensitive to the quality of the existing student population. Popular magazines, such as Business Week, Fortune, and US News & World Report, publish regularly rankings of graduate and undergraduate academic programs. This is done in order to inform potential students about the relative qualities of the listed universities. A major determinant in all these rankings is the minimum test scores of the entry exam. See Graham and Morse (1999).

[10]Of course, there is another interpretation for the utility function (1) in which "snob" effects (e.g., Veblen 1899) induce students to want to be separated from less able students in the same way as they choose to consume products and brands which are not purchased by the masses. This interpretation involves an externality stemming from exclusion or service denial associated with high admission standards, see Basu (1989), Becker (1991), and Clotfelter (1996).

long as they can be admitted). The utility function (1) implies the following students' behavior.

(a) If both institutions set identical admission criteria, students prefer to be enrolled in the school charging the lower tuition. Formally, if $s_A = s_B$ and $t_i < t_j$, then all students prefer to be enrolled at university i over university j; $i, j = A, B$.

(b) If both institutions charge the same tuition, students prefer to be enrolled in the school with the higher admission standard. Formally, if $t_A = t_B$ and $s_i > s_j$, then all students prefer to be enrolled in school i over school j; $i, j = A, B$.

Thus, students perceive professional schools' education as *vertically-differentiated* services. However, we must point out that the market for higher education differs from the markets characterized by the conventional vertically-differentiated products literature in one *major* respect which is illustrated in Figure 1.

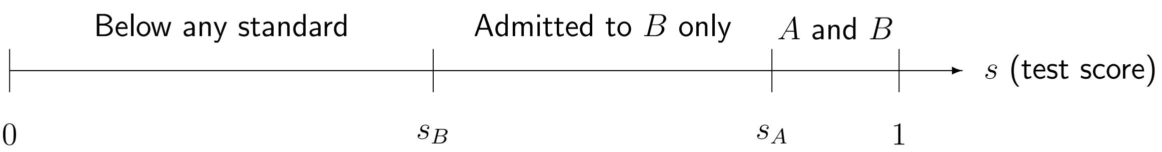

Figure 1: Vertical differentiation in the market for professional graduation schools. *Note:* Figure assumes that school A sets a higher admission standard than B.

In conventional models of vertically-differentiated products all consumers indexed on the entire interval have access to all firms (brands) regardless of their "location" on the characteristics space. In contrast, Figure 1 illustrates that, in the academic market, students can enroll only at those institutions whose admission standards are below their own test scores (hence their academic ability). Using the figure's example, all students indexed on $[0, s_B)$ are not entitled to be admitted to any school since their test scores are below the minimum admission standard set by any graduate school. Thus, unlike the "conventional" models of vertically-differentiated products, in the graduate school market low-ability students are denied service. Those students indexed on the interval $[s_B, s_A)$ are entitled to be enrolled in school B only, whereas students indexed on $[s_A, 1]$ can be admitted to both schools as their test scores are above both admission thresholds.

In the following sections we analyze two *market structures*: The single graduate school monopoly market structure, and a sequential-entry duopoly market structure. We conduct our analysis under the assumption that schools are not subjected to capacity constraints, so each can potentially admit the entire student population. As it turns out, the imposition of capacity constraints does not enrich the results of our model since, as we show below, when tuition is not regulated, universities tend to limit the number of enrolled students even when capacity is unlimited.

4. A Single Professional School

We view the professional graduate school as an institution that sells education services, by charging tuition. For the sake of simplicity, the present analysis abstracts from the production and cost structure of a university firm. The payoff generated by higher education has already been discussed in Section 3. In what follows, we treat a graduate school or a university as a profit-maximizing unregulated firm. This assumption is needed in order to explore the possibility of a market failure in admission standards. Some readers may want to associate this assumption with private universities, however, it is not clear why some public universities in general, and public professional schools in particular, cannot be viewed as profit maximizing.

We begin our analysis with a monopoly market structure. The monopoly case highlights the welfare implication of an unregulated university system.

4.1 Unregulated tuition

An unregulated profit-maximizing monopoly school controls two variables. It chooses its minimum admission standard, s_m, and its tuition level, t_m, taking into account that the potential applicants respond according to their utility functions (1), which postulate a linear tradeoff between admission standards and tuition. The subscript m stands for monopoly. Thus, given a minimum admission standard s_m, the utility function (1) implies that the the highest tuition the school can charge the applicant indexed by s_m is $t_m = \beta + \alpha s_m$. Hence, the monopoly enrolls $q_m = n(1 - s_m)$ students and therefore chooses s_m that solves

$$\max_{s_m} \pi_m = t_m q_m = t_m n(1 - s_m) = (\beta + \alpha s_m) n(1 - s_m). \tag{2}$$

Thus, profit depends on students' basic utility, β, the productivity factor, α, and the admission standard of the university. From this relationship we obtain a minimum admission standard, enrollment, tuition and profit levels that are given by

$$s_m = \frac{\alpha - \beta}{2\alpha}, \quad q_m = \frac{n(\alpha + \beta)}{2\alpha}, \quad t_m = \frac{\alpha + \beta}{2}, \quad \text{and} \quad \pi_m = \frac{n(\alpha + \beta)^2}{4\alpha}. \tag{3}$$

Thus, as expected, a monopoly graduate school exercises its monopoly power by limiting admission thereby enhancing its academic reputation. This in turn enables it to raise its tuition to its monopoly level. As a result, part of the student population is not being admitted under an unregulated monopoly university.

4.2 Optimal admission standard set by a single professional school

We define the social welfare function by the sum of students' utilities and the profit (revenue, in the present case) of the university. Clearly, the sum of utilities reflects the production gain to the economy since those who do not go to college are not matched with jobs reflecting their ability. The social planner chooses s that solves

$$\max_{s} W \stackrel{\text{def}}{=} n\left[s \cdot 0 + (1 - s)(\beta + \alpha s - t)\right] + (1 - s)nt = n(1 - s)(\beta + \alpha s), \tag{4}$$

yielding a unique optimal admission standard and the resulting social welfare

$$s^* = \frac{\alpha - \beta}{2\alpha} = s_m, \quad \text{and} \quad W^* = \frac{n(\alpha + \beta)^2}{4\alpha}. \tag{5}$$

Comparing (5) with (3), we can state the following result.

Result 1. *A monopoly school sets the socially-optimal minimum admission requirement.*

From a theoretical point of view, Result 1 is not new. Over thirty years ago, Swan (1970) has demonstrated that, from a technical-quality point of view a monopoly solves the same problem as the social planner, hence it would utilize only the price mechanism (tuition in the present context) to extract the monopoly surplus rather than distort the quality. In fact, (3) shows that the surplus extracted by the monopoly equals the welfare level given in (5).[11]

4.3 Regulated tuition

We define regulation as a regime where the government controls the tuition level. With regulation in effect, the monopoly university's choice problem is reduced from a two strategic variable decision problem to choosing a minimum admission standard only. Let $\hat{t}$ denote the tuition level mandated by the government, and let s be the minimum admission standard set by the university. Then, by (1) only the students indexed by $s \in [\max\{0, \frac{\hat{t}-\beta}{\alpha}\},\ 1]$ are enrolled to this school.

Figure 2 illustrates the demand for enrollment, q, as a function of the admission threshold s chosen by the school. The figure also illustrates the resulting profit of this tuition-regulated school also as a function of its choice of minimum admission requirement. Figure 2 demonstrates that in response to a government-controlled tuition level $\hat{t}$, the school must set its minimum admission requirement at least to a level of $(\hat{t} - \beta)/\alpha$, as otherwise the utility function (1) implies that no student would find it beneficial to enroll. Therefore, if the government raises the mandated tuition level, $\hat{t}$, the school will be forced to raise its admission standard in order to make it beneficial for higher-quality students to enroll.

Figure 2 reveals that for a given $\hat{t}$, the demand for enrollment rises above zero when the institution raises its admission standard above $s = (\hat{t} - \beta)/\alpha$. However, above this level, the demand (and hence the profit which is the demand multiplied by $\hat{t}$) falls with a further increase in s simply because higher admission standards yield lower enrollment since there are less students

[11]We should note that in general, the monopoly may choose a suboptimal admission standard when consumers (students in the present context) have different valuations (reservation utilities) for the product (professional degree in our context), provided that tuition discrimination is not feasible. The reason is that when consumers have different valuations, the uniform tuition mechanism is insufficient for the purpose of extracting maximal surplus, therefore quality distortion is needed as a second tool. In this case differential tuition levels are needed to restore the optimal choice of the admission standard.

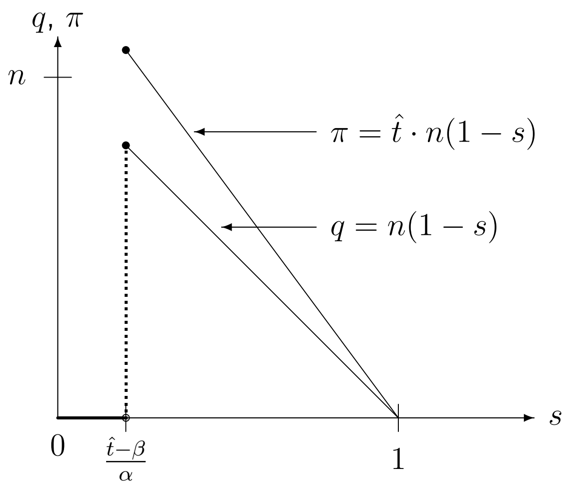

Figure 2: Enrollment and profit of a tuition-regulated institution. *Note:* Horizontal axis measures the minimum admission standard which is the only control variable under a given tuition.

who remain qualified for enrollment. Clearly, the demand (and profit) become zero when the school sets $s = 1$.

Therefore, under regulated tuition, the profit of the degree-granting university is maximized when the minimum admission requirement is set to

$$s(\hat{t}) = \max\left\{0, \min\left\{\frac{\hat{t}-\beta}{\alpha}, 1\right\}\right\}. \tag{6}$$

Therefore,

Result 2. *(a) A monopoly professional school will increase (decrease) its admission standard in response to an increase (decrease) in the mandated tuition level.*

(b) The regulator can fully control the monopoly school's minimum admission level by varying the mandated tuition level.

A regulated tuition policy reduces the school's incentive to limit the admission of low-ability students since by raising its standard it can no longer raise the mandated tuition level. In other words, by regulating tuition the regulator eliminates the school's profit incentive to raise the admission standard in order to guarantee higher salaries for its graduates. Hence, under regulated tuition the school maximizes profit by maximizing the number of students, subject to the constraint that students will not enroll if the admission standard is set too low relative to the tuition charged, as given in (6).[12]

5. Unregulated Duopoly Professional School System

Suppose now that there are two schools granting degrees, labeled as A and B. We analyze a two-stage game where school A first chooses its tuition and minimum admission standard, $\langle t_A, s_A \rangle$, and in the second stage school B chooses its tuition and admission standard pair, $\langle t_B, s_B \rangle$ knowing the levels that were chosen by university A.

There are three reasons why we chose to conduct our analysis assuming that the decisions are made sequentially. First, static games where both institutions choose tuition and admission levels simultaneously generally do not have a Nash equilibrium in pure strategies. Second, a two-stage game where in stage I both parties simultaneously choose one strategic variable (say the minimum admission levels), and in stage II both choose the other strategic variable (say, tuition levels) does not have a nice interpretation since in reality both tuition levels and admission standards can be modified at the same time. More precisely, it is hard to interpret why academic institutions must first commit to admission standards (or tuition level) and base their decision of the other variable on the assumption that admission standards (or tuition) cannot be revised. Another reason to consider sequential entry is that it can be supported by some historical facts. Suppose that university A represents a typical private university, and university B is a representative of the public higher education sector. According to Goldin and Katz (1999), until the beginning of the twentieth century most universities in the United States were private institutions. However, since the beginning of the twentieth century most of the expansion of higher education occurred in the public sector. For these reasons, we chose to deal with sequential moves of competitors which could also have the interpretation that university A was established prior to university B.

[12] The resemblance to rent control policy (or any other price-ceiling policy) is clear. Under rent control, landlords do not have any incentive to maintain the property they rent out. However, landlords are constrained to providing a minimum maintenance level as otherwise no one will be willing to pay even the reduced government-controlled rent.

5.1 The second stage game

In the second stage school B takes A's choice of $\langle t_A, s_A \rangle$ as given. Figure 3 illustrates three possible choices of admission standards for school B relative to school A.

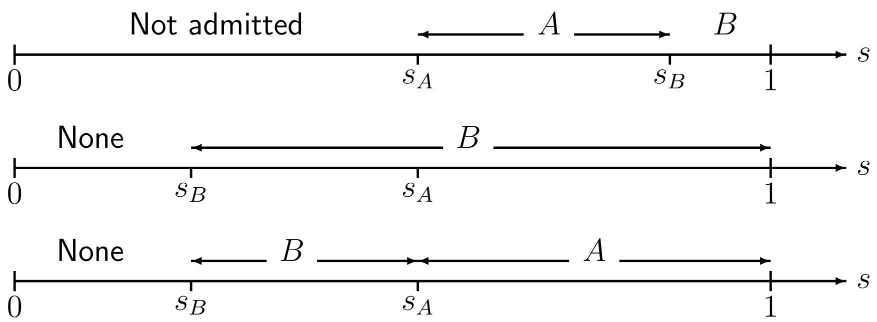

Figure 3: Second stage: *Top:* B sets a higher admission standard than A. *Middle:* B sets a lower standard and undercuts A. *Bottom:* B sets a lower standard without undercutting A.

School B sets a higher standard than A

Figure 3 (top) illustrates a situation where B sets a higher standard than A thereby leaving A with less qualified students, provided that B's tuition does not exceed $t_B \leq t_A + \alpha(s_B - s_A)$. If $t_B > t_A + \alpha(s_B - s_A)$, the utility function (1) implies that B will not have any students despite the fact that it requires higher academic standards for admission.

When B sets $s_B > s_A$, the maximum tuition it can charge while maintaining students indexed on $[s_B, 1]$ is $t_B = t_A + \alpha(s_B - s_A)$, which is A's tuition plus the quality premium according to (1). Hence, firm B takes $\langle t_A, s_A \rangle$ as given and solves

$$\max_{s_B} \pi_B \bigg|_{s_B \geq s_A} = t_B n(1 - s_B) = [t_A + \alpha(s_B - s_A)]\, n(1 - s_B), \tag{7}$$

yielding a unique solution as a function of A's choice variables given by

$$s_B = \frac{\alpha(s_A + 1) - t_A}{2\alpha}, \quad t_B = \frac{\alpha(1 - s_A) + t_A}{2}, \quad \text{and} \quad \pi_B = \frac{n[\alpha(s_A - 1) - t_A]^2}{4\alpha}. \tag{8}$$

Equation (8) reveals that B increases its admission standard, s_B, in response to an increase in A's admission standard, s_A. It also decreases s_B when A increases its tuition level, t_A, since more students would be willing to pay B's tuition fee at a reduced minimum admission requirement (then translated into a lower wage upon graduation). In addition, B increases its tuition level, t_B, in response to an increase in A's tuition, t_A, and reduces its tuition when A increases its admission standard, s_A. Thus, both admission standards and tuition can be viewed as strategic substitutes (if viewed as separate strategies), where we observe some substitution between admission standards and tuition. More precisely, suppose that A increases its tuition level, t_A. Then, school B reacts with both strategic variables by increasing its tuition but lowering its admission standard thereby increasing its market share by admitting less-able students.

School B sets a lower standard and undercuts A's tuition

Figure 3 (middle) illustrates a case where B captures the entire A's market by setting a lower standard and by lowering tuition to $t_B \leq t_A - \alpha(s_A - s_B) - \epsilon$, where $\epsilon > 0$ can be as small as the minimum currency denomination (say, 1¢). In this case, students apply only to school B. Hence, school B solves

$$\max_{s_B} \pi_B^{\text{undercut}}\Big|_{s_B < s_A} = t_B n(1 - s_B) = [t_A - \alpha(s_A - s_B)]\, n(1 - s_B), \tag{9}$$

which turns out to be identical to the problem it solves under the constraint $s_B > s_A$ which is given in (7). Hence, (8) is also the unique solution for (9). We therefore, with no loss of generality, can rule out this case.

School B sets a lower standard and divides the market

Figure 3 (bottom) illustrates a situation where B sets a lower admission standard than A, without undercutting tuition relative to A. Therefore, A continues to admit the more qualified students, whereas B admits less qualified students. This case can happen only if A charges extremely low tuition so that B would find undercutting A unprofitable. As will be shown in section 5.2 below, this case is on the equilibrium path.

In this case, where B cannot profit from undercutting t_A, it fixes tuition at the reservation level, $t_B = \beta + \alpha s_B$ and chooses s_B to solve

$$\max_{s_B} \pi_B^{\text{share}}\Big|_{s_B < s_A} = t_B n(s_A - s_B) = (\beta + \alpha s_B) n(s_A - s_B), \tag{10}$$

yielding

$$s_B = \frac{\alpha s_A - \beta}{2\alpha}, \quad t_B = \frac{\alpha s_A + \beta}{2}, \quad \text{and} \quad \pi_B = \frac{n[\beta + \alpha(s_A)]^2}{4\alpha}. \tag{11}$$

Comparing (8) with (11) reveals that

$$\pi_B^{\text{share}}\big|_{s_B < s_A} \geq \pi_B\big|_{s_B \geq s_A} \quad \text{if} \quad t_A \leq \alpha(2s_A - 1) + \beta. \tag{12}$$

Equation (12) provides the condition under which setting a lower admission standard than A while not undercutting A's tuition (bottom part of Figure 3) yields the *highest* profit compared to the other two options (top and middle parts of Figure 3). The condition given in (12) states that either s_A is high (so 'locating to the right' of A is not profitable) or that t_A is already low (so B cannot enhance its profit by undercutting A).

5.2 The first stage game

We now analyze how graduate school A sets its tuition level, t_A, and its minimum admission standard, s_A, knowing how B would respond. Condition (12) reveals that there are two possible responses by university B that must be considered: (i) B sets $s_B > s_A$, and (ii) B sets $s_B < s_A$.

(i) B sets $s_B > s_A$: Graduate school A takes B's response functions (8) as given and maximizes profit by setting $t_A = \beta + \alpha s_A$ (reservation tuition for its students) and chooses s_A to solve

$$\max_{s_A} \pi_A = t_A n(s_B - s_A) = (\beta + \alpha s_A) n \left[\frac{\alpha(s_A + 1) - (\beta + \alpha s_A)}{2\alpha} - s_A \right],$$

yielding a unique solution given by

$$s_A = \frac{\alpha - 3\beta}{4\alpha}, \quad t_A = \frac{\alpha + \beta}{4}, \quad \text{and} \quad \pi_A\big|_{s_B > s_A} = \frac{n(\alpha + \beta)^2}{16\alpha}. \tag{13}$$

(ii) B **sets** $s_B \le s_A$**:** Condition (12) reveals that to enter this range where undercutting is not profitable for school B, school A must set t_A sufficiently low and s_A sufficiently high so that $t_A \le \alpha(2s_A - 1) + \beta$. Substituting this constraint into A's profit function, A chooses s_A that solves

$$\max_{s_A} \pi_A = t_A n(1 - s_A) = [\beta + \alpha(2s_A - 1)]\, n(1 - s_A),$$

yielding a unique solution given by

$$s_A = \frac{3\alpha - \beta}{4\alpha}, \quad q_A = n(1 - s_A) = \frac{n(\alpha + \beta)}{4\alpha}, \quad t_A = \frac{\alpha + \beta}{2}, \quad \text{and} \quad \pi_A = \frac{n(\alpha + \beta)^2}{8\alpha}. \quad (14)$$

Substituting (14) into (11) yields B's choices of tuition and admission levels

$$s_B = \frac{3\alpha - 5\beta}{8\alpha}, \quad q_B = n(s_A - s_B) = \frac{3n(\alpha + \beta)}{8\alpha}, \quad t_B = \frac{3(\alpha + \beta)}{8}, \pi_B = \frac{9n(\alpha + \beta)^2}{64\alpha}. \quad (15)$$

In order for (15) to be an equilibrium, it must be that students enrolling to A gain a higher utility than enrolling to B. Indeed, in view of (1), $\beta + \alpha s_A - t_A \ge \beta + \alpha s_B - t_B$ if and only if $(\alpha + \beta)/4 \ge 0$ which always holds.

Finally, for (15) to constitute a unique equilibrium it must be that A's profit level in (15) exceeds A's profit level in (13), which is indeed the case. Hence,

Result 3. *When tuition is not regulated there exists a unique equilibrium satisfying the following properties:*

(a) School A admits the more qualified students indexed on $\left[\frac{3\alpha - \beta}{4\alpha},\ 1\right]$, school B admits less qualified students indexed on $\left[\frac{3\alpha - 5\beta}{8\alpha},\ \frac{3\alpha - \beta}{4\alpha}\right)$, and all students indexed on $\left[0,\ \frac{3\alpha - 5\beta}{8\alpha}\right)$ are not admitted to any school.[13]

(b) The school which admits the less qualified students admits more students, charges a lower tuition, but earns a higher profit than the school which admits the more qualified students. Formally, $q_B > q_A$, $t_B < t_A$, and $\pi_B > \pi_A$.

This result is fairly in line with observed behavior in the U.S. professional graduate education market. If we think of school A as representing the private segment and school B as representing

[13] Clearly, as β approaches $3\alpha/5$, [see equation (1)], all students become eligible for admission.

the public sector, in general, private universities charge higher tuition and admit more qualified students. Goldin and Katz (1999) note that among the top fifty universities ranked by U.S. News & World Report only three began college level instruction in the twentieth century, and only fourteen belonged to the public sector (of the fourteen, six belong to the University of California state system).

6. Optimal Admission Standards in a Two-School System

So far, we have computed the minimum admission standards and tuition levels in an unregulated duopoly higher education market. The welfare analysis of Section 4.2 showed that the minimum admission standard chosen by a monopoly school is optimal. It would be interesting to ask now whether this result extends to a duopoly school market. As in Section 4.2, we define the social welfare function as the sum of students' utility and universities' profit levels. Thus, the regulator chooses s_A and s_B to solve

$$\begin{aligned}\max_{s_A,s_B} W &= ns_B \cdot 0 + n(s_A - s_B)(\beta + \alpha s_B - t_B) + n(1 - s_A)(\beta + \alpha s_A - t_A)\\ &\quad + n(s_A - s_B)t_B + n(1 - s_A)t_A \\ &= n(s_A - s_B)(\beta + \alpha s_B) + n(1 - s_A)(\beta + \alpha s_A).\end{aligned} \tag{16}$$

It can be easily verified that (16) is strictly concave with respect to both arguments. Hence, when there are two institutions, the optimal minimum admission requirements are

$$s_A^* = \frac{2\alpha - \beta}{3\alpha} \quad \text{and} \quad s_B^* = \frac{\alpha - 2\beta}{3\alpha}. \tag{17}$$

Comparing (17) with Result 3 yields the following result.

Result 4. *(a) The minimum admission requirement of each school exceeds the optimal levels. Formally, $s_A > s_A^*$ and $s_B > s_B^*$.*

(b) The difference between the equilibrium minimum admission requirements and the optimal requirements:

(i) increases with the students' basic gains-from-education parameter, β, and

(ii) decreases with the students' productivity parameter, α.

Result 4(a) implies that, under this type of competition, "too many" potential students are not getting an education, and that some limited reduction in admission requirements increases aggregate welfare. Thus, competition ends up in some inefficient exclusion of students from the high-education system.

The intuition behind Result 4(b) is as follows. When β increases, the benefits from obtaining a degree from *any* university increases regardless of the difference in admission requirement levels. Hence, competition among universities is reduced and admission levels are reduced as a consequence. In contrast, when α increases, the benefit from being admitted to the university with a more rigid requirement increases, thereby generating a more intense competition on admission levels, which results in higher admission requirements than the optimal levels.

Figure 4 compares the equilibrium minimum admission requirement levels to the optimal levels for a particular case where $\beta = 0$, reflecting a situation where the benefits from obtaining a degree depends only on the admission standards (then translated into post-graduation wages). Note that

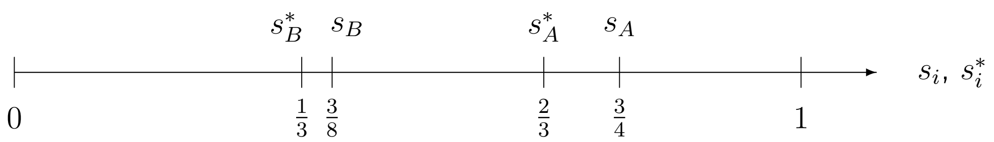

Figure 4: Equilibrium versus optimal minimum admission requirements, ($\beta = 0$ case).
Note: Superscripts * denote optimal levels.

Result 4(b) shows that differences between the equilibrium admission levels and the optimal levels displayed in Figure 4 increase as β increases.

7. Regulated Tuition in a Two School System

Suppose now that the regulating authority imposes a uniform tuition which we denote by $\hat{t}$, however, it leaves schools the freedom of choosing their minimum admission requirements, s_A and s_B. Observe that (1) implies that by setting $\hat{t}$, the regulating authority affects the minimum admission level of each school, since by (1), no student will be willing enroll to a school whose admission standard is below the level s satisfying $\beta + \alpha s < \hat{t}$. Hence, both schools will set their minimum admission standard above $s = (\hat{t} - \beta)/\alpha$.

We now look at a game where school A sets its minimum admission standard, s_A first, followed by school B which sets s_B. The proof of the following result is given in Appendix B.

Result 5. *When tuition is regulated at the level $\hat{t}$,*

(a) The regulating authority controls the minimum admission standards which determine the student population size. The student aggregate population size is then $\left[1 - (\hat{t} - \beta)/\alpha\right] n$;

(b) Schools A and B set admission levels are given by

$$s_A = \frac{\alpha - \beta + \hat{t}}{2\alpha}, \quad \textit{and} \quad s_B = \frac{\hat{t} - \beta}{\alpha}, \quad \textit{hence} \tag{18}$$

(c) Both schools admit the same number of students and earn the same profits.

The equilibrium described by Result 5 is illustrated in Figure 5, which shows that under regulated tuition both institutions ends up with the same number of students, although they set different admission standards and admit entirely different types of students.

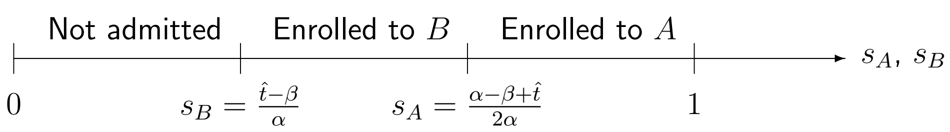

Figure 5: Equilibrium minimum admission requirements under regulated tuition.

Result 5(a) states that the regulator can influence the number of students who are not admitted to any graduate school by varying the mandated tuition level, $\hat{t}$. A natural question to ask at this point is whether the single policy instrument, mandated tuition, is sufficient to support the optimal minimum admission requirement levels given in (17)? The following result is proved in Appendix C.

Result 6. *When tuition is regulated, but schools can freely choose their minimum admission standards, there does not exist a uniform mandated tuition level which induces both schools to set the socially-optimal minimum admission requirements.*

The main message behind Result 6 is that a uniform tuition policy cannot achieve the first-best allocation of students among schools. Therefore, regulators must resort either to a differentiated tuition policy, or to a complete regulation of admission requirements.

8. Summary and Discussion

We analyzed the market for higher education utilizing a model consisting of individual students who can choose the professional graduate school that generates the highest value given the observed costs (tuition) and future market prospects. Graduate schools seek to recruit students from a pool of students of heterogeneous quality. In a deregulated market, they decide on two complementary strategies: admission standards and tuition levels. In a regulatory regime, a regulator can mandate a uniform tuition level. We assumed the existence of two representative professional graduate schools that may represent two subsectors (such as state schools versus private schools).

We demonstrate that a single (unregulated) graduate school, which can freely choose its admission standard and tuition level, selects the optimal admission standard (subject to the constraint that entry of new competing schools is not permitted). We then show that regulated low tuition level reduces the incentive to restrict admission standards to high levels in order to admit only highly qualified students. We also demonstrate that introducing competition induces graduate schools to set higher admission standards than the optimal levels, thereby depriving "too many" students from professional eduction. This result implies that there may be some social benefits by introducing low-tuition institutions in order to "capture" students with low abilities.

We conclude our analysis with the exploration of the consequences of mandating a *uniform* tuition level in all schools. We demonstrate that although the level of the regulated tuition monotonically affects the admission standard of each school, uniform tuition cannot support the first-best allocation of students among institutions according to qualities.

Our analysis clearly highlights the benefits from having different graduate schools setting different admission standards, and can be generalized to incorporate more than two institutions. For example, one possible extension of the present model would be to compute the optimal number of universities (each specializes in admitting different types of students) in a given economy. Such an extension would be done by assuming a fixed cost, say F, required for the establishment and maintenance of each university. Another extension of our model would be to assume that potential employers of university graduates have more information concerning the composition of the body of students enrolled in each university. The net-gain function (1) assumes that potential employers know only the *minimum* admission standard as publically announced by university admission offices. In practice, potential employers may know the *actual* distribution of student types. In this case, the net-gain function (1) could be written as $U = \beta + \alpha(s_i^{\max} - s_i^{\min})/2 - t_i$ (the average ability of students enrolled in university i).

As a topic for future research it may be interesting to model also the sources of competitive advantage. Firms in the higher education sector rely heavily on non-tuition revenues. Some of it may come from private donations and some from legislative allocations. As a result, some graduate professional schools in general sell their service below cost, essentially subsidizing their students. Different universities and professional schools have different access to non-tuition resources that determine the level of subsidies (and therefore their ability to emphasize quality). As a result, we may observe a differentiated hierarchy of schools. A school's position within the hierarchy signals its academic excellence of students' quality

The hierarchy that is based on differential access to non-tuition resources, is highly correlated with the length of existence. Ordinarily, we are likely to find older universities at the top. While the initial entry may have been accidental, the next stage may not. Thus, subsequent entrants may obtain large endowments such as school-naming endowments or large government subsidies. These in turn could be used to explain changes in the hierarchy in the long run.

Appendix A. Exploration of Students' Utility Function (1)

Figure 6 plots some indifference curves implied by the net-gain function (1). In difference curves

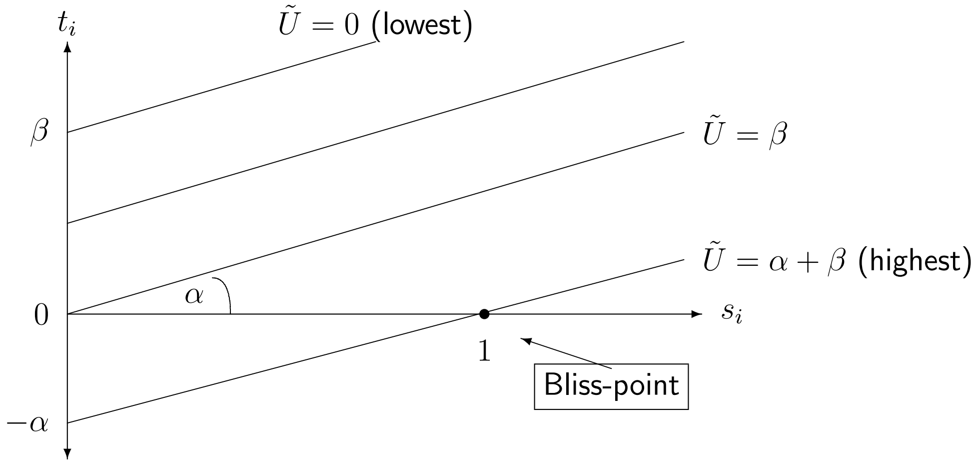

Figure 6: Students' indifference curves in the tuition vs. minimum admission requirement space. *Remark:* The figure is valid only for students who are admitted to this university (i.e., $s \geq s_i$).

are drawn from $t_i = \beta + \alpha s_i - \tilde{U}$, where $\tilde{U}$ is the utility level associated with the specific indifference curve. Therefore, the slope of all indifference curves is α. In this space, utility increases towards the South-East where either tuition declines or the minimum admission standard increases, or both. The lowest possible utility level of $\tilde{U} = 0$ is obtained when tuition is set to $t_i = \beta$, and when there is no minimum admission requirement, $s_i = 0$; or a combination of the two on the same indifference curve. The highest utility (bliss-point) is obtained when tuition is set to $t_i = 0$ and the school sets the maximum admission standard, $s_i = 1$, or any combination of the two involving negative tuition levels (a subsidy).

Appendix B. Proof of Result 5

(a) Since tuition is regulated, the objective of each school is to maximize its student population size. However, by (1), both schools must set admission standards $s_i \geq (\hat{t} - \beta)/\alpha$ as otherwise no student will find it beneficial to obtain a graduate degree. (b) Since A sets s_A before B sets

s_B, school A has to consider two cases: First, if it sets s_A "too low" (i.e., close to $(\hat{t}-\beta)/\alpha$), school B will set its minimum admission level to $s_B = s_A + \epsilon$, where $\epsilon > 0$ could be made as small we want. In this case, all students will enroll to university B. Second, school A can set a relatively high s_A, in which case school B will set $s_B = (\hat{t}-\beta)/\alpha$ and will enroll all students on the interval $[s_B, s_A)$. Since the market share of school A is $1 - s_A$, profit declines with s_A.

Given these two options, the subgame-perfect equilibrium is that school A maximizes enrollment by setting s_A to make school B *indifferent* between setting $s_B = s_A+\epsilon$ and $s_B = (\hat{t}-\beta)/\alpha$. Formally, school A sets s_A that solves

$$\lim_{\epsilon\to 0} \pi_B|_{s_B=s_A+\epsilon} = \lim_{\epsilon\to 0} n(1-s_A-\epsilon)\hat{t} = n(1-s_A)\hat{t} = n\left(s_A - \frac{\hat{t}-\beta}{\alpha}\right)\hat{t} = \pi_B|_{s_B=\frac{\hat{t}-\beta}{\alpha}} \quad (19)$$

yielding a unique solution given by

$$s_A = \frac{\alpha-\beta+\hat{t}}{2\alpha}.$$

(c) By construction, (19) implies that A and B have identical market shares. Since they charge the same mandated tuition, they make identical profits. *Q.E.D.*

Appendix C. Proof of Result 6

By a way of contradiction, suppose that there exists a uniform tuition level, t^* which implements the socially-optimal admission level, s_A^* and s_B^* given in (17). Comparing (18) with (17), we have

$$s_B = \frac{t^*-\beta}{a} = \frac{2\alpha-\beta}{3\alpha} = s_B^* \quad \Longrightarrow \quad t^* = \frac{2(\alpha+\beta)}{3}.$$

Substituting this value of t^* into s_A given in (18) yields $s_B = (5\alpha-\beta)/(6\alpha) \neq s_B^*$ given in (17). A contradiction. *Q.E.D.*

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