

Why is There No *Harvard* Among Japanese Private Universities?

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Abstract

The social and academic reputation of private universities in Japan lags far behind that of the national universities. We argue that this arises from the heavy subsidy provided by and the low tuition fees set by the central government for the national universities. Using simulations based on an assignment model of heterogeneous students and universities, we show that the levels of national university tuition fees and subsidies influence the equilibrium distribution of tuition fees and the academic quality of the private universities. Using cross-section data of Japanese universities, we find that private university tuition fees are lower in prefectures where the quality of the national university is high, as theoretically predicted.

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1 Introduction

The social and academic reputation of private universities in Japan lags far behind that of the national universities. This is in sharp contrast to the U.S. higher education market where the most academically successful universities are private, such as Harvard and Princeton. In the history of Japanese higher education, there has not been any "Harvard" among the private universities, i.e., private universities have never surpassed national universities in terms of academic quality and social reputation. This paper investigates the reason for this discrepancy.

One of the obvious reasons is the heavy government subsidy provided to national universities since their establishment. Currently, a student of a national university receives 3.87 million yen per year as government subsidy, which is 25 times that received by the average private university student (Ministry of Education, 1997). However, even in the U.S., state universities receive greater subsidies than private ones; hence, it is not immediately clear whether the subsidy aspect adequately explains the wide disparity between the national and private universities of Japan.,

In this paper, we show that the heavy subsidy provided by *and* the low tuition fees set by the central government for national universities are jointly responsible for impeding the production of high academic quality in private universities in equilibrium. We postulate that the key mechanism through which the quality and tuition fees of national universities affect the behavior of private universities is a shift in the assignment of heterogeneous students and universities with respect to tuition fees and education quality. In our model, equilibrium in the public-private mixed market can be achieved through the adjustment of the tuition fees and education quality of private universities and the length of the queue to national universities. The queue is created through the written entrance exams that randomize the students admitted to high-ranked universities. Then the length of the queue (or the inverse of the probability of passing the exam), which is endogenously determined, serves as an additional price of national universities, and an equilibrium in which the national universities are ranked above the private universities is shown to exist under this policy.

We calibrate our model to the Japanese education market to see the influence of the Japanese policy on the equilibrium. Our numerical results qualitatively support our postulation: private universities are compelled to charge low tuition fees and are unable to produce high academic quality due to the lack of adequate financial revenue. Finally, using cross-section data of all universities in Japan, we conduct empirical analyses on the determinants of tuition fees in private universities. The results generally support

our theoretical predictions. In particular, we find that in prefectures where the average quality of national universities is higher, private universities charge lower tuition, controlling for the characteristics of private universities.

Previous theoretical studies on the education market tended to focus on the roles of peer effects and human capital externality on the prices of college education services and the sorting of students across schools.¹ The paper most closely related to ours in the motivation is that by Epple, Romano, and Sieg (2003, ERS hereafter). Their paper constructs a model of a university market in which all universities, by choosing their tuition fees, admission policies, and educational expenditures, maximize the quality of education, which is determined by the quality of peer students and the educational expenditure. The primary difference between ERS and our paper is that we focus on the effects of (exogenous) national university policies on the distribution of tuition fees and education quality among private universities, whereas ERS focuses on the sorting of students by ability and income into different types of schools with no specific role for the public university policy. As in their paper, our model is embedded in the literature of assignment (hedonic price) models, developed by Rosen (1974), Sattinger (1980), and Epple (1987). Because of our purpose, we assume that students and universities are continuously differentiated in one dimension—ability in the case of students and endowment in the case of universities.² The endogenous queue to national universities is introduced in order to make our model an adequate description of the Japanese education market and to make a meaningful equilibrium exist under the policy distortions. In reality, this explains the widespread existence of “ronin” in Japan—high school graduates who wait for one year or more to be admitted to their favorite university. In the empirical section, we incorporate the effect of public intervention in the estimation of the tuition fee function explicitly based on our theoretical model unlike previous empirical studies regarding university tuition fees.³

Assigning independent roles to public university policies in the analysis of the higher education market is an important step not only for seeking an answer to our specific question but also for providing a insight into the higher education system in which public universities dominate the market. There is

¹Rothschild and White (1995) propose a competitive model of the higher education market in which a consumer’s own human capital is also an input for the human capital production of others. Epple and Romano (1998) construct a model of the local public school system, which includes student peer effects and profit-maximizing private schools. They show that in equilibrium, heterogeneous students are sorted into different types of schools, with public schools accommodating students with the lowest ability and income.

²In the ERS model, there are a finite number of colleges with which a continuum of students is matched in equilibrium. We assume that schools are continuously distributed since our objective is to observe the effects of a small change in exogenous public school policy on the equilibrium student assignment and tuition fee levels.

³Harford and Marcus (1986) estimated the determinants of levels of tuition fees in private colleges on the characteristics of colleges using a cross-section of 780 U.S. private colleges. In Japan, Yonezawa (1994) and Urata (1998) were the first to analyze the relationship between tuition fees at private colleges and the characteristics of those colleges.

a large variation in the relative dominance of public universities to private universities across different countries. In Asia and Europe, national (or other public) universities tend to be predominant in research and education, and the government policy with regard to national universities has a considerable impact on the decision-making and productivity of private universities. Our approach can provide a framework for analyzing a variety of mixed markets for higher education in various countries.

In the next section, we describe some basic facts about the Japanese higher education market. Section 3 lays out our theoretical framework. In section 4, we present several numerical results of equilibrium prices of private universities calibrated to the Japanese higher education market. Section 5 shows some empirical evidence that the tuition fees of private universities are influenced by the quality of national universities as predicted by our theory. Section 6 gives concluding remarks.

2 Background

Japan has 709 four-year universities (87 national, 80 local public,⁴ and 542 private universities). The total number of undergraduate enrollments is 2,809,295, while the student share of private universities is 77%.⁵ In terms of quality of education and research, the social and academic reputation of private universities generally lags behind that of national universities. A recent worldwide university ranking (Shanghai Jiao Tong University, Institute of Higher Education, 2004)⁶ shows that five national universities in Japan are among the top 100 universities in the world, while only one Japanese private university is ranked among the world's top 200-300 universities.

On the other hand, in the United States, the most academically successful universities are private, and their student share is smaller than that of the Japanese private universities. In the U.S., the private universities have a 27% share of all full-time students, including graduate students (Ministry of Education, 2001). In the most recent survey (2005) conducted by the U.S. News & World Report, 25 out of the top 30 (doctoral) universities are private, and among these, the top ranking is shared by Harvard and Princeton.

(Insert Table 1 and Figure 1)

To present a more concrete picture of the difference between the higher education markets of Japan and the U.S., Table 1 presents a comparison between the key data of private and public universities in these

⁴Local public universities are established and financially subsidized by prefectural or municipal governments.

⁵These are the numbers as of 2004, based on the Basic School Survey (Ministry of Education, 2004).

⁶<http://ed.sjtu.edu.cn/ranking.htm>

two countries. The annual education expenditure for one national/public university student in Japan is 4.36 million yen, which is approximately equal to the amount expended by a U.S. *private* university on one student. The expenditure incurred by a Japanese private university on one student is 1.74 million yen, which is approximately 40% that by a Japanese national university and approximately 70% that by a U.S. *state* university. In Japan, the proportion of government subsidy to the total expenditure is 89% for national universities and 8.9% for private universities. The tuition fees of national universities are approximately 64% of those of private universities in Japan, while in the U.S., the average tuition fees of *state* universities are approximately 20% of those of private universities. These numbers suggest that in Japan, national universities offer a significantly better quality of education, at least in terms of expenditure, at a lower cost than private universities do. In the U.S., such a reversal in the relationship between tuition fees and expenditure is not observed. This conjecture can be confirmed by other measures of education and research quality. Figure 1 compares four measures of quality between private and national universities. Consistent with the expenditure data, the per-student quality of education is much higher in national than in private universities.

(Insert Table 2)

In Japan, national universities are ranked higher and are more selective at the entrance examination as compared to most private universities. Table 2 shows the average “hensachi,” which indicates the relative level of difficulty of passing an entrance examination, and the ratio of applicants to actual entrants for 10 major departments of both private and national universities. These numbers show that national universities are generally more selective than private universities.

(Insert Figure 2)

How does the national university policy affect the financial resources of private universities? Figure 2 shows the trends in the average real tuition fee levels of national universities, private universities, and those of social science and humanities majors in private universities.⁷ The graphs show that the tuition fee level of national universities has risen rapidly since the early 1970s and that of private universities has also risen remarkably at a similar rate. While the ratio of national university tuition fees to private

⁷In our empirical analysis, we will focus on social science and humanities majors, which charge the lowest tuition fees among all majors. On the other hand, among all the majors offered by a private university, colleges for medicine or dentistry tend to charge the highest tuition fees.

university tuition fees has been approaching one in recent years, the absolute gap remains large.⁸ Tuition revenue constitutes a major portion of the financial resources of private universities in Japan. From Table 1, we can see that the tuition fee share of the total budget is 62.5% for private universities in Japan and 40.7% for private universities in the U.S. Thus, the manner in which the national university policy affects the private university tuition fee level should have a larger impact on educational and research resources in Japan than in the U.S.

3 Model of a Higher Education Market

In this section, we introduce a model of a higher education market. It describes the assignment of students to universities and is used to evaluate the impact of national education policies (i.e., changes in tuition fees and quality of education in national universities) on the distribution of tuition fees and education quality in private universities.

3.1 Environment

Consider an economy where there is a continuum of students, a continuum of private universities, and a single national university.⁹ College education is supplied by both private and national universities. We assume that private universities are heterogeneous in terms of their initial positive “endowments,” denoted by e , which are short-run fixed resources such as their historical reputation, library volumes, and building space. The endowments of private universities are distributed on an interval $[e_{\min}, e_{\max}]$ with density $g(e)$ and the total number of private universities is $G = \int_{e_{\min}}^{e_{\max}} g(e)de$. To produce a given quality of education services, private universities utilize their initial endowments and the educational expenditure out of the tuition revenue. We assume that their objective is to maximize their profit, that is, they maximize tuition revenues minus educational costs by determining the education quality and tuition fee level.¹⁰ Private universities can also choose to exit the university market when they cannot achieve the normal profit level.¹¹ We assume that the levels of education quality and tuition fees in national universities, denoted

⁸In the absence of readily available data on private university tuition fees prior to 1975, it is unclear from the available figures whether private universities’ fees have followed those of the national universities. Data on tuition fees based on longer periods remains to be analyzed.

⁹In the model, the term “national university” encompasses any public university whose education quality and tuition fees are controlled by the central or local government.

¹⁰An alternative formulation is to assume that private universities maximize education quality (ERS, 2003). We are working toward implementing this case in our model to investigate which assumptions better describe the empirical facts of the higher education market in Japan.

¹¹Therefore, in precise terms, the distribution of endowment is given for “private university entrepreneurs” and not necessarily for private universities that operate in equilibrium.

by q_p and t_p , respectively, are given exogenously.¹² The capacity of each (atomic) private university is assumed to be unity (one student), while the capacity of a national university is denoted by c_p , which is also given exogenously.

Each student is indexed by a positive “ability,” denoted by a . Ability of students is distributed on an interval $[a_{\min}, a_{\max}]$ with a density $f(a)$, and the total number of students is $F = \int_{a_{\min}}^{a_{\max}} f(a)da$. The utility of a student depends on the quality of education, composite consumption goods, and his/her own ability. Students divide their fixed income y , which is assumed to be homogeneous across the population, into tuition expenditure and consumption. There are three distinct modes of educational choice for students: applying to the national university, attending a private university, and participating in the labor market without acquiring university education. If they decide to attend a private university, they will choose the quality of the private university education, q , under the given equilibrium tuition fee schedule, $t(q)$. If they decide to apply to a national university, they expect to consume an education service of quality q_p at a cost of tuition t_p , if admitted. Further, if they choose not to attend any university, the levels of education quality and tuition expenditure are both assumed to be zero. Each student is assumed to be a price-taker, and students make their decisions in order to maximize utility given the tuition fee schedules of private universities, denoted by $t(q)$, a set of national university policy variables, denoted by t_p and q_p , and the behaviors of the other students.

Given the distributions of students and private universities, the optimal choice of quality by both students and private universities determines the demand and supply of the education service at each quality level. A market equilibrium should exhibit a functional relationship between tuition fees and quality for private universities, denoted by $t(q)$, so as to equalize the demand and supply at each quality level.

3.2 Student Behavior

We assume that the preferences of students with ability a are represented by the quasi-linear utility function with its sub-utility taking the Cobb-Douglas form, $u(m, q; a) = m + \theta a^\alpha q^{1-\alpha}$, where $\theta > 0$, $0 < \alpha < 1$, and m denotes composite consumption goods. Thus, the marginal utility of education quality positively depends on the student’s ability.

¹²Exogenous public university policies provide adequate boundary conditions for solving a differential equation in the later subsections. Due to the absence of a public university in the ERS model, it alternatively introduces an exogenous “tuition cap” in order to ensure the calculation of equilibrium tuition fees and college quality. Determining the more reasonable manner is dependent on the institutional context.

We first consider the behavior of students who have already chosen a mode of attending a private university. The utility maximization problem for a student with ability a is described as

$$\begin{aligned} V(a) \equiv \max_{m,q} \quad & m + \theta a^\alpha q^{1-\alpha} \\ \text{s.t.} \quad & m + t(q) = y, \end{aligned} \tag{1}$$

where y is the income and $t(q)$ is the hedonic tuition fee function for private universities. Assuming the differentiability of $t(q)$ and the internal solution, the first-order condition for utility maximization with respect to q is given by

$$t'(q) = \theta(1 - \alpha)a^\alpha q^{-\alpha}, \tag{2}$$

and the second-order condition is given by

$$t''(q) > \theta\alpha(\alpha - 1)a^\alpha q^{-\alpha-1}. \tag{3}$$

The hedonic tuition fee function must satisfy equations (2) and (3). Note that if the SOC is satisfied, the equilibrium quality choice of the student, $q(a)$, has the following property:

$$dq/da > 0. \tag{4}$$

This implies that students with higher abilities choose a higher quality of university education in equilibrium.

We next consider the case wherein students choose a mode of applying to the national university. Based on the observation that some high school graduates (ronin) spend a year or more to pass the entrance examination and procure admission into their favorite university (mostly national universities), we assume that in equilibrium, some applicants may be unable to pass the national university examination and would have to attempt it again the following year.¹³ The probability of passing is assumed identical and uncorrelated over time.¹⁴ Let U_0 be the students' utility achieved when they enter the national

¹³Although most private universities also require a written exam in Japan, they are usually given on different days, providing students with multiple chances to avoid being ronin. However, all the national universities uses the same exam which is given only once a year.

¹⁴The probability of passing the entrance examination may realistically depend on the student's ability. However, this assumption would unnecessarily complicate the following analysis with little substantial addition to the implications on the private university markets. Also the lack of serial correlation is adequate for an admission process that enrolls students automatically based on the scores of the written exam, the case for most Japanese national universities. In countries where the admission offices heavily rely on personal statements or interviews, the probability of passing must be serially correlated and there is little point in being a ronin.

university, that is, $U_0 = y - t_p + \theta a^\alpha q_p^{1-\alpha}$. Let ρ be the probability of passing the entrance examination of the national university and r be the waiting cost of spending one year as “ronin.” Then, the expected utility of students that has to be maximized can be written as

$$\begin{aligned} & \sum_{t=1}^{\infty} [(1-\rho)\delta]^{t-1} [\rho U_0 - (1-\rho)r] \\ = & \rho U_0 / (1 - (1-\rho)\delta) - (1-\rho)r / (1 - (1-\rho)\delta), \end{aligned} \quad (5)$$

where δ is the subjective discount rate.¹⁵ If we simply assume that ρ can be defined as the capacity of the national university (c_p) divided by the number of total applicants (A_p), the terms $\rho/(1 - (1-\rho)\delta)$ and $(1-\rho)/(1 - (1-\rho)\delta)$ could be described as the functions of c_p/A_p in equilibrium.

In the case of students who choose not to attend any university, their utility level would be y regardless of their abilities.

3.3 Private University Behavior

Given the equilibrium tuition fee schedule, each private university chooses the quality of education, denoted by q , in order to maximize its profit. We assume that the production function of the education quality of private universities with initial endowment e takes the following Cobb-Douglas form, $q = e^\gamma v^{1-\gamma}$, where $0 < \gamma < 1$ and v is the educational expenditure measured in dollars per student. Then, the cost function can be written as $e^\beta q^{1-\beta}$, where $\beta \equiv -\gamma/(1-\gamma)$ and $\beta < 0$. Thus, in order to achieve a given level of quality, the current educational cost decreases with an increase in the level of endowment. The profit maximization problem of private universities is written as

$$\Pi(e) \equiv \max_q t(q) - e^\beta q^{1-\beta} - F, \quad (6)$$

where is F the fixed cost required regardless of the quality of the education provided. The first-order condition for this maximization problem with respect to q is given as

$$t'(q) = (1-\beta)e^\beta q^{-\beta}, \quad (7)$$

¹⁵This dynamic nature is introduced merely in order to calculate the expected returns of applying to the national university. A fully dynamic model that includes sequential decision-making of students with regard to the mode of university choice would be an interesting future extension.

and the second-order condition is given as

$$t''(q) < \beta(\beta - 1)e^\beta q^{-\beta-1}. \quad (8)$$

Note that if the SOC is satisfied, the supply of education quality by private universities, $q(e)$, has the following property:

$$dq/de > 0. \quad (9)$$

As is the case with students, this property implies that better endowed universities choose to produce a higher quality of education in equilibrium. We also assume that the reservation profit level is zero for all universities.

3.4 Calculation of Sorting Equilibrium

We restrict our attention to those equilibria where—similar to higher education in Japan—the equilibrium assignment of students exhibits sorting by ability, and the national university has a better quality and attracts students with higher abilities compared to any of the private universities.¹⁶ We first show that such an equilibrium exists under a certain condition. Then, under this condition, students are divided into a maximum of three groups by two threshold ability levels: the highest ability group that chooses the national university, the middle ability group that chooses private universities, and the lowest ability group that decides not to attend any university. Let us denote the lower and upper boundaries of the abilities of students who attend private universities by \hat{a} and \check{a} respectively. Then, in equilibrium, students with $a \in [a_{\min}, \check{a}]$ will enter the labor market without attending any university, $a \in [\check{a}, \hat{a}]$ will attend private universities, and $a \in [\hat{a}, a_{\max}]$ will choose the national university. We consider cases in which $a_{\min} \leq \check{a} < \hat{a} < a_{\max}$ holds, i.e., there will always exist some students who attend either a national or a private university, but students who enter the labor market without acquiring any university education may not always exist in equilibrium.

¹⁶As we argue previously, the randomization of admission through the exam is essential to make a “Japanese” equilibrium exist. If there is no such a mechanism, an excess demand for national universities remains and some other non-market mechanism must be used to allocate students to schools. Then the national universities will be separated from the private university market, and the most endowed private university will charge the tuition fees without reference to the national university policy.

3.4.1 Matching of Private Universities with Students

We first consider the matching of private universities with students who are willing to attend them, given the upper and lower boundaries of students' abilities, \hat{a} and \check{a} , respectively. For ease of computation and presentation of the equilibria, we assume that both the abilities of students and the endowments of universities are uniformly distributed with density equal to 1. Then, the total demand for private universities by students with abilities higher than a is given by $\int_a^{\hat{a}} f(a) da = \hat{a} - a$. Similarly, for each e , the total supply of education by private universities with endowments higher than e is given by $\int_e^{e_{\max}} g(e) de = e_{\max} - e$. Market clearing requires that the above two expressions be equated for any private university-student matched pair; therefore, we require

$$\hat{a} - a = e_{\max} - e, \text{ for any matched pair } (a, e), \check{a} \leq a \leq \hat{a}. \quad (10)$$

Combining the FOCs for students and private universities, that is, equations (2) and (7), and eliminating e by equation (10), we can obtain the optimal quality choice made by a student with ability a as follows:

$$q(a) = \left(\theta \frac{1-\alpha}{1-\beta} a^\alpha (a + e_{\max} - \hat{a})^{-\beta} \right)^{1/(\alpha-\beta)}. \quad (11)$$

The optimal quality choice made by private universities, $q(e)$, is obtained if we eliminate a by equation (10) instead of eliminating e .

Using these conditions, we next derive the equilibrium tuition fee function. From the FOC for students, equation (2), a general solution for the tuition fee function can be written as

$$t(q) = \int_{q(\check{a})}^q \theta(1-\alpha)a(q)^\alpha q^{-\alpha} dq + C, \quad (12)$$

where C is the constant of integration and $a(q)$ is the inverse function of $q(a)$ defined in equation (11). Since an analytical expression for $a(q)$ does not always exist, we change the variable of equation (12) using equation (11) to get the following alternative form of the solution for the tuition function:

$$\begin{aligned} t(a) &= \int_{\check{a}}^a \theta(1-\alpha)a^\alpha q(a)^{-\alpha} \frac{\partial q}{\partial a} da + C \\ &= \tau(a; \hat{a}) - \tau(\check{a}; \hat{a}) + C, \end{aligned} \quad (13)$$

where $\tau(a; \hat{a})$ is the infinite integral of $\theta(1-\alpha)a^\alpha q(a)^{-\alpha}(\partial q/\partial a)$. Note that τ depends on \hat{a} , and that \check{a} ,

\hat{a} , and C are unknown parameters that have to be determined.

3.4.2 Consistency Conditions for Equilibrium

To complete the computation of the equilibrium tuition fee function, $t(a)$, we add the following consistency conditions to determine the upper and lower boundaries of the abilities of private university students, denoted by \hat{a} and \check{a} , respectively, and the constant of integration C . First, students with ability $a \in [\hat{a}, a_{\max}]$ who choose to apply to the national university in equilibrium must achieve at least as high a utility level as they would achieve by attending the most preferred private university. Second, students with $a \in [\check{a}, \hat{a}]$ who choose to attend a private university in equilibrium must achieve at least as high a utility level as that they would achieve by attending the national university. Third, students attending private universities in equilibrium must at least achieve their reservation utility level (i.e., the utility level when they choose not to acquire a university education). Finally, in order for private universities to participate in the market, they must earn positive profits in equilibrium. These conditions make students' qualitative choices—choosing no education, private university, or national university—globally optimal. Technically, these criteria generate the necessary boundary conditions to determine the unknown parameters in equation (13)— \check{a} , \hat{a} , and C .

Given the equilibrium sorting, the number of applicants to the national university, A_p , is equal to $a_{\max} - \hat{a}$, and the probability of passing the national university examination, ρ , is defined as $\rho = c_p / (a_{\max} - \hat{a})$, where c_p is the given capacity of the national university. Since the expected utility of a student with ability a applying to the national university is given by $p(\hat{a})(y - t_p + \theta a^\alpha q_p^{1-\alpha}) - w(\hat{a})r$, where $p(\hat{a}) = \rho / (1 - (1 - \rho)\delta)$ and $w(\hat{a}) = (1 - \rho) / (1 - (1 - \rho)\delta)$, the following boundary conditions are required.

Upper Boundary Conditions:

Sufficient conditions for the positive sorting of students by ability into national and private universities in an assignment equilibrium are

UB1. *For students with ability \hat{a} , attending the top private university is equivalent to applying to the national university. That is,*

$$y - t(q(\hat{a})) + \theta \hat{a}^\alpha q(\hat{a})^{1-\alpha} = p(\hat{a})(y - t_p + \theta \hat{a}^\alpha q_p^{1-\alpha}) - w(\hat{a})r. \quad (14)$$

UB2. $q(\hat{a})^{1-\alpha} < p(\hat{a})q_p^{1-\alpha}$. *(The national university has sufficiently high quality relative to the top*

private university.)

While leaving the formal proofs in the Appendix, we provide an interpretation of these conditions here. The first condition, UB1, ensures the existence of the national university in equilibrium. Since the levels of utility of attending private and national universities are both continuous functions with respect to student's ability, the utility level of attending the top private university must be equal to that of applying to the national university at the upper boundary of private university attendants. Otherwise, some students would be better off by changing their choice (from private to national, or vice versa).

The second condition, UB2, ensures the positive sorting of students by ability to national and private universities, that is, students in the highest ability group optimally choose to apply to the national university and those in the middle ability group choose to enter private universities. Since the probability of passing the examination for admission into the national university is identical for all students (regardless of their abilities),¹⁷ the term $p(\hat{a})q_p^{1-\alpha}$ can be regarded as the *discounted* (or *expected*) quality obtained by applying to the national university. UB2 states that the level of the national university quality q_p must be sufficiently high, given $p(\hat{a})$ and the quality of the top private university, $q(\hat{a})$. The single crossing property of a student's utility function (or the complementarity between ability and education quality) implies that a student's valuation for a given quality of education is positively related to his/her ability. When the *discounted* quality of the national university education is higher than the quality of the top private university, the complementarity in the utility function immediately implies a positive sorting of students by ability. However, if $q(\hat{a})^{1-\alpha} > p(\hat{a})q_p^{1-\alpha}$, students with $a < \hat{a}$ may have a greater valuation for the national university than those with $a > \hat{a}$, and positive sorting will not occur in equilibrium.

We next examine the lower boundary conditions. First, in the case of students, two situations may occur in equilibrium:¹⁸ (1) some students choose not to enter any university and (2) all students choose to attend some university. Let $V(a)$ denote the indirect utility function for students with ability a . Then, the former case can be expressed by the condition $V(\check{a}) = y$.¹⁹ The latter case can be written by the condition $\check{a} = a_{\min}$. Next, in the case of private universities, two situations may also occur in equilibrium: (1) some (potential) private universities choose not to participate in the market and (2) all private universities participate in the market. Let \check{e} denote the lowest endowment level of private universities that participate in the market and $\Pi(e)$ denote the equilibrium profit as the function of e .

¹⁷Alternatively, we could more realistically allow the probability of passing the national university entrance examination to depend on ability. Clearly, doing so would not change the single-crossing property described here.

¹⁸We exclude the third trivial case wherein all students choose not to attend any university.

¹⁹Then it can be shown that $V(a) < y$ for all $a < \check{a}$.

Then, the former case can be expressed by $\Pi(\check{e}) = 0$.²⁰ The latter case can be written by the condition $\check{e} = e_{\min}$. Now, we can classify the four patterns of the lower boundary conditions for an equilibrium, depending on the market environment.

Lower Boundary Conditions:

Sufficient conditions for the positive sorting of students by ability into private universities and no university education in an assignment equilibrium take one of the following four patterns:

LB1. $\check{a} = a_{\min}$ and $\check{e} = e_{\min}$ with $V(\check{a}) > y$ and $\Pi(\check{e}) > 0$. In this case all students attend some university and all private universities remain in the market.

LB2. $\check{a} > a_{\min}$ and $\check{e} = e_{\min}$ with $V(\check{a}) = y$ and $\Pi(\check{e}) > 0$. In this case some students do not attend any university and all private universities remain in the market.

LB3. $\check{a} = a_{\min}$ and $\check{e} > e_{\min}$ with $V(\check{a}) > y$ and $\Pi(\check{e}) = 0$. In this case all students attend some university and some private universities exit the market.

LB4. $\check{a} > a_{\min}$ and $\check{e} > e_{\min}$ with $V(\check{a}) = y$ and $\Pi(\check{e}) = 0$. In this case some students do not attend any university and some private universities exit the market.

With UB1, UB2, and one of the conditions LB1-4, we can determine the equilibrium values of the upper and lower ability boundaries of students who attend private universities, and the tuition fee function $t(a)$ from equation (13). The tuition fee function can be written in terms of endowment, denoted by $t(e)$, using the market clearing condition (equation (10)).

4 Numerical Simulations of Equilibrium Tuition Fees and Education Quality

In this section, we present some numerical simulations to examine the effect of changes in national university policy (t_p , q_p , and c_p) on levels of tuition fees and quality at private universities. Here, we focus on an equilibrium when UB1, UB2, and LB4 hold.²¹ In this case, some students will enter the labor market without acquiring any college education and some private universities will exit the market in equilibrium.

²⁰Then, it can be shown that for all .

²¹The other cases are not difficult to calculate, and they are omitted here.

First, we need to choose the parameters of our model. Let the total number of students be 123.5012 (in ten thousands, which was the college-age population in 2004). Then, we set $a_{\max} = 123.5012$ and $a_{\min} = 0$ because we assume the population density to be one. Our baseline parameter values for the Japanese national university policy are as follows: the capacity c_p is set to 14 (in thousands, which was the capacity of national universities in 2002. It is 14.5% of the total capacity of higher education), the tuition fee t_p is set to 77.38 (in ten thousand yen, which was the level of the tuition fees in 2002),²² and the education quality q_p is set to 100. We calibrate the parameters of the utility and cost functions by using the Social Stratification and Social Mobility Survey 1995 (hereafter SSM data). The entire specification of the parameter values and the details of the calibration are described in Appendix B.

When we calculate the equilibrium with the above baseline parameter values, the tuition fee at the top private university (with $e = e_{\max}$) becomes 131.0, exceeding that of the national university by approximately 70%, and its quality becomes 88.0, which is lower than that of the national university by 12%. In this case, students with abilities greater than 99.1 (19.8% of the total population) apply to the national university, and the probability of passing the entrance examination becomes 0.57. Private universities with an initial endowment lower than 40.9 exit the higher education market.

We next examine the effect of the national university policy on the equilibrium tuition fees and the equilibrium education quality of private universities. We consider the following three types of policy changes from the baseline case separately, holding the other conditions constant: (1) 30% increase in q_p (quality), (2) 30% decrease in t_p (tuition fees), and (3) 30% increase in c_p (capacity). Figures 3 and 4 depict changes in the private university tuition fees and the education quality, respectively, on the endowment domain. Since the policy change should shift the equilibrium assignment of students and universities, it is also important to observe the changes in the tuition fees and the education quality on the ability domain, that is, from the students' perspective. These are presented in Figures 5 and 6.²³

(Insert Figure 3)

Figure 3(a) shows the effect of quality improvement in the national university on the private university tuition fee function. Two equilibrium tuition fee functions are plotted on the private university endowment, $[e_{\min}, e_{\max}]$. The solid curve indicates the tuition fee function for the baseline case ($q_p = 100$), and

²²Regardless of major or institution, the first year annual tuition fee for undergraduate programs of the national university system (including admission and other additional fees) was set to 773,800 yen for 2002.

²³Equilibrium levels of utility and profit can be calculated easily. We also compute an equilibrium when no national university exists, and we compare the welfare level under the assumption that the national university is financed by lump-sum tax. These results can be sent upon request.

the broken curve indicates the tuition fee function for the case where q_p is increased by 30% ($q_p = 130$). It is found that the level of tuition fees at any private university declines with an improvement in the quality of the national university. The economic interpretation of this result is fairly straightforward. An increase in q_p will have two opposing effects on the students' decision-making. First, since the national university becomes more attractive for potential applicants due to its higher quality, some students who previously attended a private university will apply to the national university. However, an increase in the number of applicants will make it difficult for these students to be admitted. Although the lower probability of passing the entrance examination tends to impede the transfer of students from private to national universities, in equilibrium, more students apply to the national university than previously. As a result, the private university market will be tightened, and private universities will be compelled to undercut their tuition fees in order to counter the competition from the high-quality national university. Simultaneously, private universities with endowment levels lower than 44.4 will exit the higher education market as q_p increases.

A decline in tuition fees at the national university has an effect similar to that mentioned above. Figure 3(b) shows that a decrease in t_p will lower the tuition fee levels at all private universities. The interpretation of this is essentially the same as that provided above. Since a decrease in t_p makes the national university more attractive for potential applicants, it results in a transfer of some students from private to national universities; therefore, private universities are compelled to charge lower tuition fees than before. The effect of the national university capacity is shown in Figure 3(c). Since the applicants to the national university are more likely to be admitted when c_p is larger, some students will transfer from the private to the national university. Then, private universities will be compelled to charge lower tuition fees in equilibrium, as indicated in the figure.

(Insert Figure 4)

We now focus on the changes in the academic quality of private universities caused by the changes in the national university policy. Figure 4(a) shows the effect of quality improvement at the national university on the levels of quality produced by the private universities. Two equilibrium quality levels of private universities are plotted on the endowment domain. The solid curve indicates the quality for the base-line case ($q_p = 100$) and the broken curve indicates the quality in the case where q_p is increased from the base-line value by 30% ($q_p = 130$). It is found that the levels of academic quality at private universities almost uniformly decline as q_p increases. The interpretation is almost parallel to that of the tuition fees

case. Since an increase in q_p leads to a transfer of students from private to national universities, each private university is matched with students with lower abilities than the previous set of students. Then, the marginal willingness of students to pay for a given private university declines, compelling private universities to produce lower quality education while charging lower tuition fees. Figure 4(b) and (c) present the effect of changes in t_p and c_p , respectively, on the quality of private universities. They show that levels of quality produced by private universities are positively related to t_p and negatively related to c_p . The interpretations of these results can be given in a manner similar to that mentioned above and are therefore omitted here.

(Insert Figures 5 and 6)

We can reinterpret the above discussion from the students' perspective. Figure 5 shows the effect of the national university policy on the tuition fees charged to each student on the ability domain $[a_{\min}, a_{\max}]$. It is found that changes in education policies that favor the national universities will lead to slightly higher tuition fees for each student.

However, we also found that with a slightly greater α , the direction of the effect may be reversed. Theoretically, this is because the direction of this effect is sensitive to the estimated values of our model parameters. Consider an increase in the national university quality. This would transfer some students from private universities to the national university. Then, students with a given ability who remain in the private sector will be matched with a higher-endowed private university than previously. Such students are willing to pay higher tuition fees for higher quality education. Recall that $1 - \alpha$ dictates the elasticity of student utility to the quality of education. An increase in the willingness to pay is larger if α is smaller. On the other hand, being matched with less able students, each private university with a given endowment charges lower tuition fees and produces lower education quality in the new equilibrium. The total effect depends on the sizes of these two forces that are opposite in direction. With a lower α the first force dominates the second force, and the equilibrium tuition fee for a student with a given ability increases.

The changes in the education quality chosen by each student are shown in Figure 6. The results indicate that the education policies that favor the national university will improve the quality of education consumed by each student of a given ability level. As above, this result may also be sensitive to the estimated values of the model parameters.

5 Empirical Analysis of the University Market

In this section, we present some empirical evidence on the long-run determinants of university tuition fees by using the cross-section data of Japanese private universities and the prefecture-level characteristics of national universities. Our empirical strategy is based on the assumptions that prefectural university markets are geographically separated and the quality of local national universities affects the equilibrium matching of students with universities, thereby affecting the distribution of private university tuition fees. We first discuss our empirical methodology in comparison with the standard hedonic model. We then describe our data set in detail and show the empirical results regarding the influence of national universities on private university tuition fees.

5.1 Identification of the theoretical predictions

The standard hedonic demand equation with the single market data (Ekeland, Heckman, and Nesheim, 2004) takes the following form:

$$P'(q) = \varphi(q) + g(x) + \varepsilon, \quad (15)$$

where q is a vector of product attributes that are part of consumer preferences, e.g., quality, $P'(q)$ is the marginal price of the attributes, x represents the exogenous factors that determine the demands, and ε is the error term that is uncorrelated with x . In this formulation, q may be correlated with ε through the matching process of producers with consumers, and the identification of $\varphi(q)$ requires certain instruments. Since any functions including the supply-side exogenous variables may be correlated with ε (Epple, 1987; Kahn and Lang, 1988), Ekeland et al. (2004) suggested using a nonlinear function of x as an instrument of q .

Our current case is slightly different from the conventional hedonic analysis in terms of data and theoretical interests. In terms of data, q in the above formulation corresponds to the education quality and x corresponds to the exogenous factors such as ability that determine the education demand. However, we do not have direct measures of the education quality received by each student, although we are given some education input data such as college endowments and faculties. In terms of theory, the main predictions of our model are regarding changes in the equilibrium tuition fees at given levels of ability or endowment, *unconditional* on the education quality, where the changes in the matched educational quality are taken into account implicitly. Therefore, we are interested in estimating the overall effects of the national university policy on the matching of private universities with students and the levels of

tuition fees using prefectural multiple market data. In other words, we are interested in the following relationship:

$$P'(q_{jk}) = \varphi(q_{jk}(z_k, x_{jk})) + g(x_{jk}) + \epsilon_{jk} \quad (16)$$

where, including school index j and prefecture index k explicitly, z_k represents the prefecture-level characteristics of national universities that can affect the equilibrium matching of universities with students. Assuming that z_k is exogenous, we are interested in estimating the following conditional expectation:²⁴

$$\begin{aligned} P'(q) &= E[\varphi(q)|x, z] + g(x) + E[\epsilon|x, z] \\ &+ \{\varphi(q(z)) - E[\varphi(q)|x, z]\} + \{\epsilon - E[\epsilon|x, z]\}. \end{aligned} \quad (17)$$

The means of the two bracketed terms conditional on x and z are both zero. This is because, in the first bracketed term, the other variables that potentially affect the matched quality q , such as the error terms and the supply-side determinants, are all uncorrelated with x and z . Thus, by controlling for only the demand-side exogenous factors, x , we can consistently estimate the effects of the national university policy on the tuition fees matched with each level of x . Here, we discussed only the demand-side identification; however, we can clearly apply the same argument to the supply-side identification.

Now, let z_k represent the prefecture-level quality of national universities.²⁵ Then, our tests of the theoretical predictions are generally written by the following two equations:

$$\log(\textit{tuition fee}_{jk}) = \alpha_1 + \beta_1 \cdot z_k + \theta_1 \cdot e_{jk} + \lambda_1 \cdot x_{1k} + \varepsilon_{1jk}, \quad (18)$$

$$\log(\textit{tuition fee}_{jk}) = \alpha_2 + \beta_2 \cdot z_k + \theta_2 \cdot a_{jk} + \lambda_2 \cdot x_{2k} + \varepsilon_{2jk}, \quad (19)$$

where e_{jk} is the endowment of university j in prefecture k ; a_{jk} is the average ability of students in university j in prefecture k ; x_{ik} ($i = 1, 2$) represents the variables that proxy the distributions of endowments of private universities in prefecture k ; α_i , β_i , λ_i , and θ_i are the coefficients; and ε_{ijk} represents the random errors. Thus, we conduct the estimation of our tuition fee function of Japanese private universities from the supply and demand sides separately.²⁶ Equation (18) is an empirical counterpart of the tuition fee

²⁴At this point, we do not make a precise distinction between “marginal” and “level” tuition fees. The argument of the marginal price equation is easily extended to the tuition fee level, which is our topic of interest.

²⁵Since levels of tuition fees at national universities are set to be equal regardless of major or region, we cannot see the effect of changes in national university tuition fees here. All prefectures have at least one national university.

²⁶By doing this, we currently assume that the differences in $\varphi(q)$ among prefectures are controlled by a finite number of prefecture-level variables. Ideally, panel data of universities across prefectures over years would identify the effects of ability distribution under the less restrictive assumption that the distribution is heterogeneous across prefectures but is

function $t(e)$, while equation (19) is an empirical counterpart of $t(a)$ in our theoretical model.

5.2 Data

Our cross-section data of Japanese private universities are compiled for the academic year 2000-2001 mainly from the following two sources. Data on entrance *hensachi*, which are the mean standardized nationwide test scores of entrants, were provided by Sundai Yobiko based on its nationwide simulation tests. It covers the *hensachi* levels of all Japanese four-year colleges. The *hensachi* variable can be viewed as the mean ability of students enrolled in each university, a_{jk} in equation (19). Another major source of university data was *Nihon no Daigaku* (“Japanese Universities” Toyo Keizai Editorial Office, 2001), an annual college guide book for potential students. This book provides various details regarding university characteristics, such as location, tuition and other fees, enrollment, library volume, faculty size, areas of campus and buildings, etc. In addition to these primary sources, the data on the financial subsidy to private educational institutions were collected from the Promotion and Mutual Aid Corporation for Private Schools of Japan.²⁷ Data on the prefecture-level characteristics of the higher education market were collected from the Basic School Survey (Ministry of Education, 2001).

The definitions and descriptive statistics of variables are summarized in Table 3. All the variables for private universities are constructed as the averages at the department (i.e., undergraduate major) level since the annual tuition fee is usually set at the department level. Occasionally, multiple observations exist with regard to the *hensachi* for one department since some departments maintain multiple admission processes. In such a case, the multiple *hensachi* values are averaged to obtain a single observation at the department level. The variable “log (tuition fees),” which is the dependent variable in our estimations, represents the natural logarithm of the annual tuition fees including all the required fees. For data on the endowment of private universities, we have the following variables: “faculty-student ratio,” “per-student area of campus,” “per-student area of school building,” and “per-student library volume” of each university. These are expected to collectively measure e_{jk} in the estimation of equation (18).

We also control several university characteristics that potentially affect the demand for each university. For example, “female student ratio” is used to control a demographic characteristic of entrants that may affect the demand-side price. “Number of subjects,” which is the number of test subjects covered in the entrance examination, is used to capture the implicit preparation costs for and tuition fees agreed to

time-invariant. We are in the process of preparing such panel data.

²⁷http://www.shigaku.go.jp/s_home.htm

by the students.²⁸ The variable “financial subsidy” represents the per-student amount of the financial subsidy provided to private educational institutions.

The private university data used in our analysis is restricted to samples of five major “Arts” departments—economics, commerce, business, law, and literature—of all the four-year private universities in Japan. There are two reasons for this sample restriction. First, since Japanese students tend to decide on their college major in their early days at high school, we believe that the market structures should differ between the majors of Arts and Science. Second, some of the potentially important endowment measures in Science courses, such as experiment facilities or lab wares, are unavailable to us. Our initial sample size was 351. However, due to missing observations, the sample size in the following estimation is slightly lower than this.

As national university quality and demographic characteristics are factors that can shift the equilibrium tuition fee distribution in each prefecture, we construct prefecture-level variables for these factors. Strictly speaking, we do not directly observe the true education quality of any university, national or private, although the quality of the former plays a role in determining the distribution of the equilibrium tuition fee in our model. We therefore construct variables that are considered to be the major determinants of the average quality of national universities in prefecture k . These variables, denoted by z_k , are “per-student areas of campus,” “school building,” “per-student faculty,” and “library size.” Since these variables are highly correlated with each other, we estimate their effects individually.

For the variables that proxy prefecture-level characteristics of local university markets, x_{ik} , we use the “share of entrants to private universities who graduated from high schools in the same prefecture” and the “share of entrants to the national university who graduated from high school in the same prefecture as the university” in order to control for any effects of student migration across prefectures upon entering university.²⁹ We also include the “share of private university” in each prefecture (in terms of number of entrants). We also use dummies for the business, economics, commerce, law, and literature departments, as well as the actual number of entrants as the frequency weight because the ideal unit of observation for this analysis is the student.³⁰

²⁸A majority of the “Arts” major departments of private universities ask questions on two subjects, such as English and Japanese, English and Short Essay, for 90 minutes each. Strictly speaking, the difficulty of the examination or the number of subjects are implicit costs and must be modeled as determined in equilibrium. Our inclusion of such variables as controls is for the purpose of simplification. The modeling of dual determination of tuition fees and examination subjects is an interesting issue that should be pursued in the future.

²⁹For example, among 100 high school graduates in a given prefecture, assume that 20 students attend national universities and 30 attend private universities. Of these, 5 of 20 national university attendants and 10 of 30 private university attendants migrate out of the prefecture after admission. In this case, the first index will be 0.75 and the second index will be 0.67.

³⁰Our coefficient estimates do not essentially change without the weights.

5.3 Empirical Evidence

Table 4 presents the estimation results of equation (18), regressing $\log(\text{tuition fees})$ on the endowment variables of private universities. The prefecture averages of the faculty/student ratio, per-student area of school building, and library volume of national universities are all found to have negative effects on the tuition fees of private universities at least at the 10% significance level. This is consistent with our theoretical predictions that the market pressure due to the quality improvement at the national university leads to a decline in tuition fees at private universities. It is also found that almost all endowment measures for private universities, except for per-student area of campus, are significantly and positively related to levels of tuition fees charged by private universities. This result implies that more endowed private universities tend to charge higher tuition fees and thus produce higher quality education in equilibrium.

Among the other variables, receiving more government subsidies tends to lower the tuition fees, which suggests the replacement role of government subsidy rather than the complementarity of the subsidy and the higher quality/tuition fee level. The share of entrants is the proxy of the relative size of the institution, and the negative sign suggests the existence of the scale effect of institution size in the production of education rather than the market power effect. The share of private universities is the measure of the relative size of the private sector in the prefectural higher education market. The positive sign suggests that the relative size of the public sector in the prefecture tends to lower the tuition fees charged by the private universities, consistent with our theoretical prediction. Both the “share of entrants to private universities...” and the “share of entrants to the national university...” tend to have negative effects on the tuition fee level. If the former variable measures the relative scarcity of private universities outside the prefecture, this variable will proxy the high demand for local private universities. Thus, the estimated sign appears to be wrong and requires further investigation. If the latter implies the relative abundance of the national university capacity in the prefecture relative to the neighborhood prefectures, the negative sign should suggest the competition effects on levels of tuition fees in the private sector, consistent with our theoretical prediction regarding the effect of national university capacity.

In Table 5, we present the estimation results of equation (19), regressing $\log(\text{tuition fees})$ on the entrance *hensachi*, while excluding the endowment variables. The empirical results show that all the variables for national university quality have significantly positive effects on the tuition fees. Our numerical simulations predict that the education policies that favor national universities would increase the levels of tuition fees charged to each student. Therefore, the evidence is consistent with our primary simulation results.

Among the other variables, again, the share of private universities tends to raise the tuition fee level. Hensachi and the number of subjects tend to have a complicated effect on the tuition fees. We include the hensachi variable along with its interaction term with the number of subjects. The linear hensachi term tends to have a positive effect; therefore, the price-ability positive sorting appears to exist. The number of subjects also generally has positive effects, and those who are willing to take examinations with more subjects tend to agree to higher tuition fees. However, the interaction terms tend to be negative: at a fixed hensachi-ability level, the number of examination subjects has a negative effect on the tuition fees. One interpretation of this result is the substitution between the examination preparation costs and the tuition fees for students. Another way of reading this is that as the number of subjects increases, the hensachi tends to have a negative effect on the tuition fees. Then, the alternative interpretation is that the more demanding colleges that ask questions on more subjects in the entrance examination are subsidizing to students’ “abilities” owing to the existence of the spillover effects among students (Rothschild and White, 1995). However, this result is still open to other interpretations. A higher ratio of female students tends to raise the tuition fee level, which may suggest additional costs (e.g., for security, maintenance of campus environment, etc.) required to match the preferences of female students. In Table 5, with one exception, the “share of entrants to private universities...” tends to have a positive effect and the “share of entrants to the national university...” tends to have a negative effect, which appear to be consistent with our interpretations based on competition among neighboring prefectures.

6 Conclusion

In this paper we aim to analyze the reason why private universities in Japan are unable to produce high academic quality under the distortion produced by the national university policy. We focus on the tuition revenue for private universities, which is determined by the national university policy, and that determines the quality of private universities in equilibrium. We show, both through numerical simulations and empirical analyses, that the quality and tuition fees of national universities do affect the distribution of tuition fees of private universities. Consistent with our calibration results, the estimation results show that in prefectures where the national universities have relatively high quality, the tuition fees of private universities tend to be lower than average when controlling for the endowments of private universities, whereas they tend to be higher when controlling for the average ability of the entrants. Given the large share of tuition revenue in the budget of private universities, as shown in Table 1, our

theoretical and empirical results both suggest the role of national university policies in determining the severe financial constraints on private universities with regard to improving their academic quality.

Is this the only reason why there is no Harvard in Japan? We believe that our model suggests the most important reason in answering our question; however, there clearly exist many other potential factors. One factor is the government regulation on the establishment and curricula of university education. The Japanese Ministry of Education has tightly controlled the establishment, curricula, and qualifications of faculty members of both public and private university programs and provided them with few financial incentives until very recently. This has created costs for establishing innovative academic programs. Another factor is the weakness of the financial sources other than tuition revenue, such as donations, for private universities. Finally, the lack of incentives for university faculty members even among the private universities is also a factor. These factors have been changing rapidly in recent years.

Although our calibration results are qualitatively consistent with the empirical results, they may not adequately explain the actual size of the influence of the national university policy on the private university market. For example, our simulation suggests that the change in private university tuition fees is considerably smaller than the change in the national university tuition fees. On the other hand, the evidence in Figure 2 suggests that the elasticity of private university tuition fees to the national university tuition fees is fairly large. Several potential reasons could be responsible for this disparity. First, as discussed in Section 4, our current estimate of the elasticity of student utility to the quality of education ($1 - \alpha$) based on the SSM data may be downward biased if there were peer effects among students. Hensachi, which is our current proxy for student's ability, might be correlated with the peer students' abilities. If the college education quality is highly influenced by the quality of peers (Sacerdote, 2001), the estimated value of $1 - \alpha$ will be smaller than its true value. Second, our current model is not a dynamic model, the entrance examination exists only for national universities, and the probability of passing the national university examination is assumed to be identical for all students. We do not think that these simplifying assumptions qualitatively influence our theoretical results; however, they may be quantitatively important for creating the gap between our simulation and the evidence. Closing this gap will be a challenge that should be pursued in the future, and our current result should be regarded as the first step toward understanding the functioning of the higher education market.

Our empirical strategy was to test the overall implications of our hedonic model of students and universities. One of the recent directions of hedonic analyses is to move from the closed form solution with the traditional linear-quadratic specification (Epple, 1987) to the identification of structural parameters

using semiparametric models (Ekeland et al., 2004). Although our current numerical solution is based on specific functional forms, it can be used to supplement and interpret any parametric/semiparametric estimations of hedonic tuition fee functions, which could be considered for future research.

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A Proof of Upper Boundary Conditions

Upper Boundary Conditions:

Sufficient conditions for the positive sorting of students by ability into national and private universities in an assignment equilibrium are

UB1. *For students with ability \hat{a} , attending the top private university is equivalent to applying to the national university. That is,*

$$y - t(q(\hat{a})) + \theta \hat{a}^\alpha q(\hat{a})^{1-\alpha} = p(\hat{a})(y - t_p + \theta \hat{a}^\alpha q_p^{1-\alpha}) - w(\hat{a})r. \quad (\text{A1})$$

UB2. $q(\hat{a})^{1-\alpha} < p(\hat{a})q_p^{1-\alpha}$. *(The national university has sufficiently high quality relative to the top private university.)*

Proof:

When the first and second order conditions are satisfied both for students and private universities, among those who choose private universities, students with higher abilities always choose a higher quality university in equilibrium. This is verified by the single-crossing property of the indifference curves of students on q and t .

Under UB1, the assignment is in equilibrium if and only if (a) those with $a > \hat{a}$ would be strictly better off by choosing the national university instead of the top private university and (b) those with $a < \hat{a}$ would strictly better off by choosing their optimal private university instead of the national university.

(a) For those with $a > \hat{a}$, $U(\text{national}) - U(\text{top private}) = p(\hat{a})(y - t_p + \theta \hat{a}^\alpha q_p^{1-\alpha}) - w(\hat{a})r - (y - t(\hat{a}) + \theta \hat{a}^\alpha q(\hat{a})^{1-\alpha}) = \theta(p(\hat{a})q_p^{1-\alpha} - q(\hat{a})^{1-\alpha})(a^\alpha - \hat{a}^\alpha)$ using equation (A1). Therefore, applying to the national university is strictly preferred if and only if $q(\hat{a})^{1-\alpha} < p(\hat{a})q_p^{1-\alpha}$.

(b) Similarly, for students with $a < \hat{a}$, under $q(\hat{a})^{1-\alpha} < p(\hat{a})q_p^{1-\alpha}$, $U(\text{national}) - U(\text{top private}) = \theta(p(\hat{a})q_p^{1-\alpha} - q(\hat{a})^{1-\alpha})(a^\alpha - \hat{a}^\alpha) < 0$. Since for these students with $a < \hat{a}$, choosing a university with a quality lower than the top private university is the best choice among all the private universities, they will not choose the national university.

B Details of Numerical Simulations

We first describe the derivation $t(a)$ of in greater detail and then explain the parameter set used in our current simulation.

Differentiating equation (11) with respect to a , we obtain

$$\frac{dq}{da} = \frac{1}{\alpha - \beta} q(a) [\alpha a^{-1} - \beta(a + e_{\max} - \hat{a})^{-1}]. \quad (\text{A2})$$

Then, the integrand in the right-hand-side of equation (13) can be written as

$$\frac{1 - \alpha}{\alpha - \beta} \left(\frac{1 - \alpha}{1 - \beta} \right)^{\frac{1-\alpha}{\alpha-\beta}} a^{\frac{(1-\alpha)(1-\beta)}{\alpha-\beta}} (a - e_{\max} + \hat{a})^{\frac{-(1-\alpha)\beta}{\alpha-\beta}} [\alpha a^{-1} - \beta(a + e_{\max} - \hat{a})^{-1}] \quad (\text{A3})$$

The analytical expression of the infinite integral of the above expression cannot be obtained in general. Instead, we numerically integrate this function. In order to numerically determine the values for \hat{a} , \check{a} , and C under UB1, UB2, and LB4, we use $V(\check{a}) = y$, $\Pi(\check{e}) = 0$ and equation (14). Given the equilibrium values of \hat{a} , \check{a} , and C , substituting these values into the solution of equation (13) yields the equilibrium tuition fee function $t(a)$. After solving $t(a)$, we can change the variable from a to e by using the market clearing condition (equation (10)) to obtain $t(e)$. Further, once we determine the equilibrium value for \hat{a} , the equilibrium levels of quality, $q(a)$ and $q(e)$, can be easily calculated.

We calibrate the parameters in the utility and cost functions, α and β , respectively, by using the SSM data. Our basic estimation strategies are as follows. Since we construct the individual utility as quasi-linear in consumption, which is measured in monetary terms, the term $\theta a^\alpha q^{1-\alpha}$ in equation (1) can be viewed as the future earnings produced by a student with ability a attaining education of quality q . Using the production function of education quality, we can obtain the following equation to be estimated:

$$\log(inc) - \log(\nu) = \log(\theta) + \alpha[\log(a) - \log(\nu)] + (1 - \alpha)\gamma[\log(e) - \log(\nu)], \quad (\text{A4})$$

where inc is the annual earnings obtained from the SSM data. Since the SSM data provides us with the name of the university from which each individual in the sample graduated, we can obtain the *hensachi* (a), endowment (e), and the per student expenditure of their colleges (ν) by merging it with the college dataset. Using this merged dataset, we estimate equation (A4). Age and two dummy variables, having graduate degree (*GRAD*) and graduating with a social science or humanities major (*ARTS*), are also controlled in the regression. For the endowment variable (e), we use faculty-student ratio as a proxy. Our merged dataset based on SSM data has 42 observations with the financial data of 7 universities. The

estimated result was

$$\begin{aligned}
 \log(inc) - \log(\nu) &= 1.919 + 0.272 [\log(a) - \log(\nu)] + 0.341 [\log(e) - \log(\nu)] \\
 &\quad (1.43) \quad (0.86) \quad (1.37) \\
 &\quad + 0.084 \textit{AGE} - 0.459 \textit{GRAD} + 0.174 \textit{ARTS}, \quad (A5) \\
 &\quad (6.13) \quad (0.61) \quad (-1.22)
 \end{aligned}$$

where the t -values are in parentheses. From this result, we can immediately calculate the parameters of our model, $\alpha = 0.272$ and $\beta = -1.136$ (when calculating β , we use the fact that $\beta \equiv -\gamma/(1 - \gamma)$).

For the other parameters, we use the following values. Potential students are distributed on $[a_{\min}, a_{\max}] = [0, 123.5012]$, which, in ten thousands, was the college-age population in 2004. Potential private universities are distributed on $[e_{\min}, e_{\max}] = [0, 123.5012]$. The subjective discount rate δ is set to be 0.95. The fixed cost for the private universities, F , is set to be 28.856, which is the average (per-student) capital expenditure in Japanese private universities (in ten thousand yen). The waiting cost for the student, r , is 92.8411, which is the annual education expense incurred by Japanese households with high-school children (in ten thousand yen). Finally, the baseline parameters for the national university policies, namely, the quality, tuition fees, and capacity of the national university, are set to be $q_p = 100$, $t_p = 77.38$, and $c_p = 14$, respectively.

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Table 1: Comparison of the Public and Private Universities of Japan with those of the U.S.

	Japan (1998)		U.S. (1995)	
	Public ^{a)}	Private	State	Private
Education expenditure/student (Japan: million yen/U.S.: 1000 dollars)	4.36	1.74	22.41	35.66
Consumption expenditure/student (Japan: million yen/U.S.: 1000 dollars)	3.28	1.45	20.14	31.67
Ratio of government subsidy to the total expenditure (%)	88.82	8.92	51.05	16.41
Ratio of tuition revenue to the total expenditure (%)	11.18	62.5	17.51	40.72
Government subsidy/student (Japan: million yen/U.S.: 1000 dollars)	3.87	0.16	11.44	5.85
Student/faculty ratio	11.39 ^{b)}	30.27 ^{b)}	15.8 ^{c)}	12.8 ^{c)}
Average annual tuition fees (Japan: million yen/U.S.: 1000 dollars)	5.41	8.43	3323	16552

Note: Japanese data is for the year 1998, and the U.S. data is for the year 1995. Both are taken from the Ministry of Education (2001), which is originally based on

the Basic School Survey (Japan) and the Digest of Education Statistics (U.S. Department of Education).

(a) The column "Public" for Japan covers both national and local public universities.

(b) The number of faculty members in Japanese universities is for the year 1999.

(c) The 1999 Fall staff survey (U.S. Department of Education.)

Table 2: Measures of Entrance Examination Difficulty for Both Private and National Universities

	Private		National	
	Hensachi	Applicants/Entrants	Hensachi	Applicants/Entrants
Business	45.4	2.4	58.5	3.5
Economics	46.1	2.5	54.7	4.1
Commerce	46.9	2.7	55.3	3.2
Arts	43.2	1.8	53.3	3.5
Literature	49.0	3.0	59.3	3.9
Law	50.2	2.8	59.8	3.5
Engineering	46.3	2.6	51.9	3.5
Science	54.6	3.2	54.8	3.8
Science and Engineering	53.3	3.4	49.8	3.7
Medicine, Dentistry, and Pharmacy	58.1	6.3	56.9	5.1

Note: Data on "Hensachi" indicate the mean standardized test scores of entrants based on nationwide simulation test by Sundai Yobiko.
See Section 5 for details of the data used here.

Table 3: Definitions and Descriptive Statistics of Variables

Variable name	Definition	Obs	Mean	Std. Dev.	Min	Max
log (tuition fees) ^{a)}	Natural logarithm of annual tuition fees including other required fees	351	4.524	0.124	4.184	4.975
Hensachi ^{a)}	Average standardized test score of entrants ("hensachi")	351	46.874	7.743	35	69
Faculty/Student ratio ^{a)}	Faculty/Student ratio	346	0.121	0.115	0.040	1.725
Area of campus ^{b)}	Per-student area of campus (10,000m ² /student)	327	0.0080	0.0518	0.0006	0.9363
Area of building ^{b)}	Per-student area of school building (10,000m ² /student)	317	0.0013	0.0011	0.0005	0.0118
Library volume ^{b)}	Per-student library volume (10,000/student)	345	0.0077	0.0038	0.0024	0.0463
Financial subsidy ^{b)}	Per-student governmental financial subsidy (1000 yen/student)	349	100.327	64.303	0	368.592
Faculty/Student ratio (national) ^{c)}	Faculty/Student ratio of the national university (prefecture-level average)	337	0.295	0.073	0.119	0.422
Area of campus (national) ^{c)}	Per-student area of campus of the national university (prefecture-level average) (10,000m ² /student)	337	0.1291	0.4027	0.0049	2.0026
Area of building (national) ^{c)}	Per-student area of building of the national university (prefecture-level average) (10,000m ² /student)	335	0.0048	0.0022	0.0012	0.0075
Library volume (national) ^{c)}	Per-student library volume of the national university (prefecture-level average) (10,000/student)	337	0.0256	0.0106	0.0075	0.0392
Female student ratio ^{b)}	Share of female students out of total enrollment	349	0.381	0.270	0	1
Number of subjects ^{a)}	Number of subjects covered in the entrance examination	351	2.312	0.401	1	3
One subject ^{a)}	Dummy variable (1: number of subjects = 1, 0: otherwise)	351	0.023	0.149	0	1
Two subjects ^{a)}	Dummy variable (1: 1 < number of subjects ≤ 2, 0: otherwise)	351	0.769	0.422	0	1
Three subjects ^{a)}	Dummy variable (1: number of subjects = 3, 0: otherwise)	351	0.208	0.406	0	1
Share of entrants ^{a)}	Share of each university among the total entrants to private universities in the same prefecture	349	0.187	0.254	0.001	1.000
Share of private universities ^{c)}	Share of the total entrants to private universities in each prefecture	351	0.814	0.098	0.508	0.931
Share of private university entrants who graduated from high school in the same prefecture ^{c)}	Share of entrants to the private university who graduated from high school in the same prefecture	351	0.510	0.183	0.034	0.776
Share of national university entrants who graduated from high school in the same prefecture ^{c)}	Share of entrants to the national university who graduated from high school in the same prefecture	351	0.386	0.168	0.067	0.728

Notes: a) department-level variable, b) university-level variable, c) prefecture-level variable

Table 4: Empirical Result 1 (Supply Side)

log (tuition fees) ¹⁾	Coef.	Coef.	Coef.	Coef.
	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)
Faculty/Student ratio	0.1218 ** (0.0323)	0.1208 ** (0.0353)	0.1256 ** (0.0302)	0.1139 ** (0.0332)
Area of campus	-0.2209 (0.2001)	-0.2740 (0.1888)	-0.2579 (0.1973)	-0.2128 (0.1976)
Area of building	36.3523 # (21.1403)	42.2179 * (20.0408)	38.2795 # (20.9941)	33.5063 * (21.1389)
Library volume	5.0307 * (2.4747)	4.3894 # (2.4333)	4.8563 * (2.4648)	4.9111 * (2.4642)
Financial aid	-0.0007 ** (0.0001)	-0.0007 ** (0.0001)	-0.0007 ** (0.0001)	-0.0007 ** (0.0001)
Measure of national university quality	-0.2767 ** (0.1045)	0.0488 ** (0.0160)	-6.2613 # (3.8254)	-2.2595 * (0.8635)
Share of entrants	-0.1817 ** (0.0308)	-0.1587 ** (0.0324)	-0.1936 ** (0.0325)	-0.1911 ** (0.0352)
Share of private universities	0.0846 (0.0764)	0.1660 * (0.0783)	0.0988 (0.0799)	0.1436 # (0.0776)
Share of private university entrants who graduated from high school in the same	-0.1986 ** (0.0468)	-0.1908 ** (0.0476)	-0.1769 ** (0.0476)	-0.1856 ** (0.0475)
Share of national university entrants who graduated from high school in the same	-0.0163 (0.0453)	-0.1378 ** (0.0412)	-0.0562 (0.0466)	-0.0280 (0.0429)
Number of subjects	-0.0795 ** (0.0185)	-0.0756 ** (0.0185)	-0.0754 ** (0.0190)	-0.0723 ** (0.0189)
Constant	4.8278 ** (0.0881)	4.7004 ** (0.0867)	4.7557 ** (0.0905)	4.7404 ** (0.0874)
Measure of the national university quality	Faculty/Student ratio	Area of campus	Area of building	Library volume
N	303	303	301	303
R ²	0.3071	0.3095	0.3096	0.3067

Notes: **, *, and # indicate that the estimated coefficient is at the 0.01, 0.05, and 0.1 significance level, respectively. Standard Errors are White's HCSE. Department dummies are controlled in all estimations.

1) Samples used here are from the departments of economics, law, commerce, business, and literature.

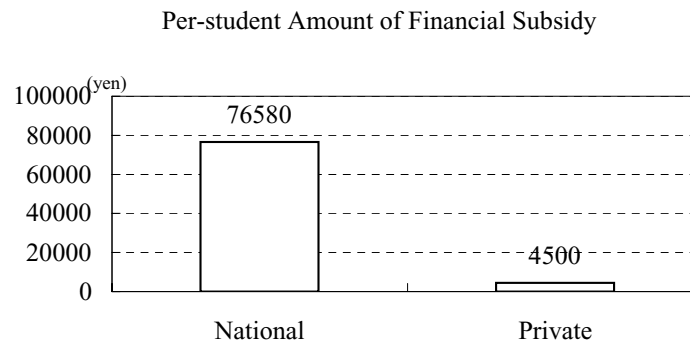
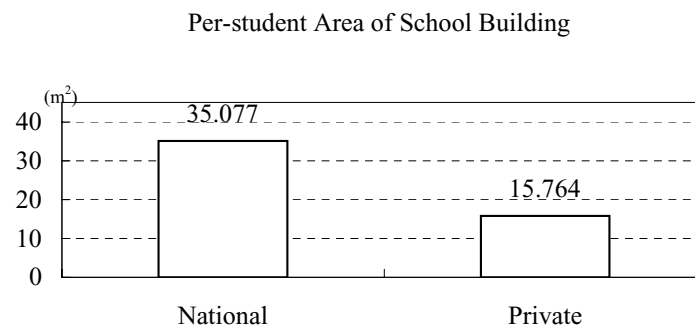
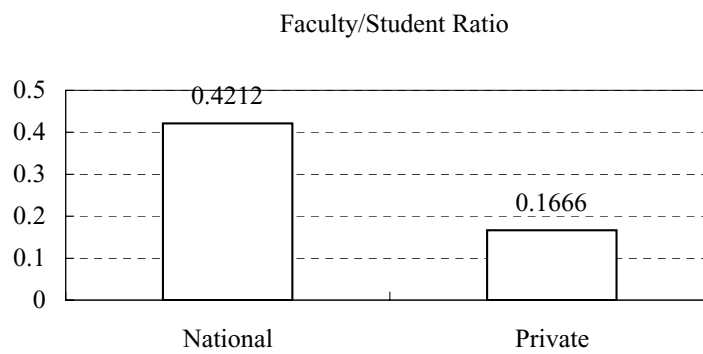
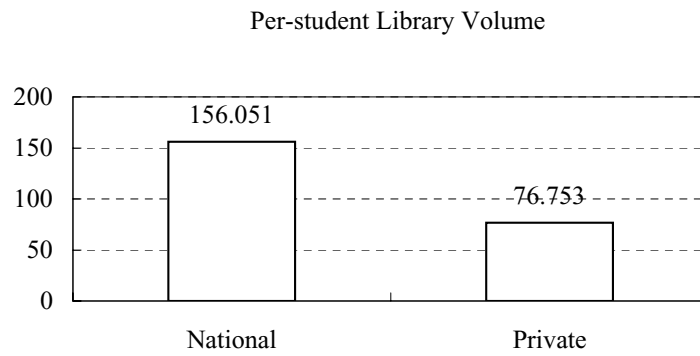
Table 5: Empirical Result 2 (Demand Side)

log (tuition fees) ¹⁾	Coef.	Coef.	Coef.	Coef.
	(Std. Err.)	(Std. Err.)	(Std. Err.)	(Std. Err.)
Hensachi	0.0280 ** (0.0015)	0.0313 ** (0.0014)	0.0267 ** (0.0015)	0.0269 ** (0.0015)
Measure of national university quality	0.0560 ** (0.0049)	0.0533 ** (0.0008)	3.6684 ** (0.1861)	0.7508 ** (0.0372)
Female student ratio	0.0496 ** (0.0014)	0.0513 ** (0.0014)	0.0516 ** (0.0014)	0.0505 ** (0.0014)
Share of private universities	0.3738 ** (0.0030)	0.4580 ** (0.0032)	0.3554 ** (0.0031)	0.3527 ** (0.0030)
Share of private university entrants who graduated from high school in the same	0.0110 ** (0.0021)	-0.0050 * (0.0021)	0.0182 ** (0.0021)	0.0054 * (0.0021)
Share of national university entrants who graduated from high school in the same	-0.1289 ** (0.0023)	-0.1513 ** (0.0018)	-0.1405 ** (0.0023)	-0.1330 ** (0.0021)
Two subjects	1.3907 ** (0.0578)	1.5222 ** (0.0543)	1.3465 ** (0.0583)	1.3575 ** (0.0584)
Three subjects	1.1418 ** (0.0579)	1.2496 ** (0.0544)	1.0860 ** (0.0586)	1.0990 ** (0.0586)
Two subjects × Hensachi	-0.0365 ** (0.0015)	-0.0396 ** (0.0014)	-0.0354 ** (0.0015)	-0.0357 ** (0.0015)
Three subjects × Hensachi	-0.0327 ** (0.0015)	-0.0353 ** (0.0014)	-0.0313 ** (0.0015)	-0.0316 ** (0.0015)
Constant	3.2146 ** (0.0584)	3.0363 ** (0.0545)	3.2817 ** (0.0586)	3.2793 ** (0.0586)
Measure of the national university quality	Faculty/Student ratio	Area of campus	Area of building	Library volume
N	335	335	333	335
R ²	0.3645	0.3779	0.3650	0.3652

Notes: **, *, and # indicate that the estimated coefficient is at the 0.01, 0.05, and 0.1 significance level, respectively.
Standard errors are White's HCSE. Department dummies are controlled in all estimations.
The number of entrants is used as the frequency weight.

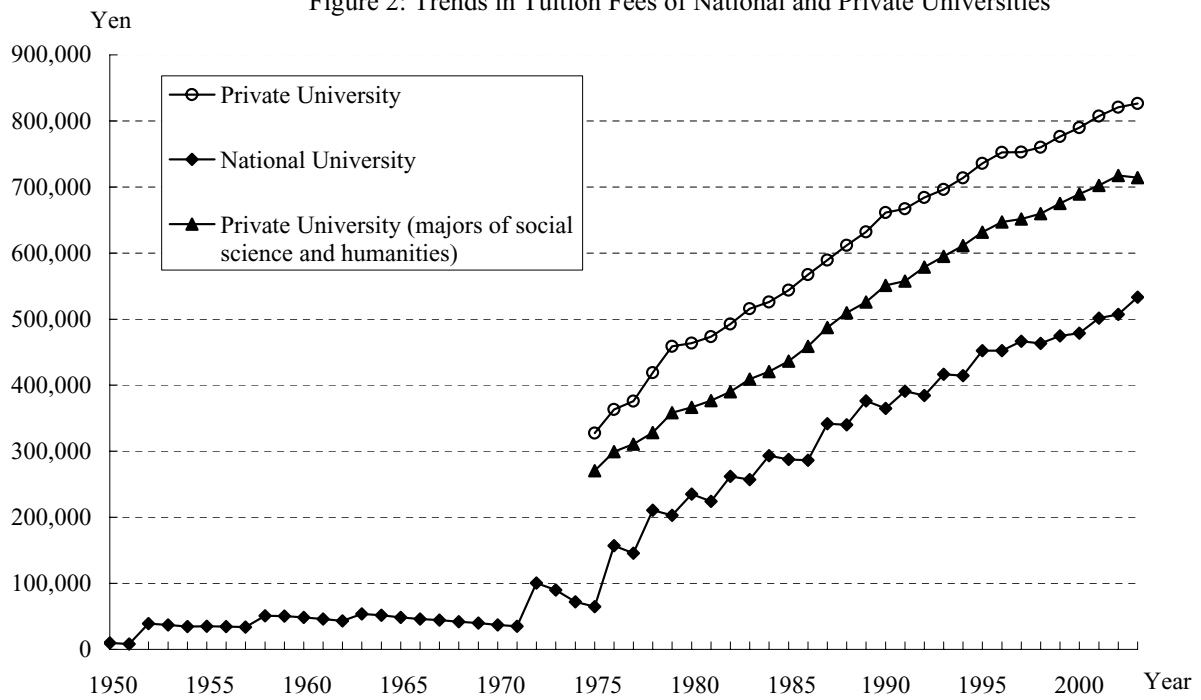
1) Samples used here are from the department of economics, law, commerce, business, and literature.

Figure 1: Measures of Education Quality for Both Private and National Universities



Note: See Section 5 for details of data used here.

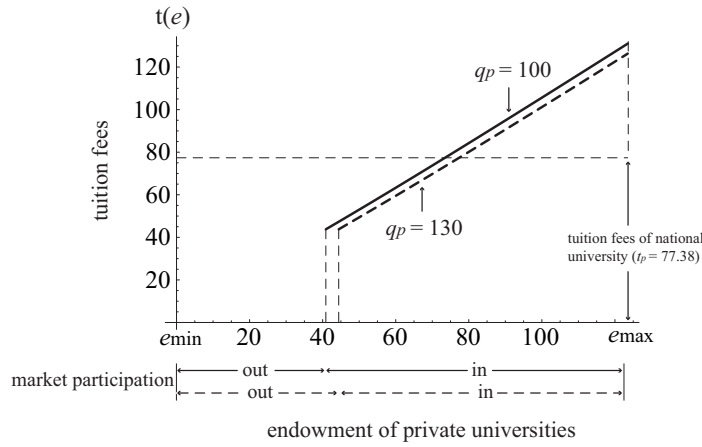
Figure 2: Trends in Tuition Fees of National and Private Universities



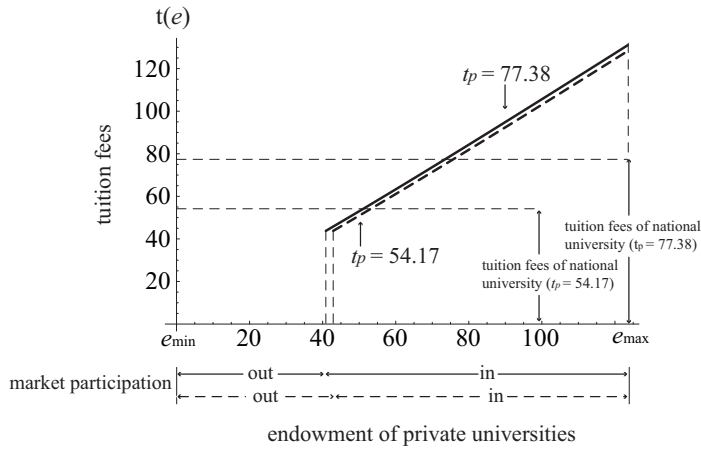
Source: Documents provided by the Ministry of Education

Figure 3: Effect of National University Policy on Private University Tuition Fees (plotted on the endowment domain)

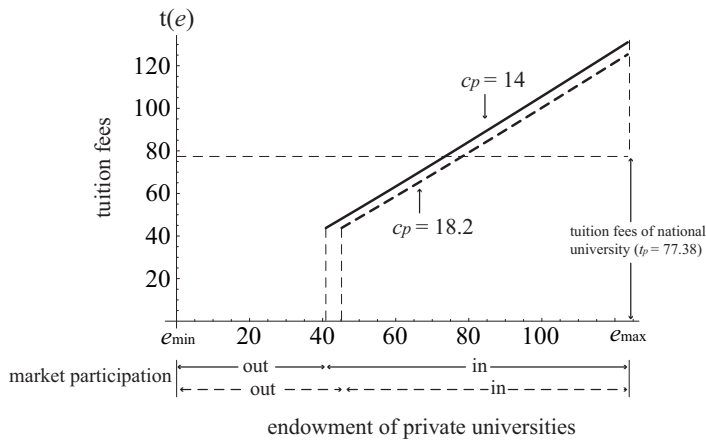
(a) Effect of National University Quality



(b) Effect of National University Tuition Fees



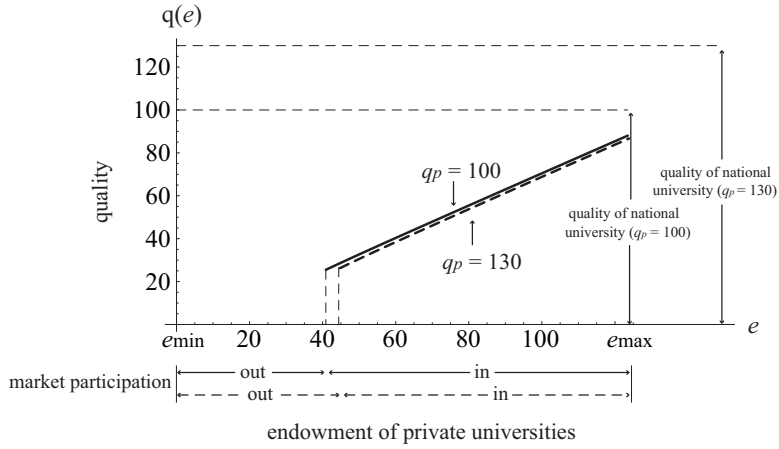
(c) Effect of National University Capacity



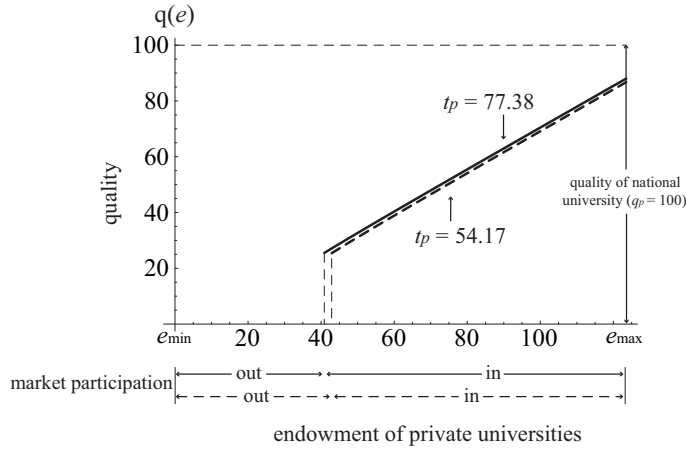
Note: q_p is the quality of the national university, t_p represents the tuition fees of the national university, c_p is the capacity of the national university.

Figure 4: Effect of National University Policy on Private University Quality (plotted on the endowment domain)

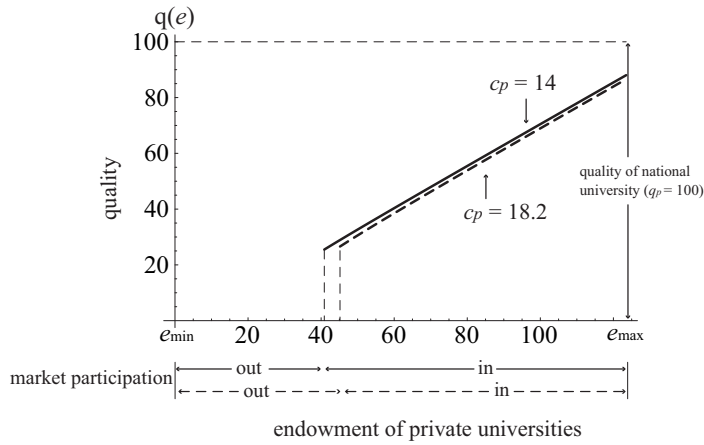
(a) Effect of National University Quality



(b) Effect of National University Tuition Fees



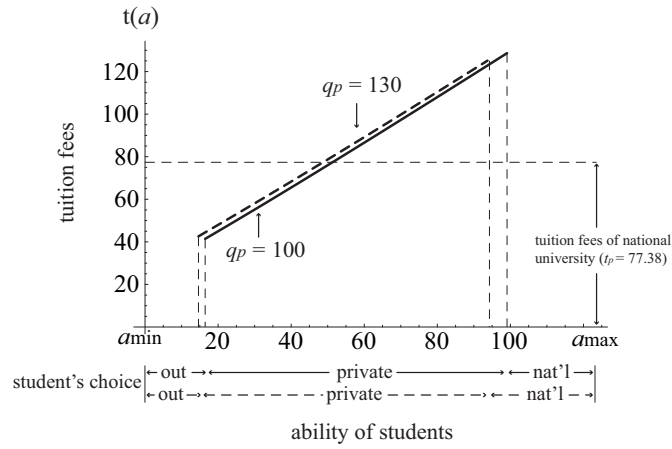
(c) Effect of National University Capacity



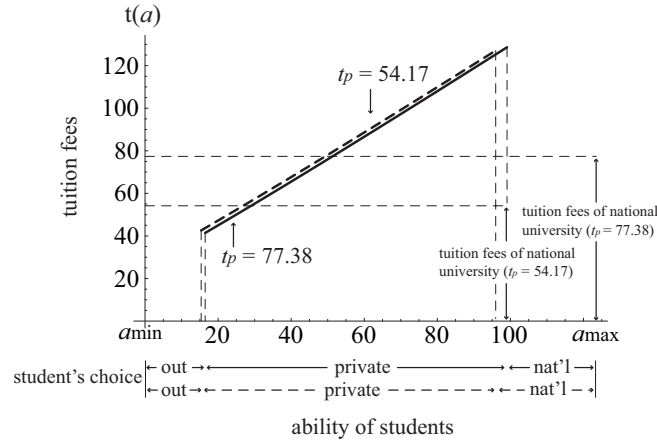
Note: q_p is the quality of the national university, t_p represents the tuition fees of the national university, c_p is the capacity of the national university.

Figure 5: Effect of National University Policy on Private University Tuition Fees (plotted on the ability domain)

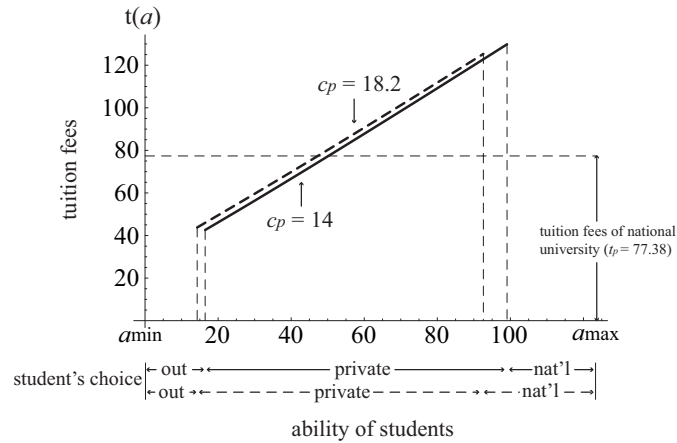
(a) Effect of National University Quality



(b) Effect of National University Tuition Fees



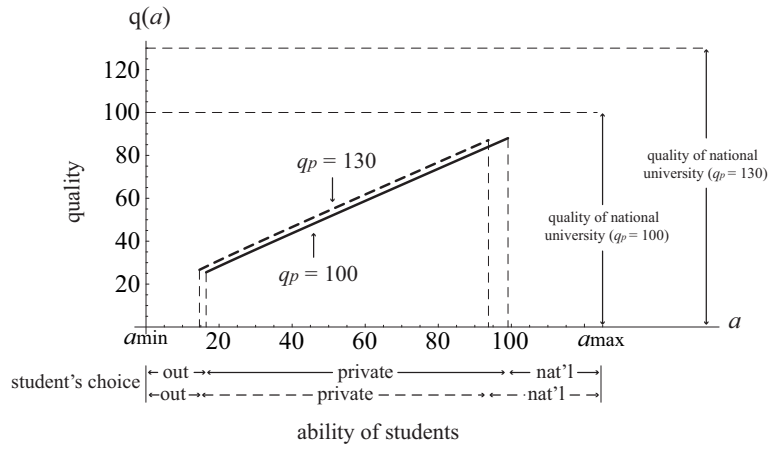
(c) Effect of National University Capacity



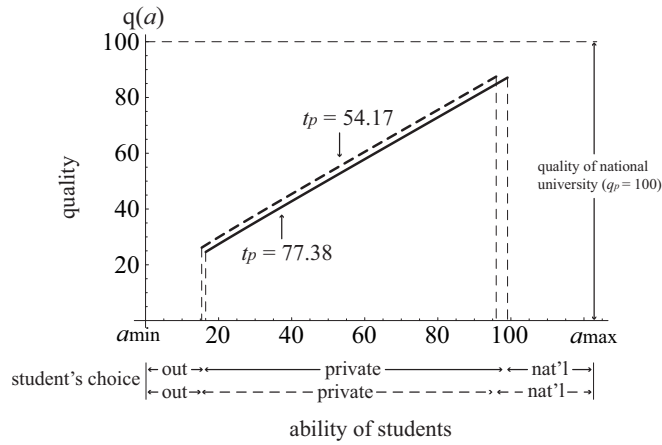
Note: q_p is the quality of the national university, t_p represents the tuition fees of the national university, c_p is the capacity of the national university.

Figure 6: Effect of National University Policy on Private University Quality (plotted on the ability domain)

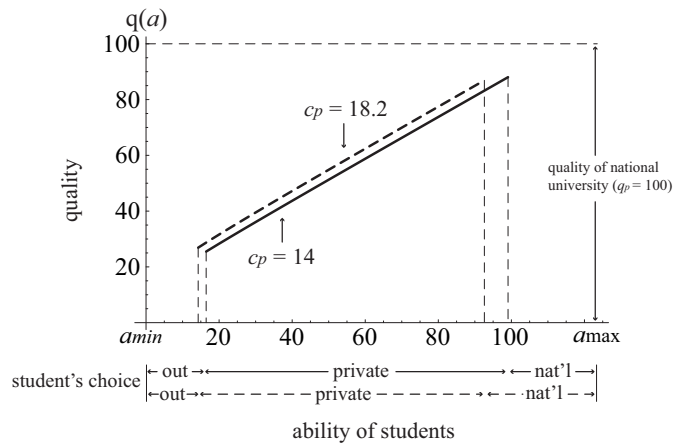
(a) Effect of National University Quality



(b) Effect of National University Tuition Fees



(c) Effect of National University Capacity



Note: q_p is the quality of the national university, t_p represents the tuition fees of the national university, c_p is the capacity of the national university.