

ZEW

Zentrum für Europäische
Wirtschaftsforschung GmbH

Centre for European
Economic Research



**Rechts-, Wirtschafts- und
Verwaltungswissenschaftliche
Sektion**
Fachbereich
Wirtschaftswissenschaften

Diskussionspapiere der DFG-
Forschergruppe (Nr.: 3468269275):

Heterogene Arbeit: Positive und Normative
Aspekte der Qualifikationsstruktur der Arbeit

Gerald Eisenkopf

**The Impact of University Deregulation on
Curriculum Choice**

September 2004

Diskussionspapier Nr. 04/17

<http://www.wiwi.uni-konstanz.de/forschergruppewiwi/>

Nr. 04/17, September 2004

The Impact of University Deregulation on Curriculum Choice

Gerald Eisenkopf

Universität Konstanz
Fachbereich Wirtschaftswissenschaften
Fach D144
78457 Konstanz
Germany

mail: gerald.eisenkopf@uni-konstanz.de

phone: +49-7531-88-3455

fax +49-7531-88-4456

Zusammenfassung:

Many European universities face demands to provide excellent education and to enrol more students at the same time. With scarce financial resources policy makers concentrate on regulations (especially admission policies, tuition fees, and the introduction of competition) to meet the different objectives. This paper analyses the curriculum choices of universities in different regulatory regimes. Universities benefit from the value of the human capital of their graduates. Students are risk-averse. They differ with respect to ability. The deregulation of tuition fees sets an incentive for universities to account for students' preferences. Complete deregulation induces a hierarchical stratification of ex-ante identical universities.

JEL Klassifikation : I22, I28, J24, L51

Schlüsselwörter : Higher Education, Education Policy, University Competition, Tuition Fees, Admission Standards

Download/Reference : <http://www.wiwi.uni-konstanz.de/forschergruppewiwi/>

The Impact of University Deregulation on Curriculum Choice

Gerald Eisenkopf
University of Konstanz*[†]

September 13, 2004

Abstract

Many European universities face demands to provide excellent education and to enrol more students at the same time. With scarce financial resources policy makers concentrate on regulations (especially admission policies, tuition fees, and the introduction of competition) to meet the different objectives. This paper analyses the curriculum choices of universities in different regulatory regimes. Universities benefit from the value of the human capital of their graduates. Students are risk-averse. They differ with respect to ability. The deregulation of tuition fees sets an incentive for universities to account for students' preferences. Complete deregulation induces a hierarchical stratification of ex-ante identical universities.

Keywords: Higher Education, Education Policy, University Competition, Tuition Fees, Admission Standards

JEL classification: I22, I28, J24, L51

*Corresponding Address: University of Konstanz, Box D 144, 78457 Konstanz, Germany, E-Mail: Gerald.Eisenkopf@uni-konstanz.de

[†]The author is thankful to Oliver Fabel, Benjamin Weigert, Heinrich W. Ursprung and participants in seminars at the University of Konstanz for helpful comments and discussions. Financial support of the Deutsche Forschungsgemeinschaft (DFG) through the research group "Heterogeneous Labor: Positive and Normative Aspects of the Skill Structure of Labor" is gratefully acknowledged. Comments are very welcome. The usual disclaimer applies.

1 Introduction

Public universities constitute the backbone of higher education in most European countries. Although the state of European public universities is much lamented the different demands for reform seem to be contradicting. On the one hand, there is a desire to compete with America's Ivy League Universities, e.g. with the creation of "Eliteuniversitäten" in Germany. On the other hand, universities are expected to admit a higher share of secondary school graduates. The British government, for example, intends to channel 50% of a cohort into higher education. Considerations of increased demand for high-skilled workers and social equality motivated the latter objective. With scarce financial resources the attention of policy-makers turns towards the current regulations in higher education to achieve the desired objectives.

In Europe, such regulatory policies shape the industrial organization in higher education. The differences in quality and program content between universities are much smaller than in the United States where regulation is less prevalent. The hierarchical stratification in the US is well documented (e.g. Epple, D., Romano, R. E. and Sieg, H., 2001), and it is a day-to-day experience for most academics. Hence, although the Ivy League Universities are widely revered as academic institutions they do not necessarily serve as a benchmark. Indeed, many explicitly commercial institutions like the University of Phoenix do not go for the top quality students nor teach at the cutting edge of research. They deliberately position themselves on a lower academic level, responding to the demand of students for more "down-to-earth" courses and calls from the industry to supply employees with practical, while not exceptional skills.

The focus of this paper is to analyze the impact of regulatory policies on product differentiation and hierarchical stratification. I concentrate on three areas of government interventions: access to higher education, the intensity of competition between universities, and the setting of tuition fees. The university is modelled as a surplus-maximizing firm in a regulated market. The university benefits from the return on education of their risk-averse students. In education as in any investment higher returns come at higher risk (see Telhado Pereira and Silva Martins (2002)).

A university certainly follows objectives beyond the profit motive. However, the surplus-

maximization assumption implies a unit measure for the university's objectives. By speaking of surplus instead of profit, it is recognized that universities do not pay out dividends to shareholders. Teaching is used as a fundraising mechanism to support other university activities. Junior academics for example are frequently supported with different forms of teaching assistantships, while they work predominantly on their research projects. For parsimony reasons, the direct impact of research on teaching is neglected throughout the paper.

The results of this paper can be summoned as follows. Due to constant absolute risk aversion among students, the less able ones prefer a program with a more certain outcome for the price of a lower expected yield. A monopolistic university responds to this demand only if its benefits from the students' returns on education are high enough, or if it is allowed to set its tuition fee autonomously. In a duopoly with regulated fees the equilibrium is symmetric and the educational programs include a share of low-risk education. In a competitive environment with autonomous tuition fees, universities differentiate with respect to the size of the student body, the ability of their students, output return, riskiness of their educational programs and their tuition fees. As a result, "elite" institutions emerge and access to higher education increases. This implies increased inequality among the graduates.

The closest relations to this paper are the articles by Gary-Bobo and Trannoy (2004) and De Fraja and Iossa (2002). De Fraja and Iossa (2002) model a non-cooperative game of two universities which choose their admission policy given the distance between the two universities and the transportation costs. In their model hierarchical stratification depends on mobility costs for students. High mobility costs induce symmetric behaviour of ex-ante identical universities, while intermediate costs create an asymmetric equilibrium. The authors do not find a pure strategy equilibrium given low mobility costs. Gary-Bobo and Trannoy (2004) discuss tuition fee-setting and admission standards in the context of asymmetric information on a student's ability. They show how universities use tuition fees for the selection of students, even if abilities are private information of the students. However, their focus is on welfare considerations, while this paper has a closer look on the behaviour of universities and the industrial organization of higher education under different policy regimes.

Some assumptions in this paper are derived from other previous contributions in the field of uni-

versity economics. Winston (1999) takes an interesting, if non-formal, approach to the economics of higher education and describes an university's objective function (2003), in particular its benefits from the success of its graduates. The results of the latter paper motivate the surplus function of the university introduced in section 2.3. Rothschild and White (1995) offer a more formal insight into the universities' choices. They emphasize the impact of a customer-input-technology on the pricing of a product. Educational services rely on such customer-input since the quality of their output correlates positively with the quality of the students. This technology distinguishes higher education from most other industries. Finally, Fabel, Brauckmann, and Rodenheber (2000) argue that a general, methodological education delivers on average higher returns than specific, applied education, because the acquired skills can be used for a longer time and in more contexts. These papers motivate significantly the human capital production function in section 2.1.

The argument in this paper proceeds as follows: section 2 introduces the human capital production function and the model's agents. Section 3 shows how a university solves its maximization problem as a monopolist in different regulatory environments. Section 4 introduces competition. Section 5 discusses the results.

2 The model framework

2.1 The human capital production function

The university's output is measured by the value of the human capital of its graduates. This value is denoted with $V_{\theta k}$ for a student a student with ability θ at university k . The ability θ is common knowledge. For parsimony it is uniformly distributed between 0 and 1. However, students with the same ability acquire different human capital at different universities, because the programs differ. Programs differ because of deliberate choices of content. Some universities teach more applied skills (like Britain's former Polytechnics or Germany's Fachhochschulen) , other focus more on a scientific, methodological education for example (like the traditional universities). On average the latter universities deliver higher returns than the former one since the acquired skills

can be used for a longer time and in more contexts (see Fabel et al., 2000). Hence, it should be associated with higher risk.

Content differences are captured as followed. The content of a program constitutes the composite of two educational "technologies". One (H) delivers high risks and high returns. The other (L) delivers low risks and low returns. The share of H -type modules in the program of university k is h_k . The share of L is $(1 - h_k)$. Suppose a program's duration is standardized to 1 course unit. With $0 < h_k < 1$, a student will get h_k lectures in methodology and $(1 - h_k)$ lectures in applied topics.

The relationship between human capital value and ability is linear such as $V_{\theta k} = (\mu\theta + \varepsilon_H)$ with $\mu > 1$ for one unit of H , and $V_{\theta k} = (\theta + \varepsilon_L)$ for one unit of L . The specific random variable ε_I , with $I \in \{H, L\}$ and $cov(\varepsilon_H, \varepsilon_L) = 0$, is normally distributed with the expected value of 0 and the variance of σ_I^2 (with $\sigma_H^2 > \sigma_L^2$). Hence, the expected value from H -type classes is greater than the expected value from L -type ones. Standardizing the program duration to one, the human capital output is

$$V_{\theta k} = h_k(\mu\theta + \varepsilon_L) + (1 - h_k)(\theta + \varepsilon_H) \quad (1)$$

For parsimony other productivity factors such as peer group effects, class size or teacher quality are ignored.

2.2 The students' preferences

Students are assumed to be risk-averse. In particular r denotes the common degree of constant absolute risk-aversion and $R(r, h_k)$ the risk premium. For $V_{\theta k} = h_k(\mu\theta + \varepsilon_L) + (1 - h_k)(\theta + \varepsilon_H)$, it is given by

$$R(r, h_k) = \frac{r}{2}h_k^2\sigma_G^2 + \frac{r}{2}(1 - h_k)^2\sigma_P^2 \quad (2)$$

However, students are heterogenous regarding their ability. Given this heterogeneity the value of the acquired human capital at university k differs among the students. Every student at university

k has to pay the tuition fee T_k . The value of an alternative to higher education is zero for all students. Hence, the utility of a student θ at university k is given by :

$$U_k(\theta) = h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P) - R(r, h_k) - T_k \quad (3)$$

One property of this utility function is that for each θ -type there exists a unique preferred share $h_k^*(\theta)$ which reflects his ability. If, hypothetically, a student θ could maximize $U_{\theta k}$ with respect to h_k , comparative statics would yield $\frac{dh_k^*(\theta)}{d\theta} > 0$ and $\frac{\partial U_{\theta k}^2}{\partial \theta \partial h_k} > 0$. Hence, with increasing ability students prefer a higher share of the high risk content and the marginal utility of an increased share of the high risk content increases with the ability. Therefore, a student faces a decision on risk and return of his educational investment when choosing his university.

2.3 The universities' objective function

A university's objective is to maximize its surplus. We abstract from all principal-agent problems within in the university. Each university can offer only one program. The number of academic subjects is one.

The university generates revenues from tuition fees ($T_k \geq 0$) or invests in students via scholarships ($T_k < 0$). Each university sets a single T_k for all of its students. Moreover, the university profits from its aggregated human capital output. These profits are not a tax but rather reflect spillovers from the output. Examples of such spillovers are handouts from donors who want to bask in reflected glory or alumni donations. Hence, the existence of appropriate fundraising mechanisms is assumed. In this paper the spillovers are measured in money terms. Spillovers are assumed to be a multiple of the human capital output ($\alpha V_{\theta k}$ for a single graduate of the university). The costs of educating a student are given by C . To simplify the analysis, these costs are identical across students, technologies and universities.

Thus, we obtain the following surplus function for university k :

$$\pi_k = \int_{\underline{\theta}_k}^{\bar{\theta}_k} [\alpha V_{\theta_k} + T_k - C] f(\theta) d\theta$$

The most and the least able students at the university are labelled with $\bar{\theta}_k$ and $\underline{\theta}_k$, respectively. Inserting from (1), the surplus function can be arranged to yield

$$\pi_k = \int_{\underline{\theta}_k}^{\bar{\theta}_k} [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (4)$$

Taking the assumptions about risk-averse students into account, the university's surplus maximization problem implies a trade-off between generating more graduates and receiving a higher revenue per student. More students mean more tuition fees and more graduates who will produce spill-overs. But more students also mean that expected spillovers per student are lower because less able students do not enrol if the program is too risky. The following two sections examines how universities solve this problem in different regulatory environments.

3 The monopoly case

Regulating competition is a key part of any political decision making in higher education. In Europe, universities can behave as a monopolist to a certain extent since they are shielded from competition. Hence, it is useful to compare a monopoly with a duopoly situation as benchmark cases for regulation. The regulatory environment is restricted to analyzing university autonomy vs. government intervention in the fields of admission and tuition fees.

Definition 1 *Regulated admission means that the university has to enrol every applicant. If the university can select among applicants, there is autonomous admission.*

Admission regulation becomes a problem for the university only if the university earns a negative

surplus with the least able applicants while the utility of these applicants from studying at the university is weakly positive. Hence, if $\pi_k \underline{\theta}_k < 0 \leq U_{\underline{\theta}_k}$, then admission regulation restrains the university's behaviour.

Definition 2 *Regulated tuition fees mean T_k is given exogenously. If the university can choose T_k , tuition fees are set autonomously.*

These definitions create three possible policy regimes. Regulated tuition fees can go with or without regulated access. Autonomous tuition fees imply an autonomous admission policy since universities can set deterring prices for undesired students.

3.1 Regime 1: Regulated admission and regulated tuition fees (RR)

In this first regime the university has to accept all applying students and cannot deter them with high tuition fees.

Proposition 1 *In an regime with regulated admission and regulated tuition fees, a monopolistic university will only use technology H for its educational program.*

Proof. The university's problem can be stated as:

$$\max_{h_k} \pi_k = \int_{\underline{\theta}_k(h_k)}^1 [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (5)$$

The first-order condition can be derived as

$$\frac{\partial \pi_k}{\partial h_k} = \int_{\underline{\theta}_k(h_k)}^1 [\alpha (\mu - 1) \theta] f(\theta) d\theta - \alpha (\mu - 1) \underline{\theta}_k > 0 \quad (6)$$

Knowing the properties of the students' utility functions (3) the university will avoid undesired students by setting h_k as high as possible, hence $h_k^{RR} = 1$. ■

The university will use only the high risk technology for its education because it delivers the highest returns per students and is the best available instrument to avoid the enrolment of undesired students.

3.2 Regime 2: Autonomous admission and regulated tuition fees (AR)

Now, the university can set an ability threshold for the applicants. The university will enrol all profitable students.

Proposition 2 *In an environment with autonomous admission and regulated tuition fees, a monopolistic university will only use technology H for its educational program, if it does not want to enrol all applicants. If the university wants to enrol all applicants, it will use technology L , only if the returns for the students from increasing h_k are smaller than the product of the degree of risk aversion times the risk associated with technology H (i.e. $\int_{\underline{\theta}_k^*}^1 (\mu - 1) \theta f(\theta) d\theta + (\mu - 1) \underline{\theta}_k^* < r\sigma_H^2$).*

Proof. The university's optimization problem changes to

$$\max_{\underline{\theta}_k, h_k} \pi_k = \int_{\underline{\theta}_k}^1 [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (7)$$

If the university does not want to enrol all applicants, there is still a strictly positive first derivative and consequently $h_k^{AR} = 1$. Hence, the lower boundary is defined by a zero-profit

condition for the least able enrolled student:

$$\pi_{k\underline{\theta}_k} = \alpha (h_k(\mu\underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P)) + T_k - C \geq 0 \quad (8)$$

However, if the university wants to accept every applicant (i.e. $\pi_{k\underline{\theta}_k} \geq U_{\underline{\theta}_k k} \geq 0$), maximization is subject to a zero-utility constraint for its least able student:

$$U_{\underline{\theta}_k k} = h_k(\mu\underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P) - R(r, h_k) - T_k \geq 0 \quad (9)$$

Maximizing (7) subject to (9), the first order conditions are:

$$\alpha \int_{\underline{\theta}_k}^1 (\mu - 1) \theta f(\theta) d\theta - \lambda [(\mu - 1) \underline{\theta}_k - r h_k^* (\sigma_H^2 - \sigma_L^2) - r \sigma_L^2] = 0 \quad (10)$$

$$-(\alpha + \lambda) (h_k (\mu - 1) + 1) = 0 \quad (11)$$

where λ is the multiplier associated with constraint (9). If h_k was not restricted between 0 and 1, the function would have a minimum and a maximum point. Since $h_k (\mu - 1) + 1 > 0$, there is $(-\lambda) = \alpha$ in order to satisfy the necessary condition (11). In appendix 1, the conditions for an interior solution are derived. ■

Hence, if non-profitable students apply, the university uses only the high return technology H to get the most out of each student and rejects all undesired applicants. The university uses some of the low return technology L in its program if some profitable students do not apply because of the riskiness of the program. Then, the university faces the above mentioned trade-off between generating more graduates and receiving a higher revenue per student.

3.3 Regime 3: Autonomous admission and autonomous tuition fees (AA)

The university can use tuition fees to deter undesired students and maximize profit per student.

Proposition 3 *In an environment with autonomous admission and autonomous tuition fees, a monopolistic university will use technology H and technology L for its educational program.*

Proof. This case is similar to the previous one. The university's optimization problem can be stated as

$$\max_{h_k, T_k} \pi_k = \int_{\underline{\theta}_k}^1 [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (12)$$

subject to:

$$U_{\underline{\theta}_k k} = h_k(\mu\underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P) - R(r, h_k) - T_k \geq 0 \quad (13)$$

With the university setting the tuition fee T_k , $\pi_{k\underline{\theta}_k} \geq U_{\underline{\theta}_k k} \geq 0$ always holds. The regulator cannot regulate admission while granting free choice of tuition fees. The first order conditions of the problem are:

$$\alpha \int_{\underline{\theta}_k}^1 (\mu - 1) \theta f(\theta) d\theta - \kappa [(\mu - 1) \underline{\theta}_k - r h_k^* (\sigma_H^2 - \sigma_L^2) - r \sigma_L^2] = 0 \quad (14)$$

$$(1 - F(\underline{\theta}_k)) + \kappa = 0 \quad (15)$$

Here, κ is the multiplier associated with constraint (13). It is obviously that $\kappa < 0$ because $0 \leq F(\underline{\theta}_k) \leq 1$. With $\kappa < 0$, the value of the determinant with the second order derivatives becomes positive (see Appendix 2). Additionally, $\frac{\partial^2 \pi_k}{(\partial h_k)^2} < 0$ and $\frac{\partial^2 \pi_k}{(\partial T_k)^2} = 0$. This establishes the sufficient condition for a maximum - assuming that risk and return parameters do not preclude such an interior solution. ■

Hence the university can include some applied education (technology L) to attract more students and charge them accordingly.

4 The duopoly case

The introduction of competition increases the number of possible policy regimes to four. Now universities cannot use tuition fees to deter undesired applicants because a small decrease in tuition fees allows the competitor to attract all students, the best as well as the worst. The regimes with regulated tuition fees all generate the same market structure with some quantitative differences only.

4.1 Regime 4 and 5: Regulated tuition fees with autonomous or regulated admission

The two competing universities 1 and 2 are ex ante identical. Hence, they solve the same maximization problem.

$$\max_{h_k} \pi_k = \int_{\underline{\theta}_k(h_k)}^{\bar{\theta}_k(h_k)} [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (16)$$

with $k \in \{1, 2\}$ and s.t.

$$U_{\underline{\theta}_k k} = h_k(\mu\underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P) - R(r, h_k) - T_k \geq 0 \quad (17)$$

In the case of an asymmetric equilibrium there is a second constraint at the boundary between the universities. Assume university 1 to have a higher share of the high risk-technology H than university 2. Then, the least able students at the first university and the most able ones at the second have the same ability. Hence, they are indifferent regarding the choice of their university:

$$U_{\bar{\theta}_2 2} = U_{\bar{\theta}_2 1} = U_{\underline{\theta}_1 1} = U_{\underline{\theta}_1 2} \quad (18)$$

The applied analytical method is a simple single-period two-agents non-cooperative game. At

the beginning of the one period, both universities simultaneously choose their h_k . At the end of the period, the outcome for the universities is observed.

Proposition 4 *The resulting equilibrium is symmetric. The universities will choose $h_k < 1$ if the hypothetical maximization of (3) with respect to h_k by any student with $\theta < 1$ yields $h_k^*(\theta) < 1$.*

Proof. Suppose that an asymmetric equilibrium with $h_1 > h_2$ and $\pi_2 = \pi_1 \geq 0$ exists. Equation (18) is binding. The students at the boundary between the universities are indifferent. Therefore, the upper boundary at university 2 ($\bar{\theta}_2$) is a function of both h_1 and h_2 which implies the following optimization problem for university 2:

$$\max_{h_2} \pi_2 = \int_{\underline{\theta}_2(h_2)}^{\bar{\theta}_2(h_1^*, h_2)} [\alpha V(\theta, h_2) + T_2 - C] f(\theta) d\theta$$

With the endogenous upper boundary, we get

$$\frac{\partial \pi_2}{\partial h_2} = \alpha V'(\bar{\theta}_2) f(\bar{\theta}_2) + \int_{\underline{\theta}_2(h_2)}^{\bar{\theta}_2(h_1^*, h_2)} V'(\theta, h_2) f(\theta) d\theta - \alpha V'(\underline{\theta}_2) f(\underline{\theta}_2).$$

This expression is strictly positive given the uniform distribution of θ^* . Additionally, it is strictly positive whether there exists a regulation on admission or not. The consequence for university 1 is a loss in profits and a reduction of h_1 as a reaction. Thus, the case of an asymmetric equilibrium can be excluded.

The symmetric equilibrium cannot be at $h_k = 1 (k \in \{1, 2\})$ under the conditions described in the proposition, because, for $\Pr(\theta = 1) = 0$, there is a positive incentive to deviate from the equilibrium. At $h_1 = h_2 = 1$, a marginal reduction, say of h_1 by university 1 attracts all students with $\theta < 1$ to that university. Suppose that the universities can choose between $h_k = 1$ and $h_k = (1 - \varepsilon)$, with $0 < \varepsilon < 1$. Table 1 shows the resulting surpluses for both universities:

*In case of a normal distribution it is possible that $\frac{\partial^2 \pi_2}{\partial (h_2)^2} < 0$. However, the reduction of the second university's incentive to converge to the standard of the first university means an increased incentive for the latter to converge.

Insert table 1 here

Let $(\pi_k | h_k = 1)$ denote the surplus university k would generate as a monopolist with $h_k = 1$. To analyze the incentive for deviating from $h_k = 1$, let ε converge to zero. Hence, for $h_1 > h_2$ we obtain:

$$\begin{aligned} \lim_{\varepsilon \rightarrow 0} \int_{\bar{\theta}_2(\frac{h_1+h_2}{2})}^1 (\pi_{i1} | h_1 = 1, h_2 = (1 - \varepsilon)) f(\theta) d\theta &= 0 \\ \lim_{\varepsilon \rightarrow 0} \int_{\bar{\theta}_2(h_2)}^{\bar{\theta}_2(\frac{h_1+h_2}{2})} (\pi_{i2} | h_1 = 1, h_2 = (1 - \varepsilon)) f(\theta) d\theta &= (\pi_2 | h_2 = 1) \end{aligned}$$

and vice versa for $h_1 < h_2$. Hence, in Nash equilibrium both universities choose $h_k < 1$. The resulting interior solution for $h_1 = h_2$ becomes smaller if $\pi_{k\theta_k} < 0 \leq U_{\theta_k k}$ does not hold or universities can regulate admission autonomously. ■

The results hold for both regulated and autonomous admission. Both cases yield a symmetric equilibrium with $h_1 = h_2 < 1$. However, under the autonomous admission regime both universities would use more of the low return technology than under the regulated one.

Compared with the respective monopoly cases, one can observe the effects of competition. The universities are induced to account for their students' preferences. Thus, they will always include some applied education (technology L) in their programs.

4.2 Regime 6: Autonomous tuition fees and autonomous admission

In this case the maximization problem of both universities remains identical to the regulated environment but there is the additional choice variable T_k :

$$\max_{h_k, T_k} \pi_k = \int_{\bar{\theta}_k(h_k)}^{\bar{\theta}_k} [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (19)$$

with $k \in \{1, 2\}$. The maximization is subject to a zero utility constraint and a zero profit

constraint (like equation (8)) for the least able student in each university:

$$U_{\underline{\theta}_k k} = h_k(\mu\underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P) - R(r, h_k) - T_k \geq 0 \quad (20)$$

$$\pi_{k\underline{\theta}_k} = \alpha(h_k(\mu\underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P)) + T_k - C \geq 0 \quad (21)$$

The structure of the game is like in the previous subsection. Both universities simultaneously decide on their choice variables and receive the outcome at the end of the single period.

Proposition 5 *The resulting equilibrium is asymmetric. There is an university 1, with a large h_1 , low T_1 , and few but more able students. And there is another university 2 with a small h_2 , high T_2 , and many but less able students.*

Proof. Assume a symmetric equilibrium with $0 < h_1 < 1$, T_1 and $\pi_2 = \pi_1 \geq 0$. In this case each university would get $\frac{1}{2}\pi(h_1, T_1)$, i.e. half of the surplus university k would generate as a monopolist. Now, a marginal reduction of the fees allows each university to attract all students. The least able are not enrolled since they create losses for the university. At that point, there exists an incentive to increase h_1 since the quality of the average student improves and this average student prefers a riskier but more rewarding education. With increasing h_1 and decreasing T_1 the incentive to implement an alternative 2 with $h_2 < h_1$ and $T_2 > T_1$ increases. Equation (22) states the surplus of such an alternative 2.

$$\pi_2 = \int_{\underline{\theta}_2(h_2)}^{\bar{\theta}_2(h_1, T_1)} [\alpha V(\theta_i, h_1) + T_1 - C] f(\theta) d\theta \quad (22)$$

The upper boundary is defined by the zero-profit condition for the least able student at university 1, which again refers to the students' utility function (3). This constraint reflects the fact

that lower tuition fees makes a university more attractive for all students. As an approximation we obtain $\bar{\theta}_2 = \underline{\theta}_1$ but $0 < U_{\bar{\theta}_2} < U_{\underline{\theta}_1}$. This implies

$$\frac{\partial \pi_2}{\partial h_1} = - \left[\frac{\partial \pi_{1, \underline{\theta}_1}}{\partial h_1} \right] > 0 \quad (23)$$

and

$$\frac{\partial \pi_2}{\partial T_1} = - \left[\frac{\partial \pi_{1, \underline{\theta}_1}}{\partial h_1} \right] < 0 \quad (24)$$

The equilibrium is determined by four equations and two binding constraints for the lower boundaries which can be solved for $h_1, T_1, h_2, T_2, \underline{\theta}_2$ and $\underline{\theta}_1$. Two equations reflect the first order conditions if π_2 from equation (22) is maximized with respect to h_2 and T_2 and subject to the constraint (21):

$$\alpha \int_{\underline{\theta}_2}^{\bar{\theta}_2(h_1, T_1)} (\mu - 1) \theta f(\theta) d\theta - \kappa_2 [(\mu - 1) \underline{\theta}_2 - r h_2^* (\sigma_H^2 - \sigma_L^2) - r \sigma_L^2] = 0 \quad (25)$$

$$(F(\bar{\theta}_2) - F(\underline{\theta}_2)) + \kappa = 0 \quad (26)$$

Constraint (17) is not binding for a university implementing alternative 2 as its problem is similar to the problem of a monopolistic university in the same regulatory environment (see equation (12)). The existence of positive profits in a monopoly situation guarantees an interior solution.

In equilibrium universities are indifferent between alternative 1 and alternative 2, if a marginal reduction of T_1 (say by $0 < \varepsilon_T$) and a marginal increase of h_1 (by $0 < \varepsilon_h$) yield the same surplus as the implementation of alternative 2. This means:

$$\lim_{\varepsilon_T \rightarrow 0} \pi_1(h_1, T_1 - \varepsilon_T) = \pi_2(h_2, T_2) \quad (27)$$

$$\lim_{\varepsilon_h \rightarrow 0} \pi_1(h_1 + \varepsilon_h, T_1) = \pi_2(h_2, T_2) \quad (28)$$

The two equations imply that, at $h_1 > h_2$ and $T_1 < T_2$, the surpluses in equilibrium are equal and positive:

$$\pi_1(h_1, T_1) = \pi_2(h_2, T_2) > 0.$$

■

This policy regime is the one without any regulations and it yields hierarchical stratification. In a duopoly, the incentive to provide "down-to-earth" courses and the emergence of an "elite" university can be analyzed.

4.3 Regime 7: Autonomous tuition fees and regulated admission

The analysis of a duopoly with autonomous fees but regulated admission yields similar results as in section 4.2. Regulated admission reduces the expected surpluses, students can join the university they prefer, irrespective of the losses for the university. Unlike in the monopoly case, tuition fees cannot be set high enough to deter these students. Such a scenario implies $\bar{\theta}_2 = \underline{\theta}_1$ and $U_{\bar{\theta}_2} = U_{\underline{\theta}_1}$.

Again, universities compete by lowering tuitions and increasing the riskiness of its program. A marginal increase of h in one university induces the most able, and most surplus-generating, students to join the university and the less able and loss creating students to stay put in the other one. This implies opposite effects on the size of the student body. While lower tuition fees attracts more low-skill students, the increased riskiness deters them. Equilibrium is determined as in the proof of proposition 5. Depending on the parameters the equilibrium may become symmetric and at the boundary, such that $h_1 = h_2 = 1$ and profits are zero for both universities.

This outcome reflect that the impacts of fee reduction and increasing riskiness in alternative 1 on the surpluses of alternative 2 counter-balance:

$$\frac{\partial \pi_2}{\partial h_1} = - \left[\frac{\partial U_{\underline{\theta}_1, 1}}{\partial h_1} \right] > 0 \quad (29)$$

$$\frac{\partial \pi_2}{\partial T_1} = - \left[\frac{\partial U_{\underline{\theta}_1, 1}}{\partial T_1} \right] > 0 \quad (30)$$

At one point, $\frac{\partial \pi_2}{\partial h_1}$ must become equal to $\frac{\partial \pi_2}{\partial T_1}$ because the students' marginal utility function (3) is falling in h_k ($\frac{\partial(\partial U_{\theta k})}{\partial h_k \partial h_k} < 0$) but not in T_k . However, a reduction of tuition fees given alternative 1 can exclude (27) because of the limited range of the possible educational technologies ($0 < h_k < 1$).

5 Conclusion

The paper has shown how the introduction of competition, a deregulation on tuition fees and the permission of university-defined admission standards shape a university's behavior. Deregulation induces the universities to pay more attention to the characteristics and preferences of a student. With the possibility to set tuition fees autonomously universities respond to the different demands from heterogeneous students by offering different educational products for different prices. The characteristics of competitive outcomes depend very much on the existence of regulations on tuition fees. Competition without autonomous tuition fees generates a symmetric equilibrium while autonomy on fees sets incentives for product differentiation, particularly in combination with self-determined admission standards.

These findings reflect some results observed by Hoxby (1997). Hoxby's study of the US higher education sector shows, that an increase in quality, fees, and product differentiation goes hand in hand with more competition between universities. The model in this paper offers an explanation why the more deregulated and competitive US higher education system is more diverse than the regulated European one. Comparing the different regimes described in this paper, it is tempting to suggest that higher education in Europe has moved from regime 1 to regimes 4 or 5. The increasing number of students and the strained public budgets induced a competition for financial resources. Politicians decide in the budget according to public demand for educational content and the number of enrolled students. Some anecdotal evidence and a lot of complaints among academics and employers suggest a parallel decline in methodological training and high-skill labor supply, e.g. in engineering. With restrictions on tuition fees and admission thresholds in place, regime 6 is still "ante portas" in Europe. It seems adequate for the United States. Whether regime 6 will or should be implemented cannot be addressed by mere positive analysis.

For transparency reasons, the model has used some simplifying assumptions. Further research activities can overcome some of these simplifications. An obvious research topic is the empirical analysis of the risk-return relationship of different types of higher education. Also, empirically observed educational production functions in the literature include teacher-quality, peer-group-effects or, more generally, a direct link between school resources and student performance. These factors have an important impact on the overall output of education and the efficient allocation of resources. Finally, the labor market demand for graduates with different forms of human capital should be integrated, so that risk and return of different educational technologies become endogenous.

References

De Fraja, G. and Iossa, E. "Competition among Universities and the Emergence of the Elite Institution." *Bulletin of Economic Research*, 2002, 54(3), pp. 275-93.

Epple, D., Romano, R. E. and Sieg, H. "Peer Effects, Financial Aid, and Selection of Students into Colleges and Universities: An Empirical Analysis". Duke University Department of Economics. Working Paper: 00/02: 2001

Fabel, O.; Brauckmann, A. und Rodenheber, M. "Der "Trade-Off" zwischen allgemeinem und spezifischem Humankapital in der betriebswirtschaftlichen Hochschullehre." *Zeitschrift für Berufs- und Wirtschaftspädagogik*, 2000, 96(3), pp. 355-75.

Gary-Bobo, R. J. und Trannoy, A. "Efficient Tuition Fees, Examinations, and Subsidies". CESifo. CESifo Working Paper: 1189, 2004

Hoxby, C. M. "How the Changing Market Structure of U.S. Higher Education Explains College Tuition". Cambridge, MA: NBER. Working Paper: 6323, 1997

Rothschild, M. and White, L. J. "The Analytics of the Pricing of Higher Education and Other Services in Which the Customers Are Inputs." *Journal of Political Economy*, 1995, 103(3), pp. 573-86.

Telhado Pereira, P. und Silva Martins, P. "Is There a Return-Risk Link in Education?" *Economics Letters*, 2002, 75, pp. 31-37.

Winston, G. C. "Subsidies, Hierarchy and Peers: The Awkward Economics of Higher Education." *Journal of Economic Perspectives*, 1999, 13(1), pp. 13-36.

Winston, G. C. "Towards a Theory of Competition: Prices, Peer Wages, and Competition in Higher Education". Williamstown: Williams College - Williams Project on the Economics of Higher Education. Discussion Paper: 65, 2003

Appendix 1: Extended proof of proposition 2

The university solves:

$$\max_{\underline{\theta}_k, h_k} \pi_k = \int_{\underline{\theta}_k}^1 [\alpha (h_k(\mu\theta + \varepsilon_G) + (1 - h_k)(\theta + \varepsilon_P)) + T_k - C] f(\theta) d\theta \quad (31)$$

which is subject to the following constraints:

$$h_k(\mu \underline{\theta}_k + \varepsilon_G) + (1 - h_k)(\underline{\theta}_k + \varepsilon_P) - R(r, h_k) - T_k \geq 0 \quad (30-1)$$

$$h_k \geq 0 \quad (30-2)$$

$$1 - h_k \geq 0 \quad (30-3)$$

$$\underline{\theta}_k \geq 0 \quad (30-4)$$

$$1 - \underline{\theta}_k \geq 0 \quad (30-5)$$

The relevant Lagrangian multipliers are λ_i with $i \in \{1, 2, 3, 4, 5\}$ for the specific constraints.

The resulting First Order Conditions in the problems with the zero utility constraint are:

$$\alpha \int_{\underline{\theta}_k}^1 (\mu - 1) \theta f(\theta) d\theta - \lambda_1 [(\mu - 1) \underline{\theta}_k - r h_k^* (\sigma_H^2 - \sigma_L^2) - r \sigma_L^2] + \lambda_2 - \lambda_3 = 0 \quad (32)$$

$$-(\alpha + \lambda_1 + \lambda_4 - \lambda_5) (h_k (\mu - 1) + 1) = 0 \quad (33)$$

One can exclude constraint (30-5) as this implies a university without students. Constraint (30-4) cannot be binding since it would violate (30-1). For $\underline{\theta}_k = 0$, (30-1) is negative. Finally, constraint (30-2) can be ignored (i.e. $\lambda_2 = 0$), since the concern in this proof is the enduring existence of a boundary solution with $h_k = 1$, as stated in the first proposition. These considerations imply $\lambda_2 = \lambda_4 = \lambda_5 = 0$. Therefore, there are only four constraint combinations left:

1. $\lambda_1 \neq 0$ and $\lambda_3 = 0$.

This combination implies an interior solution. For $0 < h_k$ it follows that

$$\alpha = (-\lambda_1) > 0$$

to satisfy (33). From (32), we then obtain

$$h_k^* = \frac{\int_{\underline{\theta}_k^*}^1 (\mu - 1) \theta f(\theta) d\theta + (\mu - 1) \underline{\theta}_k^* - r \sigma_L^2}{r (\sigma_H^2 - \sigma_L^2)}$$

Hence, an interior solution exists if

$$\int_{\underline{\theta}_k^*}^1 (\mu - 1) \theta f(\theta) d\theta + (\mu - 1) \underline{\theta}_k^* < r\sigma_H^2 \quad (34)$$

The resulting Hessian Matrix is

$$D = \begin{vmatrix} 0 & - \left(\begin{array}{c} (\mu - 1) \underline{\theta}_k - rh_k^* (\sigma_H^2 - \sigma_L^2) \\ -r\sigma_L^2 \end{array} \right) & (h_k (\mu - 1) + 1) \\ - \left(\begin{array}{c} (\mu - 1) \underline{\theta}_k - rh_k^* (\sigma_H^2 - \sigma_L^2) \\ -r\sigma_L^2 \end{array} \right) & \lambda_1 r (\sigma_H^2 - \sigma_L^2) & -(\alpha + \lambda_1) (\mu - 1) \\ (h_k (\mu - 1) + 1) & -(\alpha - \lambda_1) (\mu - 1) & 0 \end{vmatrix}$$

With $0 < h_k$, we have $\alpha = (-\lambda_1) > 0$ to satisfy (33). Hence, D is positive. This result establishes the sufficient condition for a maximum.

2. $\lambda_1 = 0$ and $\lambda_3 = 0$

This combination establishes a situation with $h_k^* < 1$ where some students would like to join the university but the university does not want to enrol them. Thus, the first order conditions are obtained as:

$$\alpha \int_{\underline{\theta}_k}^1 (\mu - 1) \theta f(\theta) d\theta = 0 \quad (35)$$

$$-(h_k (\mu - 1) + 1) = 0 \quad (36)$$

Both equations cannot hold at the same time, since the left hand sides are strictly positive in the first and negative in the second case. This leads to the boundary solution of the first statement of proposition 2.

3. $\lambda_1 = 0$ and $\lambda_3 \neq 0$

Here is a situation where $h_k^* = 1$ and the university sets a admission threshold. The first

order conditions are:

$$\alpha \int_{\underline{\theta}_k}^1 (\mu - 1) \theta f(\theta) d\theta - \lambda_3 = 0 \quad (37)$$

$$-(h_k^* (\mu - 1) + 1) = 0 \quad (38)$$

$$h_k^* = 1 \quad (39)$$

All three conditions cannot hold at the same time because the left hand side of the second one is strictly negative. Again, we obtain the boundary solution noted in the first statement of proposition 2.

4. $\lambda_1 \neq 0$ and $\lambda_3 \neq 0$

This combination defines a case in which the actual values of the parameters in (34) do not allow for an interior solution and force the university to choose $h_k^* = 1$, e.g. in the case of $r\sigma_H^2 = (\mu - 1)$.

Appendix 2: Second order condition in the proof of proposition 3

The proof of appendix 1 can be applied, restricted to the case where the risk and the return parameters actually allow for an interior solution and the zero-utility constraint for the least able enrolled student is binding. The resulting Hessian determinant D is

$$D = \begin{vmatrix} 0 & -[(\mu - 1)\underline{\theta}_k - rh_k^*(\sigma_H^2 - \sigma_L^2) - r\sigma_L^2] & 1 \\ -[(\mu - 1)\underline{\theta}_k - rh_k^*(\sigma_H^2 - \sigma_L^2) - r\sigma_L^2] & \kappa r(\sigma_H^2 - \sigma_L^2) & 0 \\ 1 & 0 & 0 \end{vmatrix}$$

where $\kappa < 0$ is the Lagrangian Multiplier associated with the zero-utility constraint. For $\kappa < 0$,

the value of D is positive. Hence the interior solution constitutes a maximum.

Table 1: Surpluses in a duopoly with regulated tuition fees

	$h_2 = 1$	$h_2 = (1 - \varepsilon)$
$h_1 = 1$	$\left(\begin{array}{c} \frac{1}{2} (\pi_k h_k = 1), \\ \frac{1}{2} (\pi_k h_k = 1) \end{array} \right)$	$\left(\begin{array}{c} \int_{\theta_{a2}(\frac{h_1+h_2}{2})}^1 \pi(\theta_i, h_1) f(\theta) d\theta, \\ \int_{\theta_{z2}(h_2)}^{\theta_{a2}(\frac{h_1+h_2}{2})} \pi(\theta_i, h_2) f(\theta) d\theta \end{array} \right)$
$h_1 = (1 - \varepsilon)$	$\left(\begin{array}{c} \int_{\theta_{z1}(h_1)}^{\theta_{a1}(\frac{h_1+h_2}{2})} \pi(\theta_i, h_1) f(\theta) d\theta, \\ \int_{\theta_{a1}(\frac{h_1+h_2}{2})}^1 \pi(\theta_i, h_2) f(\theta) d\theta, \end{array} \right)$	$\left(\begin{array}{c} \frac{1}{2} (\pi_k h_k = (1 - \varepsilon)), \\ \frac{1}{2} (\pi_k h_k = (1 - \varepsilon)) \end{array} \right)$