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University Funding Reform, Competition and Teaching Quality

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University Funding Reform, Competition and Teaching Quality

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University Funding Reform, Competition and Teaching Quality

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Abstract:

This paper explores the impact of university funding reform on teaching quality competition. It shows that a graduate tax with differentiated, but state-regulated fees maximises the higher education surplus, whereas student grants as well as pure and income contingent loans do not. Fee autonomy for universities leads to results inferior to properly state controlled fees and can make the majority of students even worse off than a central student assignment system with very poor teaching incentives.

JEL-Classification: H52, I22, L13

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1 Introduction

Market-oriented reforms, like the implementation of tuition fees, have gained considerable attention in the debate on higher education funding across Europe. In recent years, tuition and/or substantial registration fees were introduced in a number of countries including Austria, Italy, Ireland, the Netherlands and the United Kingdom (Eurydice, 2000). Similar developments are under way in other countries, e.g. Germany.

According to their supporters, tuition fees serve a dual purpose:[1] first, they enhance the efficiency of enrolment choices by making students more aware of the real cost of their study. Second, they improve teaching quality by fostering university competition for students. However, this requires that university budgets become highly responsive to payments from their students. Consequently, demands for tuition fees and university autonomy regarding fee levels and spending decisions often go hand in hand.[2]

Maybe surprisingly, the theoretical work of these popular arguments is far from comprehensive. In fact, the existing literature on competition in higher education remains almost exclusively in the realm of either conventional funding in form of per student grants (Del Rey, 2001; De Fraja and Iossa, 2002) or considers pure private funding (Epple et al., 2003). Hence, it provides little insights on how changes in educational funding affect university competition and thus teaching performance.

It is the aim of this paper to try to shed some light on this issue. We develop a simple model where two universities respond to the strategic incentives arising from various funding schemes including the popular reform options of pure loan schemes, graduate taxes and income contingent loans.[3] We consider both university autonomy and tuition fee regulation by a benevolent - that is, surplus-maximizing - government. Students are heterogenous in ability and peer groups matter for the teaching cost.

[1]These are by far not the only arguments in the debate. The long list of pros and cons of governmental involvement in higher education includes reverse redistribution (García-Peñalosa and Wälde, 2000), social selection (Wigger and von Weizsäcker, 2001), second best arguments (Bovenberg and Jacobs, 2005) and public choice explanations (Beviá and Iturbe-Ormaetxe, 2002).

[2]Greenaway and Haynes (2003) for the UK and German Rectors' Conference (2005) for Germany serve as illustrative examples in this context.

[3]Barr (1993) provides a good overview on financing alternatives for higher education.

Our analysis leads to the following main results. First, we find that uniform tuition fees fail to achieve the welfare optimum. This holds because optimality requires a differentiation of teaching qualities according to ability. However, quality choices under uniform fees are homogenous because all universities face the same incentives for quality enhancement. Indeed, uniform fees and student grants are de facto equivalent if the latter are combined with free enrolment choice. Second, the optimum can be implemented by a graduate tax with properly differentiated fees set by the government. This funding mechanism outperforms all other considered options, mainly because the graduate tax disposes of a higher number of policy instruments to affect individual and university decisions.

Obviously, optimality is lost when the government is guided by interests other than surplus-maximization.[4] Therefore, we investigate in a next step whether fee autonomy can serve as another device to achieve efficiency. As the third main result, we find this not to be the case which is basically due to excessive quality differentiation under fee autonomy. While pure loans are superior to the graduate tax when universities are autonomous, they are dominated by properly regulated uniform fees or grants and can make the vast majority of students even worse off than a central student placement system where teaching incentives are miniscule.

The two papers closest to our analysis are Epple and Romano (1998) and Eisenkopf (2004).[5] Epple and Romano (1998) study how education vouchers affect competition between public and private schools in a setting where only the latter charge tuition. In contrast, we consider a setting where regulation affects all universities equally, which better fits the European case of reforming a by and large public education sector.

Eisenkopf (2004) analyses how university deregulation affects the curriculum choice of universities when higher quality implies higher risk of failure. Similar to the present study, he finds that competition without autonomous fees leads to uniformity while fee autonomy boosts incentives for quality differentiation. However, admission regulation mitigates these incentives such that equilibrium quality choices may (but need not) be symmetric. In our opinion, the main conceptual difference to our approach lies in the university objective function. Eisenkopf (2004) assumes that

[4] We address the issue of other government objectives in the conclusions section.

[5] Moreover, Gary-Bobo and Trannoy (2004) study optimal tuition policies for various university objective functions. However, that model does not address competition between universities.

universities act intrinsically in order to promote the social surplus. We take a more sceptical stance in that respect, stressing that teaching involves opportunity costs for some other activity of universities, which is labelled as research in our model.[6] As a consequence, our analysis takes the above-mentioned link between competition and teaching effort explicitly into account. Other differences between the approaches include the fact that we consider a variety of tuition fee options and examine their welfare ramifications.[7]

The paper is organised as follows. After a presentation of the basics of the model and the efficient solution in Section 2, Section 3 investigates the working of centralised student grant systems. Section 4 introduces tuition fees which are determined by the government. Section 5 derives and compares the equilibria under university autonomy. We conclude in Section 6.

2 Basics of the Model

Consider a set of individuals with their total mass normalised to unity. Born with the same initial productivity, people differ with respect to their learning capabilities, measured by the probability of graduating from university $\theta \in [0, 1]$. For convenience, we assume a uniform distribution of abilities/types: $f(\theta) = 1$.

University attendance has two effects. First, it increases the productivity and hence the wage of a successful graduate by $q_i \geq 0$. For simplicity, the teaching quality of institution i is also measured by q_i. Second, mere university attendance gives a positive benefit ξ for all students, e.g. due to network effects or a consumption motive. Interpreting ξ in monetary terms, going to university i augments expected gross income by:

$$\theta(\xi + q) + (1 - \theta)\xi = \xi + \theta q. \tag{1}$$

As the result of an entrance examination, only the individuals with a success probability of at least $\underline{\theta} \in (0, 1)$ are allowed to study. Although it would be interesting to investigate the interplay between standard setting and funding schemes, we take $\underline{\theta}$ as exogenous throughout the paper.

[6] Hence, incentives for quality differentiation are stronger in our model: For homogenous quality, universities enjoy no rents for research, whereas they produce some social surplus.

[7] In turn, Eisenkopf (2004) explicitly incorporates student risk aversion and the effects of admission regulation, two factors not considered here. See the conclusions section for a discussion.

In what follows, ξ is assumed to be so high that all individuals fulfilling the standard $\underline{\theta}$ prefer to attend university rather than working with the initial productivity level. As a consequence, enrolment is rationed and the number of students is constant - similar to Del Rey (2001) and Epple et al. (2003) - and amounts here to $1 - \underline{\theta}$.[8]

There are two universities, $i = 1, 2$, engaged in both teaching and research. Each university is characterised by the target function:

$$\pi_i = R_i + \alpha q_i N_i, \tag{2}$$

where R_i is the research budget, N_i is the number of registered students and α measures the importance of teaching. Whenever quality differences arise, we refer to university 1 as the high- and to university 2 as the low-quality institution: $q_1 \geq q_2$.

We offer two complementary explanations for $\alpha > 0$. First, it can be interpreted conventionally as an intrinsic motivation for teaching excellence (Del Rey, 2001; De Fraja and Iossa, 2002). Second, it can reflect a spillover of teaching performance on research productivity in the spirit of the Humboldtian ideal of the unity of teaching and research. In this case, (2) should be regarded as a reduced form of these interrelations since research spills over on teaching as well.

The per capita cost of teaching quality q_i when students have average success probability $\bar{\theta}_i$ is:

$$c(q_i, \bar{\theta}_i) = \gamma q_i^2 - \beta \bar{\theta}_i, \quad \beta, \gamma > 0. \tag{3}$$

The first term measures the direct teaching cost which is strictly convex in quality. The second term reflects the peer group benefit, arising from the fact that students are not only clients, but also inputs for university services (Rothschild and White, 1995). Therefore, the resources required to attain a given quality decrease in the average ability of students.[9] The intensity of this peer group effect is measured by β.

[8] Alternatively, ξ could reflect the productivity gain from a minimum teaching quality which universities can not fall short of. In terms of the assumption on university quality setting in Section 3, this would imply $q_i \geq \underline{q} > 0$. Thus, the assumption on the level of ξ could be replaced by an assumption on the government's ability to control and restrict fund diversion. Provided that universities have an incentive to choose at least $\underline{q}$, all following results go through. Otherwise, corner solutions would arise with at least one university providing the minimum teaching quality.

[9] This is a dual definition of peer group effects to the conventional one where the ability of the other students improves individual quality for given educational expenditures. See, e.g. Gary-Bobo and Trannoy (2004) for a similar approach.

In order to focus on the main insights of this approach, we impose two restrictions on the parameters. First, we make the research-teaching tradeoff severe in the sense that universities care for research funds at least as much as for teaching: $\alpha \in [0, 1]$. Second, there is an upper bound on the peer group effect excluding the case of negative per capita teaching costs: $\beta \leq \alpha^2/(4\gamma) \leq 1/(4\gamma)$.[10] Each restriction is in fact stronger than required for the following results to hold.

The optimal solution, which we now derive, maximises the surplus in the higher education sector and serves a useful benchmark for later analysis. To focus attention on teaching issues, we disregard benefits from research other than captured in (2) and posit that one unit of research consumes one unit of financial resources. The resulting equality of the marginal costs and benefits of research renders the optimal research budget indeterminate. As a consequence, welfare is determined only by the teaching side.[11] Letting $\hat{\theta}$ denote the cut-off level of ability which generates the same marginal surplus in both universities, the problem is to maximise:

$$\begin{aligned} S &= \int_{\underline{\theta}}^{\hat{\theta}} \left[(\theta+\alpha)q_2 - \gamma q_2^2\right] \, d\theta + \int_{\hat{\theta}}^{1} \left[(\theta+\alpha)q_1 - \gamma q_1^2\right] d\theta \\ &\quad +(1-\underline{\theta})\xi + \beta\frac{1-\underline{\theta}^2}{2}, \end{aligned} \tag{4}$$

with respect to q_1, q_2 and $\hat{\theta}$. This leads to the first order conditions:

$$(1-\hat{\theta}^2)/2 + (\alpha - 2\gamma q_1)(1-\hat{\theta}) = 0, \tag{5}$$

$$(\hat{\theta}^2 - \underline{\theta}^2)/2 + (\alpha - 2\gamma q_2)(\hat{\theta} - \underline{\theta}) = 0, \tag{6}$$

$$(q_1 - q_2)[-\alpha + \gamma(q_1+q_2) - \hat{\theta}] \gtreqless 0, \tag{7}$$

where (7) holds with equality if $\hat{\theta} \in (0, 1)$.

[10] As shown below, universities choose a teaching quality of at least $\alpha/(2\gamma)$. When only the most able students attend such an institution ($\bar{\theta}_i = 1$), the per capita cost $\alpha^2/(4\gamma) - \beta$ is positive only under the above restriction.

[11] Otherwise, if an optimal research level existed but universities were underfunded, one could argue that the diversion of student grants towards research improves welfare. However, this would neglect that funds could also flow towards other, non-productive activities.

Proposition 1. *Efficient higher education requires a differentiation of teaching qualities according to ability: The brighter half of students ($\theta \geq \theta^* = (1+\underline{\theta})/2$) should attend university 1 which provides quality $q_1^* = (3+\underline{\theta}+4\alpha)/(8\gamma)$, while the less able students ($\theta < \theta^*$) should receive the lower quality $q_2^* = (1+3\underline{\theta}+4\alpha)/(8\gamma)$ at university 2.*

Proof. The first-order conditions (5)-(7) are solved by both the values reported in the proposition leading to the surplus

$$S^* = (1-\underline{\theta})\left[\xi + \frac{\alpha(1+\underline{\theta}+\alpha)}{4\gamma} + \frac{\beta(1+\underline{\theta})}{2}\right] + \frac{(1-\underline{\theta})[5+6\underline{\theta}+5\underline{\theta}^2]}{64\gamma}, \tag{8}$$

and by the uniform solution $q_1 = q_2 = (2+2\underline{\theta}+4\alpha)/(8\gamma)$ and any $\hat{\theta} \in [\underline{\theta}, 1]$. However, this solution yields a surplus

$$S^U = (1-\underline{\theta})\left[\xi + \frac{\alpha(1+\underline{\theta}+\alpha)}{4\gamma} + \frac{\beta(1+\underline{\theta})}{2}\right] + \frac{(1-\underline{\theta})[4+8\underline{\theta}+4\underline{\theta}^2]}{64\gamma} \tag{9}$$

which is unambiguously lower than (8) because $\underline{\theta} < 1$. □

The superiority of quality differentiation originates in the variation of expected marginal returns among individuals. Ideally, every student should receive the teaching quality which equalises the expected individual marginal return and the marginal cost. Therefore, it is advantageous to exploit the opportunity of offering two different qualities rather than uniformity.[12] As higher talented students are less likely to fail, they yield higher expected returns and obtain a better quality. This holds irrespective of the strength of peer group effects. In fact, these effects cancel out in the aggregate – the gain in total productivity by one university is just offset by the loss of the other. As a consequence, peer groups matter for the surplus level, but not for optimal quality and sorting.

3 Student Grants

The traditional form of higher education financing, still applied in a number of OECD countries (Fausto, 2002), is to transfer publicly funded grants directly to

[12] In principle, efficiency could be enhanced by increasing the number of universities further. However, this gain would be reduced by an additional fixed cost of setting up a new institution. To simplify the analysis, we exclude this fixed cost from the following analysis.

universities. While details of funding regulations vary across countries, the heart of the mechanism lies in the payment of a per-student grant t and a general/research budget B to universities (Del Rey, 2001, De Fraja and Iossa, 2002). Like in García-Peñalosa and Wälde (2000), we assume that these expenditures are financed by a uniform tax T on all individuals. This formulation captures the well-reported reverse redistribution of higher education funding, high lifetime income earners (the graduates) being subsidised by the less well-off general taxpayer.

In addition to funding, a number of countries also regulates enrolment. For some programs in Germany, for example, students have to apply to a central agency which allocates candidates to universities according to a wealth of criteria. In the present setup, such a central placement system implies: $N_1 = N_1^{CP}, N_2 = N_2^{CP}$ with respective average success probabilities $\bar{\theta}_1^{CP}, \bar{\theta}_2^{CP}$.

Although the government imposes tight regulatory constraints, it is virtually unable to monitor all spending decisions perfectly. Academic life offers ample scope for discretion, like the time spent for preparing lectures, staff teaching loads or the type and number of books ordered for the library. We take account of this fact by allowing universities to decide on the level of educational quality, subject only to a non-negativity constraint: $q_i \geq 0$. As a consequence, the problem of each institution is to maximise $B + (t + \alpha q_i - \gamma q_i^2 + \beta\bar{\theta}_i)N_i$. For further reference, we call the term in brackets the per student rent r_i.

In this setup, central placement is inherently inefficient: Maximising $\pi_i^{CP} = B + (t + \alpha q_i - \gamma q_i^2 + \beta\bar{\theta}_i^{CP})N_i^{CP}$ with respect to q_i gives $q_i^{CP} = \alpha/2\gamma$. Teaching quality results only from intrinsic motivation and/or research-enhancing effects. All available resources exceeding the concomitant teaching expenditures $\alpha^2/(4\gamma)N_i^{CP}$ are redirected to research. To facilitate later comparisons, we assume that the government grant covers exactly these minimal expenditures which requires a tax $T^{CP} = \alpha^2/(4\gamma) \cdot (1 - \underline{\theta})$ on each individual. The respective surplus amounts to:[13]

$$S^{CP} = (1 - \underline{\theta}) \left[\xi + \frac{\alpha(1 + \underline{\theta} + \alpha)}{4\gamma} + \frac{\beta(1 + \underline{\theta})}{2} \right] < S^*. \tag{10}$$

[13]While this finding somehow mirrors the popular complaints about poor teaching quality in state-run university systems, it should be emphasised that universities would also divert resources from research to teaching if the latter was underfunded ($t < \alpha^2/(4\gamma)$).

The inefficiency of central placement is an outright consequence of the poor incentives for universities to attract students. This problem can be addressed by allowing students to select their preferred institution. In that case, enrolment results from comparing expected net incomes $\xi + \theta q_i - T$, yielding:

$$N_i = \begin{cases} 1 - \underline{\theta} & : \quad q_i > q_j \\ (1 - \underline{\theta})/2 & : \quad q_i = q_j \\ 0 & : \quad q_i < q_j \end{cases} . \tag{11}$$

If universities differ, all students attend the better one, and enrolment is random when both institutions are identical. In either case, the average student ability is $\bar{\theta}_i = (1 + \underline{\theta})/2$. Therefore, the combination of student grants and free enrolment choice induces university i to maximise $B + (t + \alpha q_i - \gamma q_i^2 + \beta\bar{\theta}_i)N_i$, with respect to q_i, where N_i is given by (11). This leads to reaction functions:

$$q_i(q_j) = \begin{cases} \alpha/(2\gamma) & : \quad q_j < \alpha/(2\gamma) \\ q_j + \varepsilon & : \quad \alpha/(2\gamma) \leq q_j < \hat{q}(t, (1 + \underline{\theta})/2) \\ q \leq \hat{q} & : \quad q_j = \hat{q}(t, (1 + \underline{\theta})/2) \\ q \leq q_j - \varepsilon & : \quad q_j > \hat{q}(t, (1 + \underline{\theta})/2) \end{cases} , \tag{12}$$

where:

$$\hat{q}(t, \bar{\theta}_i) = \frac{\alpha}{2\gamma} + \sqrt{\frac{\alpha^2 + 4\gamma t + 4\beta\gamma\bar{\theta}_i}{4\gamma^2}}, \tag{13}$$

denotes the quality level for which the grant t equals the net per student loss in research funds when average ability is $\bar{\theta}_i$.[14]

In economic terms, each university has an incentive to attract all students whenever the per student rent is positive. As a consequence, universities find themselves in a tight Bertrand-like competition with equilibrium teaching qualities:

$$q_1^{SC}(t) = q_2^{SC}(t) = \hat{q}(t, \frac{1 + \underline{\theta}}{2}) \tag{14}$$

depending on the level of the grant.

[14]Strictly speaking, ε in (12) is an arbitrarily small indivisible unity, say a cent, and quality is a multiple of that unit. As shown by Osborne (2004, p. 66), the best-reply correspondences of the Bertrand-type game played here are not well defined when the choice variable is continuous. The following analysis sticks to the continuous rather than a discrete formulation of the problem for the sake of expositional brevity.

Allowing students to select their institution establishes a link between university revenue and teaching performance and consequently enhances educational quality relative to central assignment. Moreover, the competition for students prevents the diversion of teaching grants for research purposes. However, optimality is not attained. Maximising (4) with respect to t under consideration of (14), gives the optimal grant with free student choice (SC): $t^{SC} = \frac{(1+\underline{\theta})^2 - 4\alpha^2 + 8\beta\gamma(1+\underline{\theta})}{16\gamma}$, which implies quality $q^{SC} = (2\alpha + 1 + \underline{\theta})/(4\gamma)$. The resulting surplus:

$$S^{SC} = S^{CP} + \frac{(1-\underline{\theta})[4 + 8\underline{\theta} + 4\underline{\theta}^2]}{64\gamma}, \tag{15}$$

equals (9) and is therefore lower than S^*. This inefficiency is rooted in the tight competition inducing both universities to offer equal teaching qualities. This precludes both efficient differentiation and student sorting.

4 Tuition Fees

In a sense, the efficiency problems of the latter mechanism originate now in the incentives of students: in the absence of financial involvement, quality but not cost matters for enrolment. Tuition fees are an obvious corrective.

The recent discussion about university funding reform centers around three reform proposals (see, e.g. García-Peñalosa and Wälde (2000)): the pure loan scheme, the graduate tax and income contingent loans. While all alternatives share the provision of a governmental loan covering the fee f_i, they differ significantly in terms of repayment facilities. A pure loan scheme regime requires students to pay back their loan irrespective of educational success. In the present model, this implies the lifetime income: $\xi + \theta q_i - f_i$. The graduate tax scheme, in contrast, subsidises some fraction ρ of the fee, which is financed by a tax T^{GT} on the successful students only. Expected student income is thus: $\xi + \theta(q_i - T^{GT}) - (1-\rho)f_i$. Thence, the pure loan scheme is equivalent to a graduate tax with a zero subsidy. Finally, income contingent loans exempt unsuccessful students from fee repayment and cover the resulting deficit by a general tax. Under this alternative, expected income is: $\xi + \theta(q_i - f_i) - T^{IC}$.

Like García-Peñalosa and Wälde (2000), we consider a fundamental funding reform where fees cover the entire higher education budget. Hence, the fiscal status of the system need not improve relative to the status quo.[15] This is mostly for simplicity. As can be seen below, the existence of additional grant elements has no effect on student decisions.

For uniform fees ($f_1 = f_2$), all three regimes have identical implications for teaching quality. This holds because students continue to enrol according to (11): with equal effective attendance cost across universities, decisions depend only on teaching quality. Consequently, uniform tuition fees replicate the equilibrium under free students' choice and a grant equal to the fee level, and therefore do not produce any efficiency gain over grants. In particular, they fail to generate the required diversity. Hence, any superiority of tuition fees over student grants must originate in the possibility to differentiate prices.[16]

With non-uniform fees, enrolment choices become dependant on repayment facilities. Under the pure loan scheme, $\tilde{\theta}^{PL}$, the student type indifferent between attending university 1 and 2 is characterised by $\xi + \tilde{\theta}^{PL} q_1 - f_1 = \xi + \tilde{\theta}^{PL} q_2 - f_2$ and hence:

$$\tilde{\theta}^{PL} = \min\left[\max\left[\frac{f_1 - f_2}{q_1 - q_2}, 0\right], 1\right]. \tag{16}$$

All students with a higher success probability attend university 1: $N_1^{PL} = 1 - \tilde{\theta}^{PL}$ whereas the less able go to university 2: $N_2^{PL} = \tilde{\theta}^{PL} - \underline{\theta}$. Average abilities are $\bar{\theta}_1^{PL} = (1 + \tilde{\theta}^{PL})/2, \bar{\theta}_2^{PL} = (\tilde{\theta}^{PL} + \underline{\theta})/2$.

A similar pattern emerges for the graduate tax:

$$\tilde{\theta}^{GT} = \min\left[\max\left[\frac{(1-\rho)(f_1 - f_2)}{q_1 - q_2}, 0\right], 1\right], \tag{17}$$

whereas under income contingent loans, students focus on the earnings-fee differential in case of success, which is the same for all types:

$$N_i^{IC} = \begin{cases} 1 - \underline{\theta} & : \quad q_i > q_j - f_j + f_i \\ (1 - \underline{\theta})/2 & : \quad q_i = q_j - f_j + f_i \\ 0 & : \quad q_i < q_j - f_j + f_i \end{cases}. \tag{18}$$

[15] Sometimes, the definition of the above alternatives is linked to their revenue effects, see, e.g., Department of Education and Skills (2004a).

[16] Using differentiated instead of uniform grants would not be helpful because student decisions would still be governed by quality concerns only.

Proposition 2. *With centrally administered tuition fees, neither pure nor income contingent loans implement the efficient solution. However, efficiency can be achieved by a graduate tax for a proper choice of the subsidy rate and differentiated fee levels.*

We relegate the somewhat cumbersome proof to the Appendix and focus here on the economic forces behind the result. Income contingent loans fail due to the lack of student sorting because enrolment decisions do not depend on ability. The inefficiency of pure loans originates in the dual task of tuition fees: on the one hand, they must ensure optimal teaching by rewarding universities with the marginal social benefit of quality enhancements. On the other hand, they have to achieve efficient student sorting by equalising absolute private benefits across universities for the correct cut-off ability. The latter task is not concomitant to the other two, which renders a proper control of all three variables q_1, q_2 and $\tilde{\theta}$ by just two instruments f_1 and f_2 impossible.[17] However, the graduate tax disposes of an additional instrument, the subsidy rate. Influencing student enrolment without affecting university behaviour, it can be adjusted to replicate the efficient solution.[18]

5 University Autonomy

We now explore whether the optimal solution can be decentralised by giving universities the right to set tuition fee levels. Our motivation for this analysis is twofold. On the one hand, the above optimality result hinges crucially on the existence of a benevolent government or regulator, which is clearly a disputable assumption. On the other hand, it is useful to assess the consequences of the observed policy trend towards equipping universities with more autonomy, including fees.[19]

In order to capture all strategic interactions, universities are assumed to anticipate how quality choices affect fee setting incentives. Therefore, we consider a three

[17]Note that this problem cannot be resolved by simply assigning students to universities, as this would destroy universities' teaching incentives.

[18]In the two university case considered here, a uniform subsidy restores efficiency. For a higher number of universities, efficient differentiation is likely to require a non-linear subsidy scheme.

[19]See, e.g., Department of Education and Skills (2004b) for the UK, German Rectors' Conference (2005) for Germany and European Commission (2004) for the Netherlands. Italian universities enjoy some fee autonomy since 1993 (European Commission, 2004).

stage game: at stage 1, universities announce their teaching qualities. Then, at stage 2, they set the respective tuition fees. Finally, students decide on attendance at stage 3. Due to the complexity of the analysis, we derive the equilibria under either proposal successively.

5.1 Pure Loans

Under the pure loan scheme, students enrol according to (16) at stage 3. Anticipating this, universities choose tuition fees at stage 2 in order to maximise: $\alpha q_i N_i + B + (f_i + \beta\bar{\theta}_i^{PL} - \gamma q_i^2)N_i$. This leads to the following first-order condition of institution i:

$$\frac{\partial \pi_i}{\partial f_i} = N_i^{PL} + (\alpha q_i + f_i + \beta\bar{\theta}_i^{PL} - \gamma q_i^2)\frac{\partial N_i^{PL}}{\partial f_i} + \beta\frac{\partial\bar{\theta}_i^{PL}}{\partial f_i}N_i^{PL} = 0. \tag{19}$$

The decision on the fee level is determined by trading off three effects. First, increasing f_i generates a higher payment from all enrolled students (N_i^{PL}). Second, some students switch over to the competitor ($\frac{\partial N_i^{PL}}{\partial f_i} = -1/(q_1 - q_2) < 0$). This loss is the higher, the less teaching qualities differ and the higher the peer group effect (β and $\frac{\partial N_i^{PL}}{\partial f_i}$ interact multiplicatively). Third, the change in average student quality decreases the quality cost for university 1, but increases it for university 2.

Solving (19) for f_i as a function of qualities and the marginal student type yields:[20]

$$f_i = \gamma q_i^2 - \alpha q_i + N_i^{PL}(q_1 - q_2) - \beta\tilde{\theta}^{PL}. \tag{20}$$

For given qualities, the peer group effect impinges on the tuition fees of both institutions in a qualitatively identical way ($\frac{\partial f_1}{\partial \beta} = \frac{\partial f_2}{\partial \beta} < 0$). For university 2, a stronger peer group effect accentuates the decrease of both enrolment and average ability. For university 1, however, there are two countervailing effects, a cost reduction from a better student composition and a lower number of students on whom the cost can be saved. The latter effect dominates.

Inserting the resulting fee differential:

$$f_1 - f_2 = (q_1 - q_2)\left[1 + \alpha - 2\tilde{\theta}^{PL} - \underline{\theta} + \gamma(q_1 + q_2)\right] \tag{21}$$

[20] Here we have made use of the fact that for both universities:

$$\bar{\theta}_i^{PL}\frac{\partial N_i^{PL}}{\partial f_i} + \frac{\partial\bar{\theta}_i^{PL}}{\partial f_i}N_i^{PL} = -\tilde{\theta}^{PL}\frac{\partial\tilde{\theta}^{PL}}{\partial f_i} = -\frac{\tilde{\theta}^{PL}}{q_1 - q_2}.$$

into (16) gives the indifferent student:

$$\tilde{\theta}^{PL}(q_1, q_2) = \frac{1 - \underline{\theta} + \alpha + \gamma(q_1 + q_2)}{3}. \tag{22}$$

Enrolment at university 1 decreases not only in the quality provided by university 2, but also in the own quality. This holds because an increase of q_1 implies a disproportionate rise of the fee due to the strict convexity of direct quality cost. Hence, the fee differential widens and some students move to university 2.

Inserting (22) into (20) leads to the equilibrium fees:

$$\begin{aligned} f_i(q_i, q_j) \quad = \quad & \frac{(2 - \underline{\theta})(q_i - q_j) - \beta\gamma(q_i + q_j) - \alpha(2q_i + q_j) + \gamma(2q_i^2 + q_j^2)}{3} \\ & - \frac{\beta(1 - \underline{\theta} + \alpha)}{3}, \end{aligned} \tag{23}$$

and per student rents $f_i + \alpha q_i - \gamma q_i^2 + \beta\bar{\theta}_i$:

$$\left[r_1^{PL}(q_1, q_2), r_2^{PL}(q_1, q_2)\right] = \left[2(q_1 - q_2) + \beta, 2(q_1 - q_2) - \beta\right]. \tag{24}$$

A stronger peer group effect increases the rent for university 1, but decreases it for university 2. Moreover, the rents for both universities rise in the quality differential, because students become less responsive to fee increases.

At stage 1, universities set qualities, taking the implications for enrolment and research rents into account. However, (24) shows that these effects have opposite signs for both institutions. According to the first-order conditions, improving quality at university 1 reduces attendance but increases the per capita rent, whereas a higher quality at university 2 attracts more students, but decreases the per capita rent:

$$\frac{\partial \pi_1}{\partial q_1} = (2 - \underline{\theta} + \alpha - \gamma(q_1 + q_2)) - 2(\beta + \gamma(q_1 - q_2)) = 0, \tag{25}$$

$$\frac{\partial \pi_2}{\partial q_2} = (1 - 2\underline{\theta} - \alpha + \gamma(q_1 + q_2)) + 2(\gamma(q_1 - q_2) - \beta) = 0. \tag{26}$$

Proposition 3. *With autonomous universities, the pure loan scheme implies a differentiation of equilibrium teaching qualities and tuition fees. However, the aggregate social surplus is suboptimal: university 2 underprovides quality, whereas the quality of university 1 can be either inefficiently high or low. Moreover, enrolment at university 1 is excessive.*

Proof. From (20), (22), (25) and (26):

$$\begin{aligned}
[q_1^{PL}, q_2^{PL}] &= \left[\frac{5-\underline{\theta}+4(\alpha-\beta\gamma)}{8\gamma} \;,\; \frac{5\underline{\theta}-1+4(\alpha-\beta\gamma)}{8\gamma}\right] \\
\left[f_1^{PL}, f_2^{PL}\right] &= \left[\frac{49+25(\underline{\theta})^2}{64\gamma}+F^{PL}, \frac{25+49(\underline{\theta})^2}{64\gamma}+F^{PL}\right], \\
\left[N_1^{PL}, N_2^{PL}\right] &= \left[\frac{1-\underline{\theta}}{2}+\frac{\beta\gamma}{3} \;,\; \frac{1-\underline{\theta}}{2}-\frac{\beta\gamma}{3}\right].
\end{aligned}$$

with $F^{PL} = (16\alpha^2 - 58\underline{\theta})/(64\gamma) - \beta(168 + 120\underline{\theta} - 112\beta\gamma)/192$. Comparing these values with the efficient solution reveals immediately $q_2^{PL} < q_2^*$, but $q_1^{PL} \gtreqless q_1^* \iff \beta \lesseqgtr (1-\underline{\theta})/(2\gamma)$. Moreover, $N_1^{PL} > N_1^*$ for $\beta > 0$. The total surplus of the pure loan scheme under university autonomy amounts to:

$$S^{PL} = S^{CP} + \frac{(1-\underline{\theta})[1+14\underline{\theta}+\underline{\theta}^2]}{64\gamma} - \frac{\beta^2\gamma(1-\underline{\theta})}{24}. \square$$

This equilibrium has a familiar interpretation in terms of the maximum differentiation principle known from the vertical product differentiation literature (Shaked and Sutton, 1982): The more equal the qualities, the fiercer the fee competition. In the limit, if both institutions offered the same quality, only the cheaper one would attract students and rents would be zero. In order to avoid this, universities differentiate and obtain a per student rent to be diverted towards research.[21]

While peer group effects do not affect these general incentives, they lead to two additional findings. First, a higher β reduces equilibrium qualities, but leaves the absolute quality differential unaffected. This is due to the uniform negative impact of β on both tuition fees for any quality combination, see (20). Hence, peer group effects aggravate the inefficiency of the low quality institution and impinge on the quality incentives for university 1, such that pervasive underprovision can result.[22] This stands in some contrast to the usual findings of the vertical differentiation literature. Second, peer group effects encourage enrolment at university 1, which is caused by the strict convexity of the direct quality cost function. Hence, the uniform reduction of both qualities by the same amount caused by increasing β brings about higher cost savings and hence a higher fee reduction at university 1

[21] Some support for this result is provided by Hoxby (1997) who finds that competition among American universities has increased both product differentiation and tuition fees.

[22] Depending on the parameter constellation, quality at university 1 can even be lower than the optimal quality for low ability students: $q_1^{PL} \gtreqless q_2^* \iff \beta \lesseqgtr (1-\underline{\theta})/\gamma$.

than at university 2. As a consequence, the fee differential narrows and the ability of the marginal student decreases.

Comparing pure loans with alternative financing schemes, we find:

Proposition 4. *The pure loan scheme with university autonomy leads to a higher social surplus than central placement. However, central placement may make some or even all students may be better off.*

Proof. See Appendix.

This result highlights that the efficiency gains arising from the implementation of the pure loan scheme are very unequally distributed. In particular, students of minor ability face a higher financing burden, but only a weak improvement or even a deterioration in quality:[23] When student heterogeneity is high, differentiation becomes so intense that university 2 would offer a higher quality under central assignment:

$$q_2^{PL} < q^{CP} \quad \Longleftrightarrow \quad \underline{\theta} < \frac{1}{5} + \frac{4}{5}(\alpha - \beta\gamma). \tag{27}$$

Proposition 5. *Optimally administered uniform grants t^{SC} make universities worse and students as a whole better off than pure loans under university autonomy. Moreover, the surplus under pure loans is lower.*

Proof. The surplus differential amounts to $S^{PL} - S^{SC} = -\beta^2\gamma(1-\underline{\theta})/24 - 3(1-\underline{\theta}^2)/(64\gamma) < 0$. Universities enjoy no rents under uniform fees, so they must be better off under pure loans. However, the total surplus is lower, which implies that students as a whole must be worse off. □

In the present setting, the effect of relaxing fee competition by means of quality differentiation is so strong that students as a whole would not profit from substituting properly administered grants for pure loans with fully autonomous universities.

[23] It is easy to establish that the utility decrease of low ability students is not driven by the removal of reverse redistribution. For $\alpha = 0$, central placement grants and hence the tax are zero. Nevertheless, a significant number of students can be worse off under pure loans.

5.2 Graduate Tax

As argued above, the graduate tax proposal differs from pure loans because of the fee subsidy. The formal analysis run analogous to the one of the last subsection, (17) replacing (22). Stage-2 equilibrium fees are:

$$f_i^{GT}(q_i,q_j) = \frac{(2-\underline{\theta})(q_i-q_j)/(1-\rho)+\beta\gamma(1-\rho)(q_i+q_j)-\alpha(2q_i+q_j)}{3} \frac{+\gamma(2q_i^2+q_j^2)-\beta(1+\underline{\theta}-(1-\rho)\alpha)}{3},$$

the indifferent type is: $\tilde{\theta}^{GT}(q_1,q_2)=(1-(1-\rho)\alpha+\underline{\theta}+(1-\rho)\gamma(q_1+q_2))/3$ and per student rents become:

$$\left[r_1^{GT}(q_1,q_2), r_2^{GT}(q_1,q_2)\right] = \left[2(q_1-q_2)+(1-\rho)\beta, 2(q_1-q_2)-(1-\rho)\beta\right]. \quad (28)$$

This leads to the stage 1 equilibrium:

$$[q_1^{GT}, q_2^{GT}] = \left[\frac{5-\underline{\theta}+4(\alpha-(1-\rho)^2\beta\gamma)}{8\gamma(1-\rho)}, \frac{5\underline{\theta}-1+4(\alpha-(1-\rho)^2\beta\gamma)}{8\gamma(1-\rho)}\right]$$

$$\left[N_1^{GT}, N_2^{GT}\right] = \left[\frac{1+\underline{\theta}}{2}+\frac{\beta\gamma(1-\rho)^2}{3}, \frac{1+\underline{\theta}}{2}-\frac{\beta\gamma(1-\rho)^2}{3}\right],$$

generating the total surplus:

$$S^{GT} = S^{CP}+\frac{(1-\underline{\theta})[1+14\underline{\theta}+\underline{\theta}^2-\rho(14+4\underline{\theta}-14\underline{\theta}^2)]}{64\gamma(1-\rho)^2} -\frac{\beta(1-\underline{\theta})((1-\rho)^3\gamma-3\rho(1+\underline{\theta}))}{24}. \quad (29)$$

Proposition 6. *With university autonomy, equilibrium qualities, tuition fees and the quality differential are increasing in the subsidy rate of the graduate tax. Thus, the graduate tax leads to higher teaching qualities than pure loans. However, the surplus under any graduate tax is lower than under pure loans.*

Proof. The effects on equilibrium qualities and fees follow immediately from differentiating the above expressions. The quality differential $q_1^{GT}-q_2^{GT}=(1-\underline{\theta})/(2\gamma(1-\rho))$ increases unambiguously in ρ. The superiority of the pure loan scheme results as follows. Differentiation of (29) with respect to ρ and evaluating for $\rho=0$ gives:

$$\left.\frac{\partial S^{GT}}{\partial\rho}\right|_{\rho=0} = -\frac{(1-\underline{\theta})[18(1+\underline{\theta})^2-\beta\gamma(28\beta\gamma+12(1+\underline{\theta}))]}{96\gamma}<0. \quad (30)$$

Hence, a marginal subsidy reduces the surplus. Although S^{GT} need not be concave in ρ, it can be shown that $\frac{\partial S^{GT2}}{\partial \rho^2}$ changes its sign at most once. As $\lim_{\rho \to 1} S^{GT} = -\infty$, $S^{GT} < S^{PL}$ for all $\rho \in (0, 1]$. $\square$

The fee subsidy exempts students from some cost of their enrolment decision, which implies the following effects. On the one hand, university 1 attracts more students for given qualities and fees ($\frac{\partial \tilde{\theta}^{GT}}{\partial \rho} < 0$). This induces university 2 to improve its quality. On the other hand, students become less responsive to fee increases ($\frac{\partial (\tilde{\theta}^{GT})^2}{\partial f_i \partial \rho} > 0$). Therefore, a given quality differential allows both universities to charge higher fees which boosts the incentives for quality differentiation. Consequently, university 1 increases quality by more than university 2. However, the concomitant fee increase is so strong that enrolment at university 1 declines ($\frac{\partial N_1^{GT}}{\partial \rho} < 0$).

Moreover, increasing the subsidy has complex implications for the social surplus. First, all students who choose university 2 anyway ($\theta < \theta^{GT}$) receive a higher quality. This improves welfare by mitigating quality underprovision for these types. Second, the rise of q_1 increases or decreases the surplus from all students with $\theta \geq \tilde{\theta}^*$, depending on whether over- or underprovision prevails. Third, more resources are spent on inefficiently poor talented university 1 students ($\theta \in [\tilde{\theta}^{GT}, \tilde{\theta}^*)$). While this deteriorates welfare if $q_1^{GT} > q_2^*$, it is beneficial when $q_1^{GT} < q_2^*$. However, in that case another inefficiency arises because the students switching from university 1 to university 2 get less quality. In the present setup, the negative effects dominate so the graduate tax gives inferior results to a pure loan scheme.

Figure 1 illustrates the welfare effects of substituting a graduate tax for pure loans when peer group effects are small such that $q_1^{PL} > q_1^*$. Vertically shaded areas indicate welfare gains, whereas losses arise in the horizontally shaded areas. For this constellation, the quality improvement for those students choosing university 2 in the presence of a graduate tax is beneficial, but the surplus generated by all students who attend university 1 falls.

[Insert Figure 1 about here]

5.3 Income Contingent Loans

Recently, a number of countries, including Australia and the UK, have introduced elements of income contingent loans into higher education funding (Chapman, 1997, Greenaway and Haynes, 2003). In contrast to the above proposals, this option leaves the general taxpayer involved as the deficit resulting from failing students is financed by a uniform tax T^{IC}.

Faced with the two quality/fee offers at stage 3, students choose universities according to (18). Compared to the other schemes, competition intensifies because the university offering the smaller quality-fee differential loses all students. Tuition fee reaction functions at stage 2 are:

$$f_i(f_j) = \begin{cases} q_i - (q_j - f_j) - \varepsilon & : \quad f_j > q_j - (1+\alpha)q_i + \gamma q_i^2 - \beta(1+\underline{\theta})/2 \\ \{f : f \geq q_j - q_i + f_j\} & : \quad f_j \leq q_j - (1+\alpha)q_i + \gamma q_i^2 - \beta(1+\underline{\theta})/2 \end{cases} \tag{31}$$

Whenever the per student rent is positive, each university has an incentive to set the fee to surpass the competitor's quality-fee differential.[24] Otherwise, any fee that attracts no students at all is a best response. As a consequence, these reaction function render the number of stage 2 equilibria infinite.

We dissolve this indeterminacy by assuming that the university with the lower quality-fee differential sets a fee of at least $\gamma q_i^2 - \alpha q_i - \beta(1+\underline{\theta})/2$. This can be justified by a kind of trembling-hand argument: if some student enrolled erroneously at an university charging a fee below that threshold, it would suffer from a negative rent. With this refinement, the stage 2 equilibrium becomes unique:

$$f_i(q_i, q_j) = \begin{cases} q_i + (1-\alpha-\gamma q_j)q_j - \beta\frac{1+\underline{\theta}}{2} - \varepsilon : (1+\alpha)(q_i - q_j) < \gamma(q_i^2 - q_j^2) \\ \gamma q_i^2 - \alpha q_i - \beta\frac{1+\underline{\theta}}{2} \quad : (1+\alpha)(q_i - q_j) \geq \gamma(q_i^2 - q_j^2) \end{cases}, \tag{32}$$

According to (32), income contingent loans allow the university with the higher quality-fee differential to extract (almost) the whole surplus students enjoy from

[24] The domain of this part of the reaction function results from the compatibility of the respective fee with the positivity constraint on the per student rent: $f_i + \alpha q_i - \gamma q_i^2 + \beta(1+\underline{\theta})/2$.

selecting that institution instead of the other.[25] Using (32) allows the formulation of the stage 1 university target functions:

$$\pi_i(q_i, q_j) = \begin{cases} (1+\alpha)q_i - \gamma q_i^2 - (q_j - \gamma q_j^2) - \varepsilon & : \quad (1+\alpha)(q_i - q_j) > \gamma(q_i^2 - q_j^2) \\ 0 & : \quad (1+\alpha)(q_i - q_j) \leq \gamma(q_i^2 - q_j^2) \end{cases} \tag{33}$$

Maximising the upper entry of this expression yields $q_i = (1+\alpha)/(2\gamma)$, the quality which equalises the marginal cost and the marginal surplus extracted from students. However, as the respective fee must be low enough to attract students, the per student rent is non-negative only if the other university sets a quality of at most $\bar{q} = \frac{1+\alpha}{2\gamma} - \sqrt{\frac{\varepsilon}{\gamma}}$, where $\bar{q}$ results from $\pi_i(\dfrac{1+\alpha}{2\gamma}, \bar{q}) = 0$. For a higher quality of the rival j, university i is indifferent between attracting one half of the students and spending all fees on teaching, or attracting no students at all by setting $q_i < q_j$. Hence, stage 1 reaction functions are:

$$q_i(q_j) = \begin{cases} \dfrac{1+\alpha}{2\gamma} & : \quad q_j \leq \bar{q} \\ q \in [0, q_j] & : \quad q_j > \bar{q} \end{cases} . \tag{34}$$

As a consequence, any symmetric solution with $q > \bar{q}$ is an equilibrium. However, since ε is very small, $q^{IC} = (1+\alpha)/(2\gamma)$ is a good approximation for the lower bound of teaching qualities under income contingent loans.

Proposition 7. *Under income contingent loans and university autonomy, both universities offer inefficiently high teaching qualities. No fee revenues are diverted towards research.*

Income contingent loans reward the university offering the higher quality-fee differential with the aggregate tuition revenue. This creates another Bertrand-like situation with uniform equilibrium qualities and no diversion. However, the tuition revenue received by universities is too high from a social perspective because it encompasses the taxpayers' compensation for failing students. Hence, universities do not take the true social cost of quality improvement into account.[26]

[25] In algebraic terms, university i attracts all students when it has a lower minimum fee: $\gamma q_i^2 - \alpha q_i - \beta(1+\underline{\theta})/2 < \gamma q_j^2 - \alpha q_j - \beta(1+\underline{\theta})/2$. This is equivalent to $(1+\alpha-\gamma q_i)q_i < (1+\alpha-\gamma q_j)q_j$ which can be rearranged as $(1+\alpha)(q_i - q_j) < \gamma(q_i^2 - q_j^2)$.

[26] In the light of this inefficiency, it would be interesting to investigate to what extent the performance of income contingent loans could be improved by assigning the losses arising from student failure to the respective university.

The comparison of income contingent loans for $q^{IC} = \frac{(1+\alpha)}{2\gamma}$ with other reform options gives:

Proposition 8. *Income contingent loans with autonomous universities implicate a lower total surplus than optimal uniform grants. Moreover, the surplus is lower than with pure loans unless peer group effects are sufficiently high.*

Proof. Follows from: $S^{IC} - S^{SC} = -(1 - \underline{\theta}^2)/(16\gamma) < 0$ and $S^{IC} - S^{PL} = \beta^2\gamma(1-\underline{\theta})/24 - (1-\underline{\theta}^2)/64\gamma$, which is positive if and only if $\beta > \sqrt{3/8}\cdot(1-\underline{\theta})/\gamma$.□

The inferiority of income contingent loans relative to uniform grants originates in the massive overinvestment in low ability students: $q^{IC} > q^{FC} > q_2^*$. An equal argument applies to the comparison with pure loans: $q^{IC} > q_2^{PL}$, whereas $q^{IC} \gtrless q_1^{PL} \iff 4\beta\gamma \gtrless 1 - \underline{\theta}$. However, as pure loan qualities decrease in β, income contingent loans bring about higher welfare when the peer group effect is sufficiently strong.

6 Conclusion

This paper has investigated how the reform of higher education funding can affect university competition and hence the quality of tertiary education. Since it argues that optimality can be achieved by a properly administered graduate tax and that university autonomy leads to either too high or too diverse qualities, the analysis makes a general case for some government involvement in the fee setting process. However, this recommendation is subject to the well-known caveat that state authorities pursue socially optimal policies. Otherwise, full or restricted autonomy by imposing fee ceilings like in the UK might yield a better solution.

As it stands, this simple analysis has neglected a number of interesting aspects. First, we have taken the admission standard as exogenous and equal in all settings which deprives the government of an instrument to make up for some problems of university choices. However, allowing for standard adjustments would not affect our surplus results: Since these findings obtain for arbitrary standards, they continue to hold when schemes are evaluated at the respective optimal admission levels. Second, we have focussed on educational funding, identifying university autonomy as the right to set tuition fees. Much of the existing literature on higher education competition stresses admission standard aspects instead (Epple et al., 2003, De Fraja and Iossa, 2002). In our model, admission is controlled only indirectly by the fee policy.

Space restrictions preclude an integrated analysis of both admission and fee autonomy. However, useful insights can be gained by the analysis in Eisenkopf (2004) which suggests that admission autonomy reinforces the incentives for differentiation. One may therefore conjecture that providing universities with an additional tool to exert market power would not be beneficial for efficiency.[27]

Third, we have considered success probabilities as exogenous. Alternatively, one can argue that the risk of failure rises with the complicacy of the study (Eisenkopf, 2004) and/or is influenced by the average ability in class. Meier (2004) has shown that the latter interrelation makes the welfare comparison between differentiation and uniformity ambiguous. This would affect, but not vitiate our Proposition 1. In particular, when differentiation remains optimal in such an extended framework, our findings remain valid, because the superiority of the graduate tax in terms of the number of instruments and the distortion of incentives under fee autonomy still apply. If uniformity was optimal instead, the surplus would be maximised by respective uniform fees or grants combined with free enrolment choice. Nevertheless, university autonomy would still be undesirable.

Another interesting extension would be to allow students to care for both teaching and research, the latter indicating the reputation of the university. In a respective model, Warning (2006) finds that universities differentiate maximally in one attribute and are homogenous in the other even with student grants. Whether differentiation occurs with respect to teaching or research, depends on the diversity of quality intervals. However, the concept of strategic groups advanced by Warning (2006) is likely to lead to low teaching differentiation when grants (or fees) are uniform. This is in line with the findings of this paper. The analysis of welfare issues or the effects of the various fee proposals considered here along these lines - not conducted by Warning (2006) - are promising topics for further research.

Despite these limitations, it is informative to relate our results to the existing literature. In a setting where individuals differ in financial wealth, García-Peñalosa and Wälde (2000) find the pure loan scheme to be dominated by the other options, with a tendency of the graduate tax to outperform income contingent loans. Focussing on ability differences, Del Rey and Racionero (2006) conclude that both pure loans and graduate taxes lead to efficient total enrolment when individuals are risk neu-

[27] Some support for this claim is provided by Epple and Romano (1998) where schools price discriminate according to ability and efficiency results only from free market entry and exit.

tral. However, both models studies endogenous total attendance at institutions with fixed quality, whereas our contribution has variable quality but an exogenous overall number of students. Interestingly, the efficiency ranking of the alternatives need not be affected by this structural modelling difference: In our setting, a properly designed graduate tax is optimal as well. This suggests that the graduate tax is an adequate tool to control both teaching quality competition as well as student access.

Ideally, this statement should be validated in a fully fledged model of educational reform with variable quality and total attendance. Due to space restrictions, we briefly report on the ramifications of such an extended setup.

With variable enrolment, the central assignment equilibrium would depart from optimality in two respects. On the one hand, the lacking price signal for students would induce too many students - that is, students with inefficiently low ability - to study, on the other hand, the poor teaching quality would discourage from going to university. Therefore, the total number of students under central assignment could either exceed or fall short of optimal enrolment. However, the competition created from allowing students to select among institutions would improve quality and the total number of students. Hence, the inefficiency problem of public higher education could even be aggravated by such a measure.

Tuition fees drive a wedge between the income from going to university or not and can therefore address this inefficiency. In particular, the above equivalence between grants and fees would be broken. As shown by Del Rey and Racionero (2006), both pure loans and the graduate tax give efficient signals to prospective students. This suggests that an extended version of the graduate tax can achieve optimality, with the fee for the low quality university not only setting proper incentives for quality provision, but also for enrolment. As these two tasks are likely to conflict, the amount university 2 should receive may differ from the amount its students should pay. This makes an additional argument for government intervention and optimality of university autonomy less likely.

The analysis of university autonomy with endogenous total enrolment has strong similarities to the vertical product differentiation literature with variable total demand. Unfortunately, this type of model features serious problems of tractability. In a setup with endogenous total demand and costless quality, Wauthy (1996) has shown that the exogenous total demand equilibrium results when the heterogeneity of customers is low. Otherwise, only a part of the market is covered and the low quality firm chooses a higher quality than in the fully covered case.

In our context, this implies that the results still hold for endogenous total attendance, provided that the admission standard is sufficiently strict and teaching is not too costly. When these conditions are not met, the quality differences between universities is likely to be lower than reported above. Intuitively, the incentives for university 2 to lower its quality are mitigated as this makes not going to university more attractive. Nevertheless, differentiation is still excessive.[28] Therefore, fee autonomy is unlikely to maximize the higher education surplus also in this richer setting.

[28]The optimal solution in Wauthy (1996) would be both firms supplying the highest possible quality.

Appendix

Proof of Proposition 2. We concentrate on differentiated fees $f_1 > f_2$ straightaway because the impossibility of achieving efficiency by uniform fees has been established in the main text.

For both pure loans and the graduate tax, the quality response functions for each university are given implicitly by the first-order conditions:

$$(\alpha - 2\gamma q_i + \beta \frac{\partial \bar{\theta}_i}{\partial q_i}) N_i + (f_i + \alpha q_i - \gamma q_i^2 + \beta \bar{\theta}_i) \frac{\partial N_i}{\partial q_i} = 0, \tag{35}$$

where both N_i and $\bar{\theta}_i$ are dependent on the financing scheme. Combining these expressions with (5) and (6) yields the tuition fees required for universities to choose efficient qualities:

$$\begin{aligned} f_1^* &= \frac{1 - \theta^{*2}}{2\theta^*}(q_1^* - q_2^*) - \alpha q_1^* + \gamma q_1^{*2} - \frac{\beta(1 + \theta^*)}{2} \\ f_2^* &= \frac{\theta^{*2} - \underline{\theta}^2}{2\theta^*}(q_1^* - q_2^*) - \alpha q_2^* + \gamma q_2^{*2} - \frac{\beta(\theta^* + \underline{\theta})}{2}. \end{aligned}$$

Plugging in q_1^* and q_2^* and rearranging gives:

$$\frac{f_1^* - f_2^*}{q_1^* - q_2^*} = \frac{1 + \underline{\theta}}{2} + \frac{1 + \underline{\theta}^2}{1 + \underline{\theta}} - 2\beta\gamma. \tag{36}$$

Under pure loans, this would lead to optimality ($\tilde{\theta}^{PL} = (f_1^* - f_2^*)/(q_1^* - q_2^*) = (1 + \underline{\theta})/2$) only if $\beta\gamma = \frac{1+\underline{\theta}^2}{2(1+\underline{\theta})}$ which violates the assumption on β. However, even if β assumed that value, efficiency would result by chance and not because of the structural features of the pure loan scheme.

However, the graduate tax achieves optimality when $\tilde{\theta}^{GT} = (1 - \rho)(f_1^* - f_2^*)/(q_1^* - q_2^*) = (1 + \underline{\theta})/2$. This condition can be fulfilled by choosing the subsidy rate

$$\rho^* = \frac{1 + \underline{\theta}^2 - 2\beta\gamma(1 + \underline{\theta})}{(1 + \underline{\theta})^2 + 1 + \underline{\theta}^2 - 2\beta\gamma(1 + \underline{\theta})}, \tag{37}$$

which is positive, but less than unity. Thus, the superiority of the graduate tax relative to pure loans grounds in the availability of an additional instrument to influence enrolment decisions without compromising quality choices.

With income contingent loans, universities' rents are:

$$\pi_i = \begin{cases} B + (f_i + \alpha q_i - \gamma q_i^2 + \beta \bar{\theta}_i)(1 - \underline{\theta}) & : \quad q_i > q_j + (f_i - f_j) \\ B + (f_i + \alpha q_i - \gamma q_i^2 + \beta \bar{\theta}_i)(1 - \underline{\theta})/2 & : \quad q_i = q_j + (f_i - f_j) \\ B & : \quad q_i < q_j + (f_i - f_j) \end{cases}, \tag{38}$$

leading to the quality reaction functions:

$$q_i(q_j) = \begin{cases} \alpha/(2\gamma) & : \; q_j < \alpha/(2\gamma) - (f_i - f_j) \\ q_j - (f_i - f_j) + \varepsilon & : \; \alpha/(2\gamma) - (f_i - f_j) \leq q_j < \hat{q}(f_i, \bar{\theta}_i) - (f_i - f_j) \\ q \leq \hat{q}(f_i, \bar{\theta}_i) & : \; q_j = \hat{q}(f_i, \bar{\theta}_i) - (f_i - f_j) \\ q < q_j - (f_i - f_j) & : \; q_j > \hat{q}(f_i, \bar{\theta}_i) - (f_i - f_j) \end{cases}, \tag{39}$$

where $\hat{q}(f_i, \bar{\theta}_i)$ is given by (13), with f_i replacing the uniform grant t. Thus, whenever the rent is positive $q < \hat{q}(f_i, \bar{\theta}_i)$, each university has an incentive to provide a slightly higher quality than the competitor. Thus, whenever $\hat{q}(f_i, \bar{\theta}_i) - (f_i - f_j) > \hat{q}(f_j, \bar{\theta}_j)$, university i crowds out university j and attracts all students. This cannot be optimal because then all students get the same quality.

In any equilibrium with quality differentiation:

$$\hat{q}(f_i, \bar{\theta}_i) - (f_i - f_j) = \hat{q}(f_j, \bar{\theta}_j) \tag{40}$$

must hold. However, then all students are indifferent between both institutions. Random matching leads to $\bar{\theta}_i = \bar{\theta}_j = (1 + \underline{\theta})/2$, which violates efficient sorting.

But even if students sorted according to ability for whatever reason ($\bar{\theta}_1 = (1 + \theta^*)/2, \bar{\theta}_2 = (\theta^* + \underline{\theta})/2$), income contingent loans miss efficiency except in a single case. Efficient quality choices require $\hat{q}(f_1^*, (1+\theta^*)/2) = q_1^*$ and $\hat{q}(f_2^*, (\theta^* + \underline{\theta})/2) = q_2^*$. Solving these conditions for the required fees and subtracting yields:

$$f_1^* - f_2^* = \frac{1 - \underline{\theta}^2}{8} - \frac{\beta(1 - 2\underline{\theta})}{2}. \tag{41}$$

But from (40), this expression equals $q_1^* - q_2^*$ only if $\beta = (1 - \underline{\theta})^2/(4\gamma(2\underline{\theta} - 1))$ by coincidence. Otherwise, the efficient solution cannot be implemented as an equilibrium under income contingent loans. □

Proof of Proposition 4. The surplus comparison yields:

$$S^{PL} - S^{CP} = \frac{(1 - \underline{\theta})[1 + 14\underline{\theta} + \underline{\theta}^2]}{64\gamma} - \frac{\beta^2\gamma(1 - \underline{\theta})}{24} > 0. \tag{42}$$

The difference in individual net earnings is:

$$\theta(q_i^{PL} - \alpha/(2\gamma)) - (f_i^{PL} - \alpha^2(1 - \underline{\theta})/(4\gamma)). \tag{43}$$

from which one can derive the ability of the student who is indifferent between both schemes. Doing so is rather cumbersome and reveals no deeper insights than presenting examples where all students are worse off under pure loans. When $\alpha = \beta = 0$, (43) is negative for all students with a success probability below $(49 - 58\underline{\theta} + 25\underline{\theta}^2)/(40 - 8\underline{\theta})$. This level is lower than unity only if $\underline{\theta} < 1/5$ and exceeds $\underline{\theta}$ if and only if $\underline{\theta} < 7/11$. Thus, all students are better off under pure loans when student heterogeneity is sufficiently low. When $\alpha = 1, \beta = 0$, the threshold ability to be better off under pure loans becomes $(81 - 42\underline{\theta} + 25\underline{\theta}^2)/(72 - 8\underline{\theta}) \gtrless 1 \iff \underline{\theta} \lessgtr 0.36$. When $\alpha = 1, \beta = 1/(4\gamma)$, the critical ability becomes $(232 - 156\underline{\theta} + 51\underline{\theta}^2)/(192 - 24\underline{\theta}) \gtrless 1 \iff \underline{\theta} \lessgtr 0.3504$. This level is higher than $\underline{\theta}$, if and only if $\underline{\theta} < 0.8070$.
$\square$

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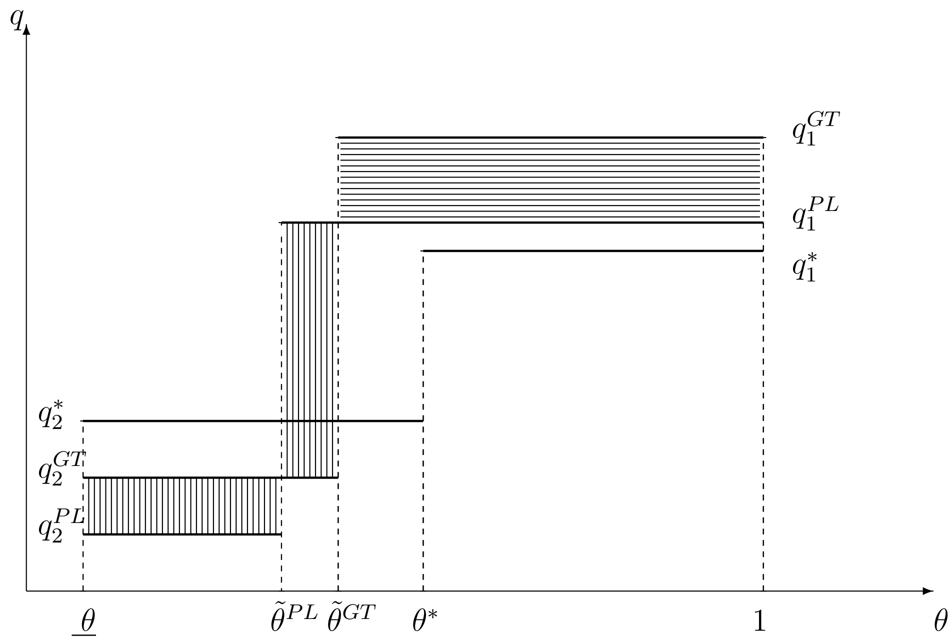

Figure 1: Pure loan and graduate tax with autonomous universities

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