

We thank both referees for their helpful and constructive comments. Below is our response to each referee's comments separately.

Response to Anonymous Referee #1

The paper contributes to the existing literature in a number of ways that have not been picked up before. In particular: (i) it provides a clear categorization of university types based on the nature of funding, in the most simple setting without introducing extra influences (e.g., competition amongst HE institutions, different type of academics with the concomitant incentive issues, etc.) that would inevitably make the analysis cumbersome and dilute the main message the paper tries to convey; (ii) it places the budget constraint faced by a (representative) university on centre-stage, unlike other contributions in the field.

Addressing your major comments:

1. *Absence of competition amongst universities.* This is a deliberate choice dictated not only by a desire to keep the modelling simple and the analysis tractable but more importantly driven by the understanding that if one can derive a sharp result in the absence of oligopolistic competition (as in the present paper) then these results would carry over in a more complicated model with HE competition, and the phenomena of 'research elite' or 'binary divide' would be accentuated but then we would not be able to point out with clarity to the fundamental determining factors, i.e. the basic financing constraints as captured by the budget constraint. Enriching the analysis in the way you suggest would certainly bring out what you mention regarding the 'research elite' etc. but it would necessitate a completely different model. The various research exercises in the UK (RAE, now called REF) do have a funding component attached to research quality but this is more related to the actual ratings obtained and although these are somehow related to the ability of attracting good researchers, this is not the full story. And, indeed there are some very few teaching positions that are used to alleviate teaching pressures from the 'star' researchers but these are far and few between and generally not allowed in the majority of universities. We have also added Grazzini et al. (2010) to the references and refer to it in the Introduction in footnote 4.

2. *Homothetic preferences* in the universities objective function: not as strong an assumption as it seems. To obtain the results you just need well-behaved preferences. *Assumption on decreasing returns to scale in research:* the crucial assumption here is that each academic has one unit of time available to her to utilise between teaching and/or research. It is in this particular sense that decreasing returns to scale relate. I would be cautious of introducing increasing returns to research as, as you correctly anticipate, this would bring in a certain degree of non-convexity and then as we all know well 'anything can happen'. Regarding the cases picked up by set B, on page 10 bottom paragraph, we explain that this 'arises when the funding for teaching is not sufficient to

cover the gap between academic salaries and the required funds for research', a not so common situation.

3. *Empirical evidence:* In relation to the student-staff ratio and equation (1) in the paper, we refer to some empirical evidence in footnote 10 (papers by Drennan and Beck (2001) and Turner (2005)).

4. *Relation between teaching and research quality:* The paper concentrates on the time allocation of research and teaching. Your suggestion to consider an alternative technical relation, other than time allocation, is an interesting one that could be explored in future research (e.g., building on Quiggin (2004)). Thanks for raising it. It is also correct what you say about PhD and Masters' courses cross-subsidising other degrees but in this paper we are not making a distinction between PG and UG offerings of universities. We take the point you make and hope to be able to explore it in detail in a sequel to this paper.

5. *Universities break-even assumption:* On page 11 there are two cases (i) a university can run a surplus and (ii) a university breaks even. The choice of (ii) is dictated by the observation that universities are operating as not-for-profit organizations, hence a good approximation is to assume that they break-even. It is not clear that having at least one university accumulating surplus would eliminate the 'research elite'. There are also efficiency reasons for why a university would break even. Have added footnote 16 about this.

Addressing your minor comments:

1. We have revised the abstract to stress the contribution of the paper.
2. The footnote regarding 'research elite' and 'binary divide' (fn 1 in the DP version) has been moved to the main text, end of first paragraph of the Introduction.
3. The relevant paragraph (next to last in DP version) is now the second paragraph in the Introduction.
4. Figure 1 has been corrected.

Response to Referee #2

The paper contributes to the existing literature in a number of ways that have not been picked up before. In particular: (i) it provides a clear categorization of university types based on the nature of funding, in the most simple setting without introducing extra influences (e.g., competition amongst HE institutions, different type of academics with the concomitant incentive issues, etc.) that would inevitably make the analysis cumbersome and dilute the main message the paper tries to convey; (ii) it places the budget constraint faced by a (representative) university on centre-stage, unlike other contributions in the field.

Addressing your major comments:

1. *Absence of competition amongst universities.* This is a deliberate choice dictated not only by a desire to keep the modelling simple and the analysis tractable but more importantly driven by the understanding that if one can

derive a sharp result in the absence of oligopolistic competition (as in the present paper) then these results would carry over in a more complicated model with HE competition, and the phenomena of 'research elite' or 'binary divide' would be accentuated but then we would not be able to point out with clarity to the fundamental determining factors, i.e. the basic financing constraints as captured by the budget constraint. Introducing competition within the present framework would necessitate a completely different model and a different paper.

2. *Homothetic preferences* in the universities objective function: not as strong an assumption as it seems. To obtain the results you just need well-behaved preferences. The main point is that of the non-convexity (kink) of the efficiency frontier: this restricts the research quality interval chosen by universities. This interval exists whether the indifference curves of universities are linear or not, and is shown in Figure 2 as relatively wide (to make the point) but could be drawn smaller. The main issue is that there are research quality values that, due to the non-convexity of the constraint set implied by the research incentivization, will not be chosen. How wide this interval of 'missing research quality' is remains a matter for empirical validation and outside the scope of the present paper. Using non-linear indifference curves would make the interval smaller but would not get rid, as it is the non-convex frontier that matters most: so yes, there will be a quantitative effect in altering the preference specification but not a qualitative one. Have added a footnote 13 and 19 about this.

3. *Diminishing returns to the time spent on research*. We refer to empirical evidence on this in footnote 11.

4. *Academics are paid a fixed salary independent of research quality*. Have added footnote 12 to acknowledge that this assumption is made technical reasons.

Addressing your minor comments:

1. We have revised the abstract.
2. Have added the reference to Johnes (2007).
3. Have corrected the typos etc. As per the figures, tried our best but there are some issues with transferring and editing Powepoint diagrams into Latex and I am still in the process of learning the PSTricks package.

References

- Drennan, L.T. and Beck, M. (2001), "Teaching quality performance indicators: key influences on the UK universities' scores", *Quality Assurance in Education*, 9(2), 92-102.
- Quiggin, J. (2004), "Research and Teaching: complements or substitutes?", *Australasian Journal of Economics of Education*, 1(1), 18-29.
- Turner, D., (2005), "Benchmarking in universities: League tables revisited", *Oxford Review of Education*, 31(3), 353-371.