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University merging process*

Marisa Hidalgo-Hidalgo and Guadalupe Valera**

Abstract

There is a recent tendency toward encouraging universities to merge. This policy is based on the idea that mergers create synergy gains that enhance universities' prestige by increasing their international visibility. However, this process may reduce competition for both research funds and professors. This paper analyzes whether or not mergers among universities are optimal from an aggregate excellence point of view. We find that the relationship between cost differentials of competing universities, the amount of research funds and universities' recruitment standard plays a key role when comparing aggregate excellence in a merging and a competition settings. In particular, we show that the higher the heterogeneity between potential merger institutions in terms of their reputation the greater the amount of funds needed to make mergers profitable.

Keywords: Higher Education, University Competition, Mergers, University Funding System.

JEL classification numbers: H52, I22, D78, I23.

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1 Introduction

Merger processes among universities are at the heart of many recent debates on higher education system reforms.[1] Although these initiatives are not new in the higher education sector, we observe currently an increasing number of merging alliances across both USA and European universities. Some examples are UniverSud Paris in France, Leiden University in The Netherlands, Stockholm University in Sweden, University of Manchester in UK, but the list is not complete (see Skodvin (1999)).[2] This growing tendency towards promoting mergers is mainly driven by increasing competition in the global higher education sector. That is, it is based on the idea that mergers create synergy gains that enhance universities' excellence and increase their visibility in *international* markets, by means of attracting better professors and more research resources.[3] However, mergers also impact *national* higher education markets. First, even though they indeed reduce costs and create synergy gains, mergers also reduce the degree of competition for resources and professors which, in turn, affects excellence negatively. Second, by reducing competition mergers may also reduce the bargaining power of faculty candidates, and hence their wages. This might positively affect university aggregate excellence by making more funds available for other expenditures. Therefore, mergers among universities raise immediate efficiency questions. Surprisingly, it is difficult to find clear theoretical policy guidelines on this respect in the related literature. This paper contributes to the ongoing debate in several national higher education sectors by addressing the following question: to what extent mergers achieve higher excellence than competing universities?

In this paper we analyze under which conditions merging guarantees higher aggregate excellence or prestige than competition between universities. We focus here on the effects of mergers on national or country level markets for two reasons. First, the majority of faculty members are hired on national markets.[4] Second, most research

[1] This increasing interest is reflected in various articles published in international press. See, for example, "Leader: Together, they are stronger", published by The Times, December 2011 available at http://www.timeshighereducation.co.uk/story.asp?storycode=418436.

[2] For instance, the Carnegie Institute of Technology merged with the Mellon Institute to become Carnegie Mellon University already back in 1967.

[3] For example, in 2006 Germany launched the "Initiative for Excellence" (2006-2012) program. At the same time, France launched the program "Pôles de Recherche et Enseignement Supérieur" (PRES 2006). Lately, Spain developed the initiative "Campus de Excelencia Internacional" in 2009.

[4] There is a huge variation in the percentage of foreign-born academics. Particularly notable is the virtual absence of foreign scientists in Italy with 3.0 percent, Japan with 5.0 percent and Spain with

funds come from national funding agencies. On average less than one percent of total funds came from international sources in Europe in 2003 (see Eurostat (2007)).

To address these issues we model the higher education sector in the following way. Universities differ in their initial cost of acquiring quality, which varies inversely with the initial reputation that corresponds to the quality of the incumbent faculty members, and act as non-profit institutions with the goal of maximizing prestige or excellence subject to a budget constraint. They do so by choosing the quality of the incoming faculty members, which it turn also determines the amount of research resources received from a funding agency and the amount of resources provided for teaching. We analyze university performance in two different settings: in one of them there is just one merged university while in the other there are two universities competing for faculty candidates and resources.

We find that the interrelation between universities' initial reputation, the amount of research funds and universities' recruitment standard plays a key role in determining the success or failure of mergers. Our main finding is that the higher the heterogeneity between competitors or potential mergers institutions the higher the amount of funds needed to make the merger profitable in terms of aggregate excellence. The intuition is that a higher heterogeneity induces tougher competition between universities resulting in higher aggregate excellence, which, in turn implies that the amount of funds needed to make the merger profitable will be larger.

There are several branches of literature related to our work. First, the competition for students, resources and professors in higher education has been the object of some academic interest within the literature on university governance. Gary-Bobo and Trannoy (2008) are concerned with the welfare effects of increased competition and conclude that whether or not competition leads to optimal outcomes depends on the incentives given by the government through the financing scheme. However, they concentrate on the education provision role of universities leaving research out of the scope of their analysis. In this paper we consider university competition for research resources and faculty candidates, and leave the competition for students' aspect in the background. There are also some papers on competition for resources, for instance, Aghion et al. (2009) empirically analyze the link between competition and governance and show that university autonomy and competition are positively correlated with

7.3 percent of scientists studying or working there who lived abroad at age 18. There are, however, some exceptions to this pattern. In Switzerland and US there are about 50 and 38.4 percent of foreing scientists, respectively. See Franzoni, Scellato and Stephan (2012).

university output, both among European and US public universities. Another branch relates to the analysis of merging among non-profit institutions. Prüfer (2011) shows that it is not possible to assess the net effects of a merger between two non-profits without considering the objectives of the owners involved. We concentrate here on the role of universities' initial reputation, the amount of research funds and universities' recruitment standard choice on determining the success or failure of mergers. Similar to the approach of Rothschild and White (1995) regarding students, we argue here that professors can also be viewed as both inputs and clients for the services provided by the university. As such, there are two important reasons why universities may compete for faculty candidates. On the one hand, as inputs they are scarce resources required for the university production process. On the other hand, as clients, faculty indirectly provides the university with the funds it needs to operate. Finally, the third branch covers the interrelation of faculty's reputation and its competition for new candidates which determines the optimal faculty size explicitly. Prüfer and Waltz (2012) perform a similar analysis, however, in contrast to them we characterize the equilibrium recruitment standard which, in turn, determines here faculty size, wages and university's prestige. In addition, our paper complements theirs by considering the impact of competition versus merging on both the equilibrium recruitment standard and the aggregate excellence level achieved by the higher education market. By doing so our analysis confirms the fact that the number of universities operating in the academic labor market affects their wages and thus the university salary bill.

The paper is organized as follows. Section 2 introduces the model and characterizes the equilibria in the merger and competing settings. Section 3 presents the results on the comparison between competition and merge. Section 4 discusses the robustness of the main results to alternative assumptions. Finally, Section 5 concludes.

2 The Model

In this section we describe the behavior of the agents comprised in the higher education market: universities and faculty candidates. There are two universities labeled 1 and 2, characterized by a reputation parameter $a_i \in (0, 1)$ for $i = 1, 2$, which is the effort needed to acquire quality (by hiring faculty candidates as we see below). This effort or cost of acquiring quality varies inversely with their initial reputation or quality of their incumbent faculty members at that university i. That is, the higher is a_i the lower the reputation of university i. This means that less reputable universities require more effort to attract a given quality level and thus find it more costly in term of lost income. We assume here that universities aim at maximizing their prestige or excellence.[5] The pursuit of excellence appears to be the motivation of the administration or government board of most universities. Nevertheless, the goals of universities are not easy to define. Universities mission statements usually refer to teaching, research and other activities as means to foster development, growth, etc. Hence, we can understand here excellence as equivalent to the social value of these activities to the extent that they generate benefits to society by enabling a more developed and sustainable society.[6] To achieve this objective universities hire the most able faculty members, and pursue the highest-quality academic and cultural environment. To sharpen the analysis we consider that universities focus on improving excellence during the next academic period, E_i. Accordingly E_i must be interpreted as the increase in excellence during next period instead of total excellence. Such increase depends positively on two factors: the new human capital H_i and physical capital K_i. The former is captured by the quality-weighted number of incoming faculty members, i.e., $H_i = n_i x_i$, where $x_i \in [0, 1]$ denotes the recruitment standard that university i requires from faculty candidates and n_i denotes the number of candidates hired. We assume that physical capital K_i depends on the expenditure on maintaining and improving university's facilities.[7] We start from a given quality or reputation cost of two universities and we study the effect of setting a recruitment standard x_i on the increment of excellence during next period. We believe this is a sensible approach since most universities instead of introducing large reforms every academic period (firing most faculty, etc.) they introduce small reforms in several steps (hiring new faculty). To further simplify, we propose the following objective function:

$$E_i = H_i + \delta K_i, \tag{1}$$

[5] Alternatively, we could consider that universities are organizations whose aim is to maximize rents, that is, the difference between the total sum of revenues and the total university cost. See Section 4 for a detailed analysis on the university objective function.

[6] See, for example, University of California's Mission Statement at http://www.universityofcalifornia.edu/aboutuc/mission.html

[7] This may include labs, research assistants, sabbatical, pay for travel to conferences, the purchase of computer software or datasets, and the like.

where $\delta > 0$ measures the weight of the physical capital on excellence.[8] In this setting universities set the recruitment standard x_i which, as we see below, determines the number of candidates hired n_i, the new human capital H_i and the physical capital K_i.

We assume that universities' revenues are provided by some funding agency. In particular, the total funds that each university i receives come from two sources. The first one is related to the number of faculty hired, $t_r n_i$, where t_r can be interpreted as the students/lecturer ratio, thus $t_r > 1$. Therefore, teaching funds are increasing in the number of faculty candidates hired (or reversibly, increasing in the total number of students for some fixed number of faculty members).[9] We focus on university faculty candidates hiring policy and abstract here from analyzing students' behavior. That is, we are implicitly assuming that by hiring the best lecturers and providing the best campus facilities universities can attract more students and this fact allows them to select the best students.[10] In addition, universities obtain extra funds through research grants. We denote by g the total grant available from the funding agency to finance research and that will be allocated competitively among universities operating in the market. Thus, each university i gets a proportion p_i of g.

$$R_i = t_r n_i + p_i g. \tag{2}$$

Each university spends those resources on maintaining facilities K_i, seeking for high quality faculty candidates and paying salaries. As we said above, we assume that seeking for faculty candidates in the higher education market by means of setting any recruitment standard is costly and varies inversely with the university reputation level. In particular, the total cost of setting a recruitment standard x_i is $a_i x_i$.[11] In

[8] Our specification of the objective function may seem restrictive as it considers perfect substitutability between physical capital and human capital. However, as discussed below, in general, it does not imply corner solutions.

[9] We consider here that t_r is fixed or, equivalently, the number of admitted students adjusts (ex. through rationing) to hold t_r fixed.

[10] Winston (1999) and Epple, Romano and Sieg (2007) use a similar argument in their models. Siow (1997) found that schools with more successful researchers have larger shares of out-of-state and foreign students.

[11] As Graves et al. (1982) point out, universities' reputation serves several related functions. Faculty candidates can use such reputation as a proxy for the quality of the research/teaching environment at particular universities. For students, such reputation is suggestive of the faculty skills and knowledge. Finally, reputation serves as a signal of trustworthiness to the funding agency. That is, we do not consider here the opportunity cost of seeking for candidates (which will obviously

addition universities have to pay salaries to those candidates. The candidates' salary scheme is the sum of a fixed minimum wage, t_s plus a reward proportional to the candidate's research output. Notice that the best research teams are more likely to be given research contracts. Graves et al. (1982) also find that those departments with higher number of published works per faculty member are the ones who pay higher salaries. Thus, we assume here that academic research output depends on the university recruitment standard, x_i. To simplify, let each candidate wage be equal to $t_s + x_i$.[12] Thus this scheme captures the idea that the willingness to accept a position is positively related to the academic standard of the university because of the research spillovers with other professors. The total salary bill paid by university i, S_i, is equal to $(t_s + x_i)n_i$. Finally, we denote by t the fixed component of the university's net profit per candidate hired, i.e., $t = t_r - t_s$.

The salary scheme is supposed to be the same regardless of the number of universities hiring candidates in the market. That is, we do not impose a different specification for the salary in the merging setting and the competition setting, which resemble a monopsony and an oligopsony, respectively (see Boal and Ransom (1997) for a similar way of modelling the academic labor market). However, interestingly, we find that the relation between the equilibrium salary bill in each setting coincide with the standard result. Namely, the equilibrium salary bill under the merging setting is always lower or equal than the one resulting under competition (see Section 2 below and Ransom (1993) for some related empirical evidence).[13]

Thus, the university budget constraint is:

$$K_i + S_i + a_i x_i = R_i. \tag{3}$$

We assume there is a continuum of faculty candidates that differ according to

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be higher for the most reputable universities). Instead, and following Graves et al. (1982), we assume here that setting the same recruitment standard is more costly for the least reputable university.

[12] See Gautier and Wauthy (2007) and Del Rey and Wauthy (2006) for a quite similar faculty salary modelling. Other possible schemes include for example, t_s plus some function of the mean productivity of admitted candidates. Nevertheless by modelling salaries in this alternative way we find very similar results.

[13] Therefore, and to the extent that a lower university salary bill may imply a lower load for taxpayers, this result could be considered as an additional advantage of merging. As our focus is not on a comparison of different general tax-subsidy schemes but on the trade-off faced by the policy maker when deciding whether or not to merge universities from an aggregate excellence point of view, we abstract from the effects of mergers on agents other than universities and faculty candidates.

their productivity for teaching and research activities.[14] For convenience we assume that candidates are uniformly distributed in the interval [0,1]. Recall that x_i denotes the recruitment standard set by university i to incoming faculty candidates. That is, only those candidates with productivity above x_i, are offered a position at university i. This value must just be interpreted as the recruitment standard that university i sets for the next academic period. That is, we do not exclude the possibility that universities become so selective that they do not hire any new candidate ($x_i = 1$). In other words, they can decide whether or not to expand along the next period. Thus the decision regarding the recruitment standard can also be interpreted as a quantity-quality trade-off between receiving a greater funding from teaching activities, which would be the case if they set a low recruitment standard, and receiving the maximum amount of resources from research activities which follows from setting the highest recruitment standard and not allowing new member enters the faculty. Below we analyze how the university's recruitment standard decision depends on the higher education setting: competition vs. merger.

Universities set their recruitment standard x_i by maximizing excellence subject to a budget constraint:

$$\begin{aligned} \underset{\{x_i\}}{Max} \quad & E_i = H_i + \delta K_i \\ s.t. \quad & K_i + S_i + a_i x_i = R_i. \end{aligned} \tag{UP}$$

Let x_i^* denote the equilibrium recruitment standard set by university i. As we commented above, it is not a steady state solution of the university maximization problem. In the next section we solve the university optimization problem in the competing and the merging settings.

In what follows, it is assumed that a_i, i.e., the cost of acquiring one extra unit of quality is low enough to guarantee that the maximum excellence level is not achieved for $x_i^* = 0$. Otherwise, corner solutions would arise with universities providing no quality at all or hiring the whole population of faculty candidates, which does not seem reasonable. In order to rule out this possibility we establish the following assumption.
Assumption 1(A.1): $a_i < g - t$.

Now we consider two settings: In one of them, there are two universities competing for resources. We compute the Nash-equilibrium for this particular university market

[14] As in Prüfer and Waltz (2012) this productivity might also capture the candidate's relative value for faculty members in social exchange processes and can be attributed to a wide set of characteristics such as methodological and writing skills as well as network relations.

structure. In the other one, universities are induced to merge. We focus on the comparison of aggregate excellence in the competing versus the merged regulation setting.

2.1 Two competing universities

We analyze a game where both universities simultaneously choose their recruitment standards, x_1 and x_2, taking the competitor's standard as given.[15]

Financing in this setting is as follows. First, the proportion of total research grant that university i can get $p_i(x_i, x_j)$ (for $i = 1, 2$) depends on the relative recruitment standard set by both universities:

$$p_i(x_i, x_j) = \begin{cases} \dfrac{x_i}{x_i + x_j} & if \quad x_i + x_j > 0 \\ 0 & if \quad x_i + x_j = 0. \end{cases} \tag{4}$$

This reward structure can be interpreted as a particular tournament where there is a rank-order payment scheme.[16] Thus, we assume that universities always receive a proportion of the award g as long as they set a positive recruitment standard. Note that, the funding agency always fully allocates g except for the case when both universities choose the lowest recruitment standard. If this is the case, no award is provided. Second, recall that each university receives funds depending on the number of faculty hired, $t_r n_i$. Observe that given the salary scheme, a faculty candidate when being admitted to both universities, chooses to work at the one with the highest recruitment standard as there she gets the highest salary. Thus, the partition of candidates between both universities is:

$$n_i(x_i, x_j) = \begin{cases} x_j - x_i & if \quad x_i < x_j \\ \frac{1-x_i}{2} & if \quad x_i = x_j \\ 1 - x_i & if \quad x_i > x_j. \end{cases} \tag{5}$$

[15] The focus here is on universities' behavior while operating in the higher education market rather than on whether or not entering into this market. Thus, we think this approach is more appropriate than considering sequential decisions.

[16] Tournaments are extensively used as allocation mechanisms, see Lazear and Rosen (1981). Indeed, Gautier and Wauthy (2007) find that the optimal allocation of resources among departments should be based on the relative performance of their research projects.

Hence, the university i optimization problem is:

$$\begin{aligned} &\underset{\{x_i\}}{Max} \quad E_i(x_i, x_j) = H_i(x_i, x_j) + \delta K_i(x_i, x_j) \\ &s.t. \qquad K_i + S_i + a_i x_i = R_i. \end{aligned} \tag{6}$$

Now we proceed to analyze the optimal recruitment decision of both universities. Each university solves the maximization problem described in (6) where $R_i(x_i, x_j)$ is given by Equation (2) and $p_i(x_i, x_j)$ and $n_i(x_i, x_j)$ are given by Equations (4) and (5), respectively. We assume that university 1 and 2 differ in their reputation cost. In particular, we consider that university 1 is more reputable than university 2, that is, $a_1 < a_2$.[17]

We do not consider here the case where universities get out of the market. That would be the case if their equilibrium excellence value were non-positive. However, this is not possible in our model as each university will always receive some funds regardless of its recruitment standard (that is, $E_i(x_i = 0, x_j) = \delta t n_i > 0$ or $E_i(x_i = 1, x_j) = \delta(p_i g - a_i)$). We show now that, for all research grant levels and costs of acquiring quality for the universities, there is no symmetric equilibrium in which both universities admit, at least, some candidates but not all of them. That is, there is no equilibrium where $x_i^* = x_j^* = x$ and $x \in (0, 1)$. Suppose that there is an equilibrium in which $x_i = x_j = x$. If $x_j = x > 0$, then from Equations (4) and (5) the objective function of university i is as follows:

$$E_i(x_i, x) = \begin{cases} (x_i(1+\delta) + t)(x - x_i) + \delta(\left(\frac{x_i}{x_i + x}\right) g - a_i x_i) & if \quad x_i < x \\ (x(1+\delta) + t)\left(\frac{1-x}{2}\right) + \delta(\frac{g}{2} - a_i x) & if \quad x_i = x \\ (x_i(1+\delta) + t)(1 - x_i) + \delta(\left(\frac{x_i}{x_i + x}\right) g - a_i x_i) & if \quad x_i > x. \end{cases} \tag{7}$$

It is clear that by evaluating $E_i(x_i, x)$ at $x_i = x$ we get:

$$\delta(\frac{g}{2} - a_i x) < (x(1+\delta)+t)\left(\frac{1-x}{2}\right) + \delta(\frac{g}{2} - a_i x) < (x(1+\delta)+t)(1-x) + \delta(\frac{g}{2} - a_i x). \tag{8}$$

Then, (x, x) can never be an equilibrium as a small deviation to the right always increases the excellence of university i. Now, if $x_j = 0$ then from (A.1) it is clear that the best reply of university i is to set some $x_i > 0$.

[17] See Section 4 for a brief analysis of the symmetric case, i.e., $a_1 = a_2 = a$.

We next characterize the optimal recruitment standard set by both universities in equilibrium, x_1^* and x_2^*. In order to guarantee equilibrium existence we need to set a lower bound for the research grant.

Assumption 2 (A.2): $g > \underline{\underline{g}}(a_1, a_2, t) = \dfrac{(a_1 + a_2 + 2t)^2 2t}{(a_2 + t)2t + (a_1 - a_2)^2}$.[18]

We comment now on A.2, and in particular we focus on the role of the net profit per candidate hired t, in this lower bound for the research grant. First note that, if $t > 0$ then both universities have incentives to reduce their recruitment standard below their competitors in order to hire more candidates and thus equilibrium existence is not guaranteed. To avoid this case, and compensate for incentives coming from the teaching revenue source, we require the research grant to be high enough. Now, with a sufficiently high research grant university 1 is more willing now to set a recruitment standard high enough to dissuade university 2 (the least reputable university) from setting a recruitment standard just above its own standard, i.e., $x_2 = x_1 + \varepsilon$. This can be so as university 1 can take advantage of its reputation to reinforce its position in the market. That is, university 1 receives more research funds and university 2 hires the highest amount of faculty candidates expanding its size along the next period in order to maximize its excellence. Now, if $t = 0$ then (A.2) just requires a positive g to guarantee that, in equilibrium, university 2 sets a recruitment standard lower or equal than that of university 1. In this case, the teaching funds received by universities just cover the minimum wage paid to the candidates hired and therefore universities have not anymore incentives to increase their sizes. This explains why any positive amount of resources guarantees that the most reputable university is setting a recruitment standard higher or equal than the least reputable university.

Finally, to obtain tractable analytical solutions we impose here $\delta = 1$, which means that both human capital and physical capital have the same weight on universities' excellence. We do not ignore that this assumption may lead to extreme solutions. Thus, we interpret our results here as magnified tendencies. Nevertheless, we think that the qualitative results would not dramatically change had we assume $\delta < 1$. Proposition 1 shows that the most reputable university always sets the highest recruitment standard. We also find that there is a lower (upper) bound for the

[18] If (A.2) does not hold we would just need to impose additional conditions on a_1 and a_2 to ensure the existence of the equilibrium. However, under these additional conditions no new equilibrium emerges. Thus, we propose (A.2) to avoid unnecessary complexity.

research grant g below (above) which both universities set a recruitment standard below (equal) to one. We denote these values by $\underline{g}$ and $\overline{g}$, respectively.

Proposition 1 *Suppose (A.1) and (A.2) hold and let $a_1 < a_2$ and $\delta = 1$. The equilibrium recruitment standards (x_1^*, x_2^*) depend on the total research grant:*

(i) If $g < \underline{g}$ then $x_2^* < x_1^* < 1$.

(ii) If $g \in (\underline{g}, \overline{g})$ then $x_2^* < x_1^* = 1$.

(iii) If $g > \overline{g}$ then $x_2^* = x_1^* = 1$.

Proof. From Equations (6) to (4) we can check first that $E_i(x_i, x_j)$ is concave in each of the different intervals. In addition, from (A.1): $\lim\limits_{x_i \to 0} \frac{\partial E_i}{\partial x_i} \mid_{x_i < x_j} > 0$. Note that $\lim\limits_{x_i \to 1} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j} < 0$ if either $x_j < \widehat{x}_j(a_i, g, t)$, where $\widehat{x}_j(a_i, g, t)$ is such that $\dfrac{(1+\widehat{x}_j)^2}{\widehat{x}_j} = \dfrac{g}{a_i + t}$, or $\dfrac{g}{4(a_i+t)} < 1$. The sign of $\lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i < x_j}$ and $\lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j}$ also depends on the value of x_j. In particular, $\lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i < x_j} = \lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j} > 0$ if and only if $x_j < \dfrac{g}{4(a_i+t)}$. Consider two cases: (a) $\dfrac{g}{4(a_i+t)} < 1$ which implies that $\lim\limits_{x_i \to 1} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j} < 0$. If $x_j < \dfrac{g}{4(a_i+t)}$ then $\lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i < x_j} = \lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j} > 0$ and thus from Equations (4) to (6) the best reply of university i, $b_i(x_j) = -x_j + \sqrt{x_j \dfrac{g}{(a_i+t)}}$ which is higher than x_j. If $x_j > \dfrac{g}{4(a_i+t)}$ then $\lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i < x_j} = \lim\limits_{x_i \to x_j} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j} < 0$ and thus, from Equations (4) to (6) we have that the best reply of university i depends on the value of x_j. In particular if $x_j < \widetilde{x}_j(a_i, g, t)$, where $\widetilde{x}_j(a_i, g, t)$ is such that $E_i(-\widetilde{x}_j + \sqrt{\widetilde{x}_j \dfrac{g}{(a_i+t)}}, \widetilde{x}_j) \mid_{x_i < x_j} = \lim\limits_{x_i \to \widetilde{x}_j} E_i(x_i, \widetilde{x}_j) \mid_{x_i > \widetilde{x}_j}$, then $b_i(x_j) = x_j + \epsilon$ and if $x_j > \widetilde{x}_j(a_i, g, t)$ then $b_i(x_j) = -x_j + \sqrt{x_j \dfrac{g}{(a_i+t)}}$ which now is lower than x_j. To sum up, if $\dfrac{g}{4(a_i+t)} < 1$ then the best reply of university i is:

$$b_i(x_j) = \begin{cases} -x_j + \sqrt{x_j \dfrac{g}{(a_i+t)}} & if \quad x_j < \dfrac{g}{4(a_i+t)} \\ x_j + \epsilon & if \quad \dfrac{g}{4(a_i+t)} \leq x_j < \widetilde{x}_j(a_i, g, t) \\ -x_j + \sqrt{x_j \dfrac{g}{(a_i+t)}} & if \quad x_j \geq \widetilde{x}_j(a_i, g, t). \end{cases} \tag{9}$$

(b) $\dfrac{g}{4(a_i+t)} > 1$. If $x_j < \widehat{x}_j$ then $\lim\limits_{x_i \to 1} \frac{\partial E_i}{\partial x_i} \mid_{x_i > x_j} < 0$ thus from Equations (4) to (6) we have that the best reply of university i is $b_i(x_j) = -x_j + \sqrt{x_j \dfrac{g}{(a_i+t)}}$ which is higher than x_j. If $x_j \geq \widehat{x}_j$ then $\lim\limits_{x_i \to 1} \frac{\partial E_i}{\partial x_i} |_{x_i > x_j} \geq 0$ and thus from Equations (4) to (6) the best reply of university i, $b_i(x_j) = 1$. Thus, if $\dfrac{g}{4(a_i + t)} > 1$ then the best reply of university i for any x_j is:

$$b_i(x_j) = \begin{cases} -x_j + \sqrt{x_j \frac{g}{(a_i+t)}} & if \quad x_j < \widehat{x}_j(a_i, g, t) \\ 1 & if \quad x_j \geq \widehat{x}_j(a_i, g, t). \end{cases} \tag{10}$$

Figure 5 depicts the best reply functions of both universities in each possible scenario.

Now, (i) Let $g < \underline{g}$ where $\underline{g} = \dfrac{(a_1 + a_2 + 2t)^2}{a_2 + t}$ and now we can distinguish two cases: a) if $g > 4(a_1 + t)$ then an equilibrium exists if the following two conditions holds: a.1) $b_2(x_1 = 1) < \widehat{x}_2$, which holds if and only if $g < \underline{g}$ and a.2) $\widetilde{x}_1(a_2, g, t) < x_1^*$, which holds if and only if $g > \underline{\underline{g}}(a_1, a_2)$ and thus from A.2 this condition holds. b) if $g < 4(a_1 + t)$ then an equilibrium exists if the following two conditions holds: b.1) $b_1(x_2 = \dfrac{g}{4(a_1 + t)}) > \widetilde{x}_1$ and b.2) $\widetilde{x}_1(a_2, g, t) < x_1^*$. However, it can be checked that $b_1(x_2 = \dfrac{g}{4(a_1 + t)}) > x_1^*$ for any a_1, a_2 and g. Thus, b.2) is a sufficient condition to ensure the existence of equilibrium in this case. Thus, from A.2 then this equilibrium always exists. The equilibrium is $x_i^* = \dfrac{a_j + t}{(a_j + a_i + 2t)^2} g$ for $i = 1, 2$.(ii) Let $g \in (\underline{g}, \overline{g})$ where $\overline{g} = 4(a_2 + t)$. Then, from (10) for university 1 and (9) for university 2, we can check that an equilibrium will always exist if $b_2(x_1 = 1) > \widehat{x}_2$ which holds if and only if $g > \underline{g}$. This equilibrium is $x_1^* = 1$ and $x_2^* = -1 + \sqrt{\frac{g}{a_2 + t}}$. (iii) and finally, let $g > \overline{g}$. Then, from (10) for $i = 1, 2$ the unique equilibrium is $x_1^* = x_2^* = 1$. ■

Proposition 1 shows that, as expected, the equilibrium recruitment standard set by each university increases with the amount of the research grant, g. This is due to the fact that as research funds increase, then increasing the recruitment standard is better rewarded. First, if the research grant is low, that is $g < \underline{g}$, then university 1 does not need to set the highest recruitment standard. Only by setting a higher recruitment standard than its competitor, university 1 can maximize excellence. This is so because as the research is poorly rewarded, it is better for university 2 to expand its size in order to maximize excellence. Even if the amount of research grant is just fair $g \in (\underline{g}, \overline{g})$, university 1 sets a higher recruitment standard than university 2 and its excellence remains higher than that of university 2. In this case university 1 needs to set the highest recruitment standard to reach the highest amount of excellence.

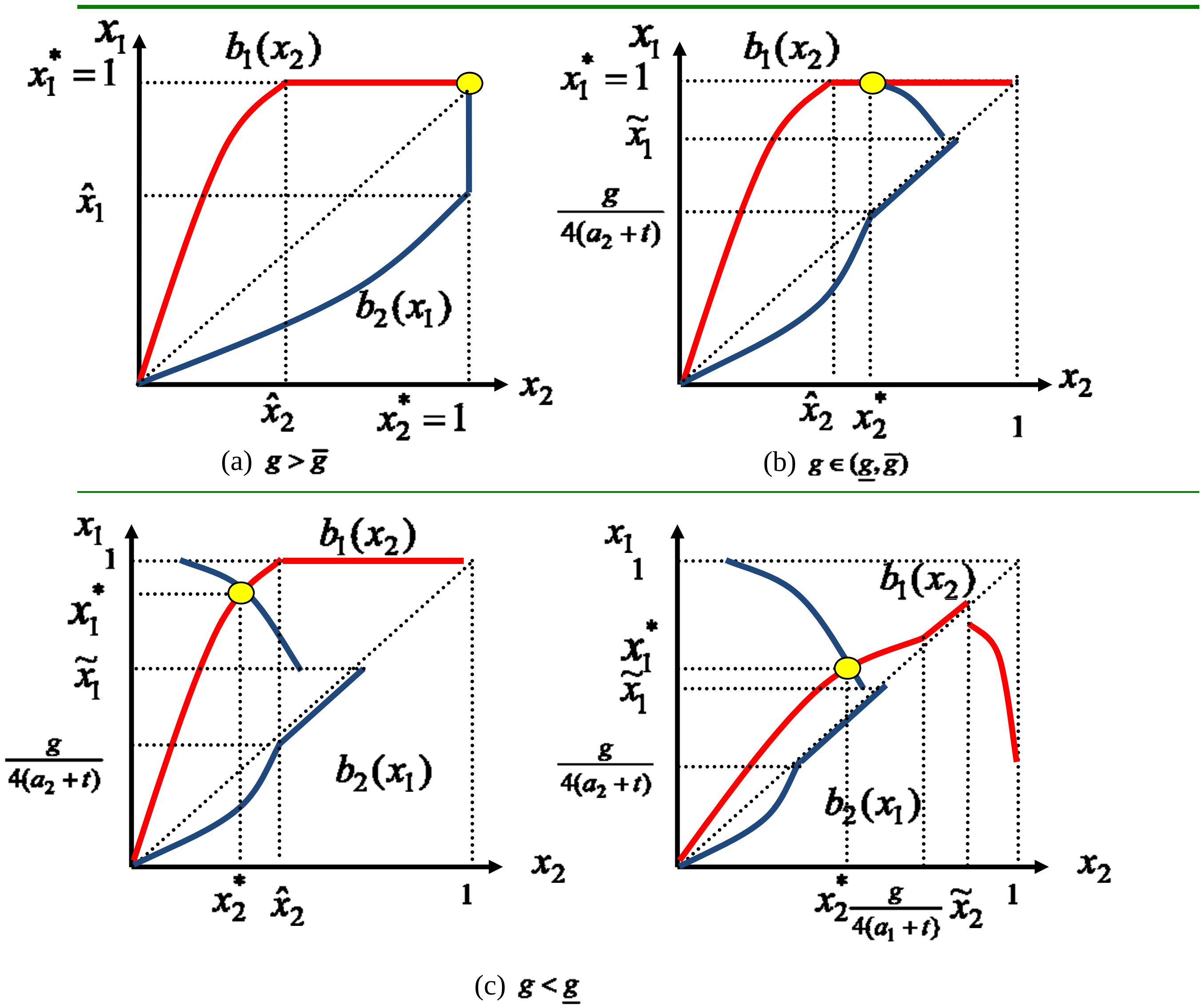

Figure 1: Best reply functions and equilibrium

The idea behind this result is that the amount of the research grant is high enough to incentivize university 2 to find increasing quality profitable. Thus, this university does not need to set the recruitment standard to the most to maximize excellence. As such, university 1 best choice to maximize excellence is to set $x_1^* = 1$ in order to get the highest proportion of the research funds put into competition. Finally, if the research grant is high, that is, $g > \overline{g}$, this induces an increase in competition among universities in such a way that recruitment standards are increased to the utmost. University 2 is induced to make strategic choices that improve its excellence by means of attracting more research funds. Similarly, university 1 is encouraged to choose the highest recruitment standard in order to achieve the maximum excellence level. However, as recruitment standards are constrained to be lower or equal to one, when university 1 reaches that limit it is not possible to increase research funds. It cannot longer take advantage of its reputation to reinforce prestige. In particular, if the amount of research funds is very high (higher than $\overline{g}$) observe that there is only room for university 2 to increase its excellence by capturing more research funds. At this point, the amount of research funds at stake is so high that offsets the difference in the cost of acquiring quality to choose the recruitment standard.

In addition we find that regardless of the amount of the research funds the recruitment standard set by university 1 is non-increasing with the net profit per candidate hired t. However, the impact of t on the recruitment standard set by university 2 depends on the amount of research funds and its reputation cost. In particular, if the research funds are high enough, higher than $\underline{g}$, then x_2^* is non-increasing with t. On the contrary, if the research funds are not that high, and its reputation costs are not low, then an increase in t implies university 2 sets a higher recruitment standard. Moreover, it can be shown that as t increases the threshold levels $\underline{g}$ and $\overline{g}$ get higher. That is, it is required a higher amount of research funds to incentivize universities to set the highest recruitment standard. Figure 1 and 2 illustrate the results in Proposition 1. Figure 1 depicts the best reply functions of both universities in the three possible scenarios. Figure 2 depicts the objective function of both universities, for any equilibrium value of the recruitment standard set by the other university.

Remark 1 below shows how both universities share the total research resources in equilibrium. It provides us with several insights about the design of a competitive research system based on relative quality.

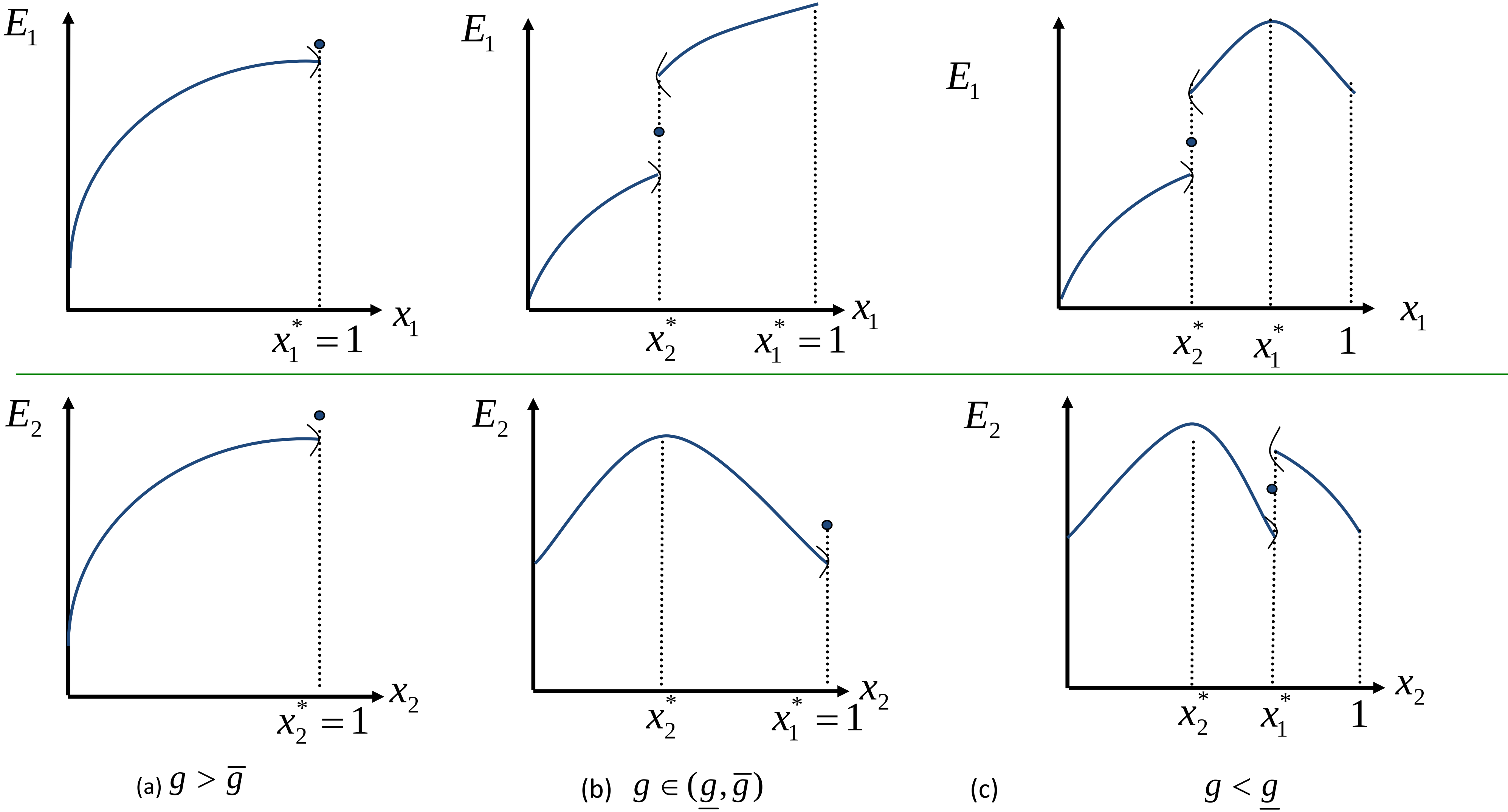

Figure 2: Excellence and equilibrium recruitment standards

Remark 1 *The research grant is shared as follows:*

(i) $p_1(g) \geq p_2(g)$ *for any* g,

(ii) $p_1(g)$ *is decreasing with* g, *whereas* $p_2(g)$ *is increasing with* g.

Proof. From Proposition 1 and Equation (4) we get that if $g < \underline{g}$, then $p_1 = \dfrac{a_2+t}{a_1+a_2+2t} > p_2 = \dfrac{a_1+t}{a_1+a_2+2t}$. If $g \in (\underline{g}, \overline{g})$ then $p_1 = \sqrt{\dfrac{a_2+t}{g}} > 1 - \sqrt{\dfrac{a_2+t}{g}} = p_2$. Finally, if $g > \overline{g}$ then $p_1 = p_2 = 1/2$. (ii) Hence, it is easy to check that $1/2 < \sqrt{\dfrac{a_2+t}{g}} < \dfrac{a_2+t}{a_1+a_2+2t}$ thus p_1 decreases in g. Finally, as $1/2 > 1 - \sqrt{\dfrac{a_2+t}{g}} > \dfrac{a_1+t}{a_1+a_2+2t}$ then it is clear that p_2 increases in g. ■

First, the proportion of resources received by the less reputable university is not higher than the proportion received by the most reputable one. Furthermore, the lower the amount of research funds, the higher the difference in the proportion of resources received by each university. Second, we find that raising the level of funding allocated by merit-based competition increases the proportion of resources received by the least reputable university. This result is in line with Aghion et al. (2009) who, albeit in a different context, find that if research funding depends more on universities' performance, then universities make strategic choices that improve the percentage they get from grants for which they must compete. Finally, notice that the proportion of research funds received by university 1, that is, the university with the lower cost of acquiring quality decreases as the total amount devoted to research funding increases. Figure 2 shows the proportion of research funds received by both universities as a function of the total amount of research grant.

We consider in turn each possible equilibrium configuration, and thus we distinguish three alternative scenarios which differ from each other in the amount of funds devoted to finance research g. We label the three scenarios or intervals for the amount of funds as *high* if $g > \overline{g}$, *fair* if $g \in (\underline{g}, \overline{g})$ and *low* if $g < \underline{g}$. We denote by $E^*_{i,s}$ the excellence achieved in equilibrium by university i in scenario s, i.e., $E^*_{i,s} = E_i(x^*_i, x^*_j)$ for $E_i(x_i, x_j)$ in Equation (7) and $\delta = 1$ and $s = h, f$ and l for high, fair and low.

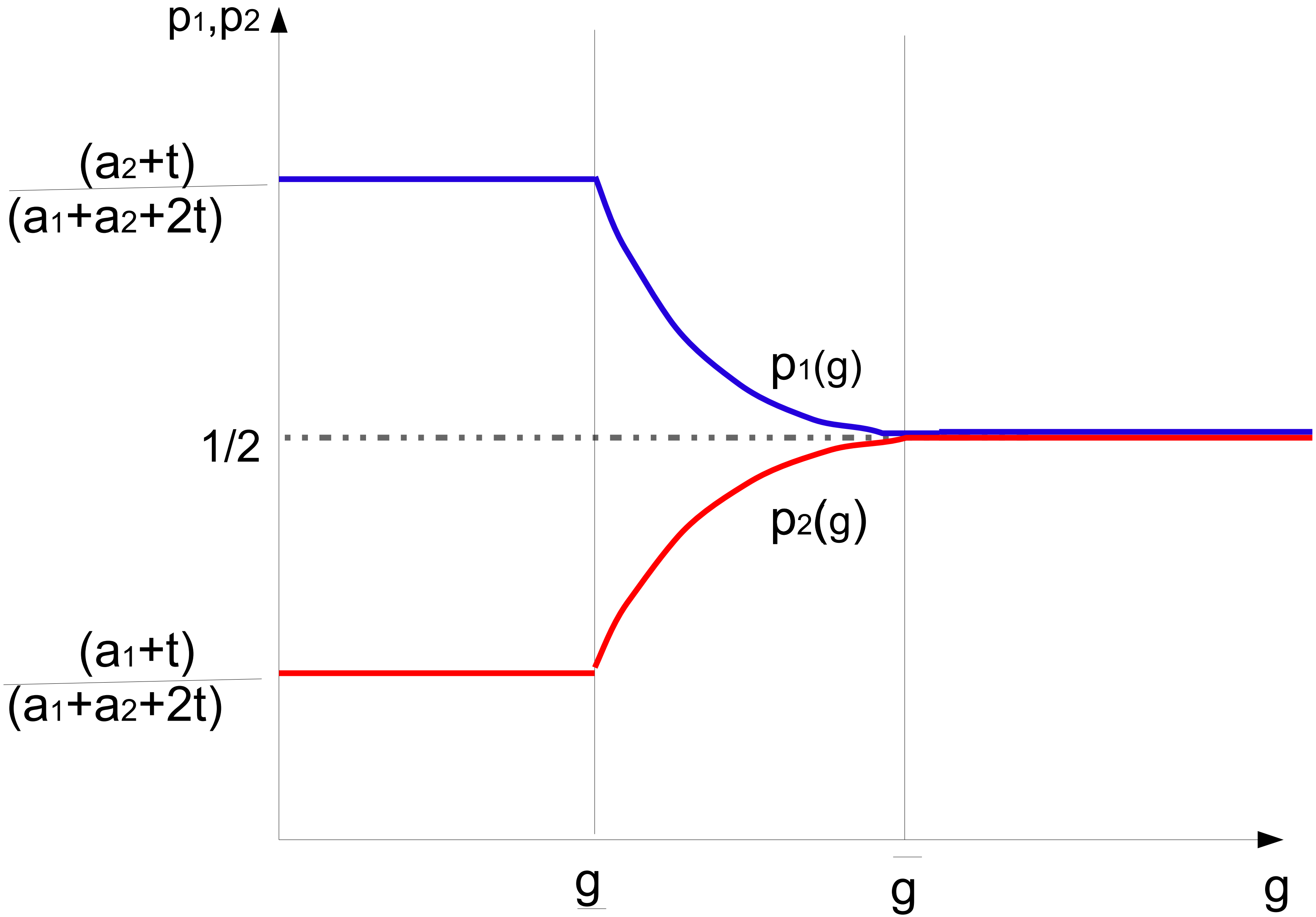

Figure 3: Universities´ research funds sharing

Table 1 reports the excellence values in the three possible scenarios:

Table 1: The excellence in equilibrium

Funds\Excellence	$E^*_{1,s}$	$E^*_{2,s}$
High	$\frac{g}{2} - a_1$	$\frac{g}{2} - a_2$
Fair	$\sqrt{(a_2+t)g} - a_1$	$g + a_2 - 2(\sqrt{(a_2+t)g} - t)$
Low	$\frac{g}{2} - a_1 t + \left(\frac{a_2+t}{a_1+a_2+2t}\right)^2 g$	$\frac{(a_1+t)+(a_2+2t)}{(a_1+a_2+2t)^2} g$

Several comments can be made from Table 1. First, and as expected, the equilibrium excellence of each university is non-decreasing with the net profit per candidate hired, t. Second, the equilibrium excellence achieved by each university is increasing in the amount of the research grant, g. And third, the excellence obtained in equilibrium is higher for the most reputable university than for the least reputable one regardless of the amount of funds, as it benefits from its advantage in reputation. That is, $E^*_{1,s} > E^*_{2,s}$ for any s. We next define the concept of heterogeneity between universities which is useful for the analysis in the rest of the paper.

Definition 1 *Heterogeneity between universities: This is the differential cost between them,* $a_2 - a_1$.

Finally, Remark 2 below shows how an increase in the heterogeneity between universities, affects the equilibrium excellence of each university.

Remark 2 *The higher the heterogeneity between competing universities, the higher the equilibrium excellence of university 1 and the lower the equilibrium excellence of university 2.*

Proof. From Table 1 it can be check first that $E^*_{1,s}$ is strictly decreasing with a_1 and non-decreasing with a_2 for any s. Second, $E^*_{2,s}$ is strictly decreasing with a_2 and non-decreasing with a_1 for any s. ■

2.2 Two merged universities

Consider now there is just one university that can be interpreted as the salient one after a process of aggregation of two (or more) universities with joint proposals.[19]

[19] Good illustrations of this case might be the recent cases of universities in Germany, France and Spain mentioned in the Introduction.

This university can be thought as it is endowed with some form of market power. Let the cost of acquiring quality for the merged university be denoted by a_m, where $a_m \in [a_1, a_2]$. That is, we consider as extreme cases those where the merger creates zero synergy gains, that is, $a_m = a_2$ and those where the merger fully exploits the potential synergy gains, that is, $a_m = a_1$. The former case represents a situation where the salient university after the merging process is perceived as a copy of the least reputable university among the merged universities. On the contrary, the latter case captures a situation where the most reputable university leads the merging process and imposes its reputation level to the salient university.

We analyze the university optimization problem, Equation (6), in a context where the competition for resources and faculty candidates vanishes. Let x_m denote the recruitment standard set by this merged university. As there is no competition for candidates with other universities then the number of candidates hired by the merged university is $n_m(x_m) = 1 - x_m$. In addition, there is no competition for research resources with other universities and thus the merged university gets a proportion of the total research grant g equal to its recruitment standard. That is, we assume that $p_m(x_m) = x_m$.[20]

It is easy to check that from (A.1) the excellence function of the merged university E_m, is concave on x_m. Hence, its optimal recruitment standard is $x_m^* = \frac{(1-\delta)+\delta(g-a_m-t)}{2(1-\delta)}$, which is decreasing in the cost of acquiring quality a_m and increasing in the weight of facilities on excellence, δ. That is, the higher the weight of facilities on excellence the lower the number of candidates hired but the higher its quality. The equilibrium excellence achieved by this university is:

$$E_m^* = t + (g - a_m - t)\left(\frac{(1-\delta) + \delta(g - a_m - t)^2}{2(1-\delta)}\right). \qquad (11)$$

Thus, the excellence achieved by the merged university is increasing in the weight of facilities on excellence, δ and decreasing in a_m, that is, the higher the cost of acquiring quality, the lower the level of excellence achieved. Finally, from (A.1) we have that if $\delta = 1$ then $x_m^* = 1$ and $E_m^* = g - a_m$. Observe that, in this case, the equilibrium salary bill for this merged institution ($S_m = 0$) is always lower or equal to that of competing universities . That is, even though we did not modelled different salary schemes for the competing and the merged settings we indeed obtain the standard result when comparing both as commented above.

[20] As we see below, the funding agency always fully allocates g in equilibrium. Thus, the amount of research resources spent in the "merged" and the "competing" settings coincide.

3 Competition versus merge

In the following section we compare aggregate excellence in the competing and the merged settings. We denote by $E^*_{c,s}$ the equilibrium aggregate excellence obtained in the competing setting in the three different scenarios s, for $s = h, f, l$:

$$E^*_{c,s} = E^*_{1,s} + E^*_{2,s}, \tag{12}$$

where $E^*_{1,s}$ and $E^*_{2,s}$ are defined in Table 1. That is:

$$\begin{aligned} E^*_{c,h} &= g - a_1 - a_2, & (13)\\ E^*_{c,f} &= g - a_1 + a_2 + 2t - \sqrt{(a_2+t)g}, & (14)\\ E^*_{c,l} &= t + \frac{((a_1+t)^2 + (a_2+t)^2 + t(a_2+t))}{(a_1+a_2+2t)^2} g. & (15)\end{aligned}$$

It can be checked from (13) to (15) that, as expected, the equilibrium aggregate excellence in the competing setting is increasing with the amount of the research grant, g and non-decreasing with the net profit per candidate hired, t. We also analyze here the impact on aggregate excellence of the heterogeneity between the competing universities. Recall from Remark 2 that an increase in the heterogeneity between the competing universities increases the equilibrium excellence of university 1 and reduces the equilibrium excellence of university 2. Therefore, the total effect on aggregate excellence depends on which effect dominates. If the amount of resources is high then, from (13) it can be checked that both effects cancel out and then the cost differential has no impact on aggregate excellence. However, as we show in Remark 3 below, in other cases, the first effect dominates.

Remark 3 *The higher the heterogeneity between the competing universities the higher the aggregate excellence achieved in equilibrium $E^*_{c,s}$ if s=f,l.*

Proof. From (14) and (15) it is easy to check that both $E^*_{c,f}$ and $E^*_{c,l}$ are decreasing with a_1 and increasing with a_2. ■

This remark tells us that, provided that at least one of the universities hires some candidates (because the research funds are not large enough), then an increase in the differential cost between both universities will have a stronger positive impact on the equilibrium excellence level of university 1 than the negative effect it causes on the equilibrium excellence level of university 2. The intuition is that a higher heterogeneity induces tougher competition between universities resulting in an increase in excellence for the most reputable university and a reduction in excellence for the least reputable one. In other words, as long as the amount of funds associated with winning the research tournament is small (i.e., lower than $\underline{g}$ here), then university 2 may find raising teaching funds (by setting a low x_2 and thus increasing its size) an easier way to increase excellence than hiring the most promising and qualified faculty candidates. As the least reputable university has an equilibrium excellence lower than that of the most reputable one, the first effect dominates and aggregate excellence under competition increases.

We analyze now the factors that influence the difference between aggregate excellence in the competing $E^*_{c,s}$ and the merged settings, E^*_m in the three different scenarios regarding the amount of research resources available g, that is for $s = h, f$ and l. We focus precisely on how both the amount of resources g and the reputation cost of the competing and the merged universities modulate this comparison. Recall from Equation (11) that the equilibrium excellence for the merged university is $E^*_m = g - a_m$. Now, if the amount of research resources is high, i.e., $s = h$, then from Equation (13) it is clear that aggregate excellence under merging is always higher than under competition, regardless of the cost of acquiring quality for the competing and the merged institutions, that is $E^*_m > E^*_{c,h}$ for any a_1, a_2 and $a_m \in [a_1, a_2]$. However, this is not the case in the other two scenarios, that is, for $s = f, l$. We show next that if the reputation cost of the merged institution is more than twice the reputation cost of university 1 ($a_m > 2a_1$) then the comparison between aggregate excellence under merging and competition just depends on the amount of research resources, g. If it is the case, then there is a threshold for the research resources above (below) which merged (competing) universities produce higher aggregate excellence than competing (merged) ones. We denote it by g_f, which stands for $g_f(a_1, a_2, a_m, t)$. However, if the reputation cost of the merged institution a_m is below $2a_1$, which we believe capture a more relevant situation, then the comparison between aggregate excellence in both settings depends not only on the amount of resources but also on the reputation cost of university 2. Namely, there is a minimum value for the reputation cost of university 2 $\underline{a}$, which stands for $\underline{a}(a_1, a_m, t)$, below which aggregate excellence in the merged setting is always higher than under the competing setting regardless of the amount of research resources. If the reputation cost of university 2 is above this boundary (which, for some fixed a_1, implies that the cost differential between competing universities increases) then the comparison between aggregate excellence under merging and competition depends on the amount of research resources. That is, there is a threshold for the research resources above (below) which merged (competing) universities produce higher aggregate excellence than competing (merged) ones. We denote it by g_l, which stands for $g_l(a_1, a_2, a_m, t)$.

Proposition 2 summarizes the previous results. It shows that whether or not competing universities produce higher aggregate excellence than the merged institution depends on the reputation cost of the competing and the merged institutions and the amount of research resources.

Proposition 2 *Suppose (A.1) and (A.2) hold and let $\delta = 1$. Then, the following conditions hold:*
(i) If $a_m > 2a_1$ then $E^*_m > (<) E^*_{c,s}$ if and only if $g > (<) g_f$ for $s = h, f, l$.
(ii) If $a_m < 2a_1$ then the following two cases arise:
(ii.1) If $a_2 < \underline{a}$ then $E^*_m > E^*_{c,s}$ for $s = h, f, l$.
(ii.2) If $a_2 > \underline{a}$ then $E^*_m > (<) E^*_{c,s}$ if and only if $g > (<) g_l$ for $s = h, f, l$.

Proof. First we define $g_f \in (\underline{g}, \overline{g})$ as the level of g that satisfies $E^*_{c,f}(a_1, a_2, g_f, t) = E^*_m(g_f, a_m)$, that is $g_f = \dfrac{(a_2 - a_1 + a_m + 2t)^2}{(a_2 + t)}$. Similarly $g_l \leq \underline{g}$ is defined to be such that $E^*_{c,l}(a_1, a_2, g_l, t) = E^*_m(g_l, a_m)$ that is $g_l = \dfrac{(a_m + t)(a_2 + a_1 + 2t)^2}{(2a_1 + t)(a_2 + t)}$. Finally, $\underline{a}$, which stands for $\underline{a}(a_1, a_m, t)$ is such that $a_2 \leq (\geq) \underline{a}$ if and only if $g_l \leq (\geq) \underline{g}$. (i) Let $a_m > 2a_1$. First, if $g > \overline{g}$ then from Equation (13) it is clear that $E^*_m > E^*_{c,h}$. Second, if $g \in (\underline{g}, \overline{g})$ then from Equation (14) and the definition of g_f it can be checked that $E^*_m > E^*_{c,f}$ if and only if $g > g_f$. Finally, if $g < \underline{g}$ then from Equation (15) and the definition of g_l it can be checked that as $g_l > \underline{g}$ then $E^*_m < E^*_{c,l}$ always holds. (ii) Let $a_m < 2a_1$ and then we distinguish two cases depending on the reputation cost of university 2: (ii.1) Let $a_2 < \underline{a}$. Then, from Table 1 and the definition of $\underline{a}$ we get that $E^*_m > E^*_{c,s}$ always holds for $s = h, f, l$. (ii.2) Let $a_2 > \underline{a}$ and first, if $g > \overline{g}$ then from Equation (13) it is clear that $E^*_m > E^*_{c,h}$. Now, if $g \in (\underline{g}, \overline{g})$ then from Equation (14) and the definition of g_f it can be checked that as $g_f < \underline{g}$ then $E^*_m > E^*_{c,f}$. And finally, if $g < \underline{g}$ then from Equation (15) and the definition of g_l and $\underline{a}$ it can be checked that $E^*_m > E^*_{c,l}$ if and only if $g > g_l$. ■

Proposition 2 tells us that, in order to obtain higher aggregate excellence in the competing setting than in the merged situation, if the reputation cost of the merged institution is high enough then it is required a low amount of research resources. Interestingly, as the reputation cost of the merged universities diminishes we still find some cases where aggregate excellence in competition is higher than under the merger. This is the case if the research resources are very low.

Figure 3 below illustrates the comparison between aggregate excellence under competition and mergers in the relevant case. Namely, if the reputation cost of the merged institution is not very high, $a_m < 2a_1$. It represents in the space (a_2, g), and for some fixed a_1, t and a_m, the areas where competing (merged) universities achieve higher aggregate excellence than the merged institution (competing universities).

Next we analyze how the degree of heterogeneity between competing universities affects the comparison of aggregate excellence in competition and merging. In addition we study the role of the reputation cost of the salient university after a merging process and the net profit per candidate hired on that comparison. Proposition 3 summarizes the main results.

Proposition 3 *Let $\delta = 1$. Then, the following statements hold:*
(i) The amount of resources required for mergers to achieve higher excellence than competition, g_f and g_l, increases with a_m, t and the heterogeneity between competing universities.
(ii) The minimum reputation cost of university 2 required for mergers to achieve higher excellence than competition $\underline{a}$ decreases with a_m and increases with t.

Proof. (i) From the definitions of both $g_f(a_1, a_2, a_m, t)$ and $g_l(a_1, a_2, a_m, t)$ in the proof of Proposition 2 above it can be checked that both are increasing with a_2 and decreasing with a_1. In addition it can be checked that both $g_f(a_1, a_2, a_m, t)$ and $g_l(a_1, a_2, a_m, t)$ are increasing with a_m and t. (ii) From the definition of $\underline{a}(a_1, a_m, t)$ in the proof of Proposition 2 it can be checked that it diminishes with a_m and increases with t as long as $a_m < 2a_1$, which is always the case for $\underline{a}$ to be defined. ■

First, this proposition tells us that the higher the heterogeneity between the competing universities the higher the amount of resources needed for the merged institution to produce higher aggregate excellence than the competing ones. Recall from Remark 3 that the higher the heterogeneity between universities, the tougher the competition between them, which in turn results in higher aggregate excellence. Therefore, if the differential cost between the competing universities is very high,

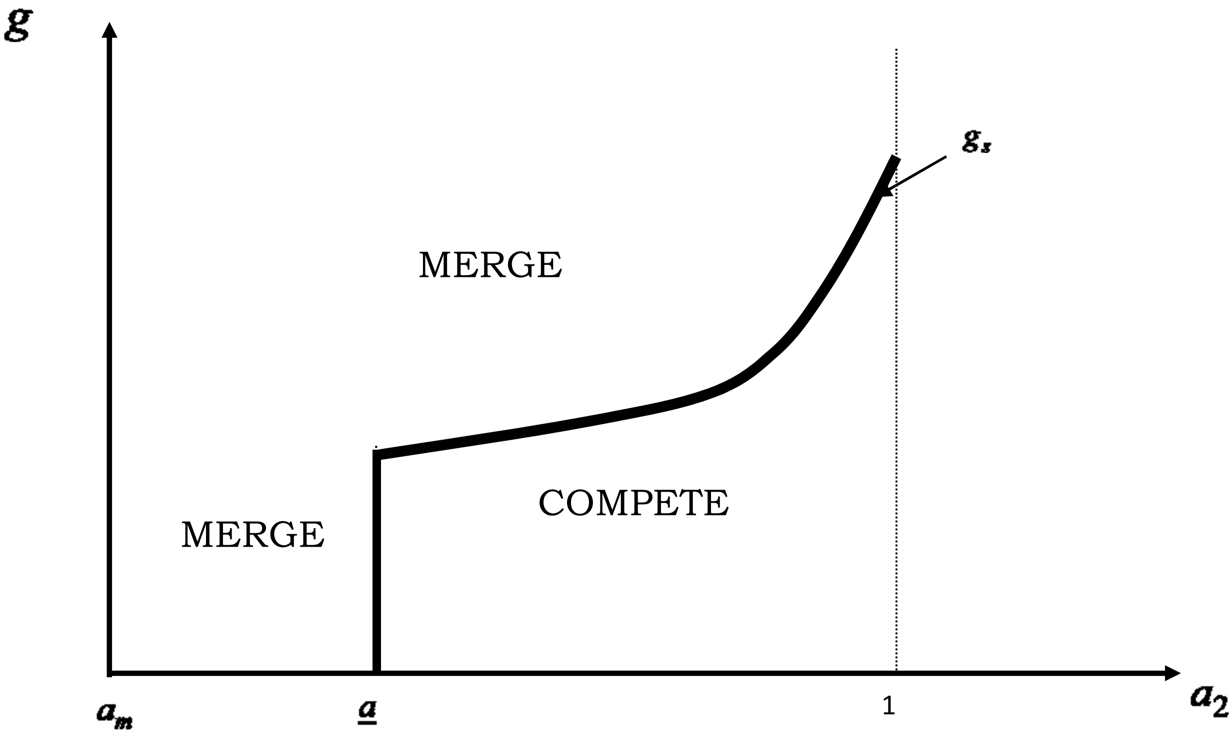

Figure 4: Competing versus merged. Resources

unless the amount of research resources is very large, then aggregate excellence in the competing setting is higher than in the merged one. Figure 4 below illustrates these results in the same particular case as above, i.e., $a_m < 2a_1$. Namely, if the reputation cost of the merged institution is not very high. It represents, for some fixed a_m and t, combinations (a_2, a_1) giving rise to the same value of $g_l(a_1, a_2, a_m, t)$.

Second, Proposition 3 shows that the higher the reputation level of the salient university after the merging process (the lower a_m), the higher the amount of resources required for the competing universities to produce higher aggregate excellence than the merged one. That is, the lower a_m, the higher the number of combinations (a_1, a_2), where the aggregate excellence of the merged university is higher than that of competing universities. This is due to the fact that the merged university always sets the highest academic standard whereas competing universities set higher quality standards the higher the amount of the research grant (see Proposition 1 above). In addition, Proposition 3 tells us that, as expected, $g_f(a_1, a_2, a_m, t)$ and $g_l(a_1, a_2, a_m, t)$ are increasing with t. That is, the higher the university's net profit per candidate hired, the higher the area where the merged institution produce more aggregate excellence than competing universities regardless of the amount of research resources. This means that the higher the university's net profit per candidate hired, and for some fixed a_1, a_2 and a_m, the higher the amount of resources needed for the merged university to produce higher aggregate excellence than the competing universities. This is immediate as we know that, on the one hand, the equilibrium excellence of the merged institution does not depend on t. And, on the other hand, from (13) to (15), the equilibrium aggregate excellence is non-decreasing with the net profit per candidate hired, t. From Proposition 1 we know that the higher the amount of research resources available, the higher the recruitment standard. This results in a lower number of candidates hired, which implies that t becomes less meaningful to get a higher level of aggregate excellence.

To sum up, the main result we find is that the higher the heterogeneity between competing (or pre-merging) institutions the higher the amount of funds needed to make the merger profitable in terms of aggregate excellence. To illustrate it, we propose the following examples of university mergers in Spain and France that differ in the amount of research funds available and the success of mergers. Whereas the amount devoted in France was 5.000 million euros in Spain the figure was 150

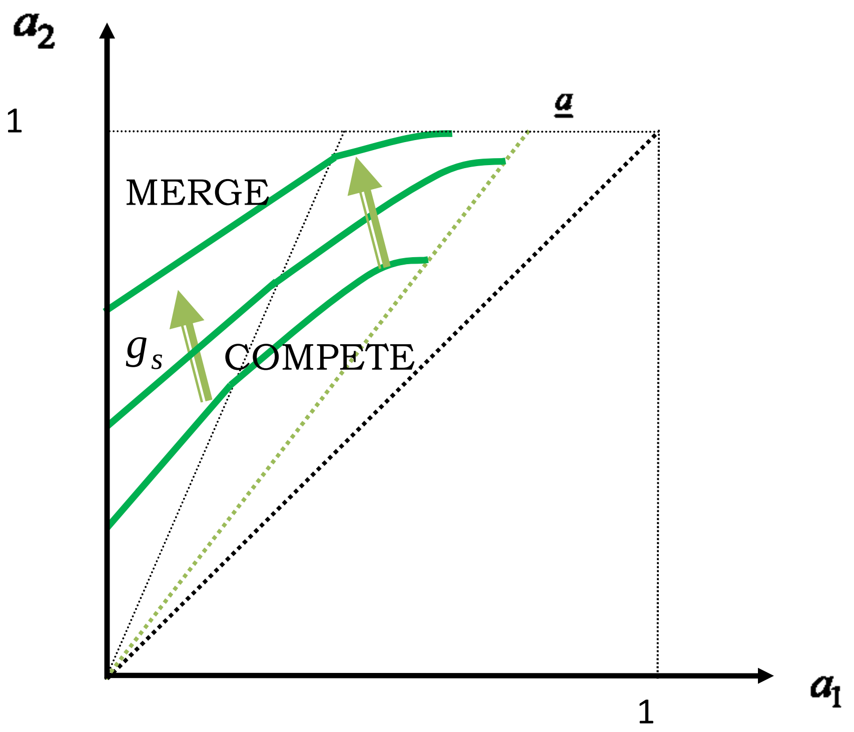

Figure 5: Competing versus merged: cost differential

million euros. We proxy the reputation cost of the competing universities with their positions in international rankings before they merge. Similarly, we proxy the reputation cost of the merged institution (the salient after the process of aggregation) with its position in the same ranking after the merger process. Our first example refers to Spanish universities. In particular, the Autonomous University of Madrid (UAM) and the Technical University of Madrid (UPM). Before merging in 2009, the UAM was among the world top 300 universities in the Shanghai International Ranking while the UPM was not even placed among the world top 500 universities (see ANRU 2007). Our second example refers to French universities. In particular, the University of Provence-Aix Marseille I, University of Mediterranean-Aix Marseille II and Paul Cezanne University-Aix Marseille III. These three universities have merged with the name of University Aix-Marseille under the Excellence Program implemented in France. In the last ANRU Edition, published August 12, 2012, we find that the University of Aix-Marseille is placed in the slice 102-150 global ranking on the 500 universities classified, which means an improvement over the ranking of universities evaluated separately (see Combes and Linnemer (2003) or Bosquet and Combes (2012) to check the position of these universities in some European rankings).

4 Robustness Analysis

4.1 University objective

The university objective function is undeniably important not only in the mind of both faculty members and college students (as consumers of educational services) but also for policy makers. Nevertheless, the debate on the appropriate university objective is not settled. For example, the pursuit of excellence is widely used as the universities' objective (see, among others, James (1990) and Clotfelter (1999)). See also Winston (1999) for a detailed analysis of the university objective function. Nevertheless, as we commented above, the university objective could also consist of maximizing rents. Universities have traditionally been viewed as pursuing purely social interests in which the production of graduates and research, unconstrained by resource shortages, have figured prominently. However, most universities are now subject to both severe resource constraints and also to increasing competition at both national and international level. Failure to meet these constraints would jeopardize their existence and hence their "social" objectives might be left in the background to give priority to this new additional objective, grounded in self-interest, namely survival. An additional hypothesis concerning the behavior of universities' objective could consider the behavior of the bureaucrats (or deans) managing universities. As these managers are unable to correctly understand the meaning of the public interest and because they have neither the omniscience nor the sovereignty to be able to accurately define such a concept, they can only give their personal interpretation of what the public interest is. This opens the door to all kinds of interpretations and facilitates actions to satisfy personal interests. The latter can be satisfied through a higher budget and a discretionary budget. By doing so it is possible to hire more bureaucrats, to create opportunities for more manager positions, and to allocate some resources for particular tasks. A bigger bureau gives more prestige to its manager-director, and more power for managers over many subordinates (see Carnis (2009) for a more detailed analysis of this view). Interestingly both approaches, maximizing excellence and rents, are equivalent in our analysis under two mild conditions. In particular, this equivalence holds as long as $\delta = 1$ and the salary scheme just include the fixed wage for faculty candidates.

4.2 The symmetric case

Let suppose that both universities are symmetric, that is, they face the same cost of acquiring quality. This situation might illustrate those merging processes between nearby universities offering very similar degrees and with similar reputations. The following proposition summarizes the equilibrium result when both competing universities face the same cost of acquiring quality.

Proposition 4 *Let $a_1 = a_2 = a$ and $\delta = 1$. If $g < \underline{g}$ there is no equilibrium. If $g \geq \overline{g}$ there is a unique equilibrium in which $x_1^* = x_2^* = 1$.*

Proof. First, it is obvious that if $a_1 = a_2 = a$ then $\underline{g} = \overline{g} = 4(a+t)$. Now, let $g < \underline{g}$ Then, from (9) for $i = 1, 2$ there is no equilibrium. Finally, let $g > \overline{g}$. Then, from (10) for $i = 1, 2$ the unique equilibrium $x_1^* = x_2^* = 1$ arises. ■

That is, if both universities face the same cost of acquiring quality a, then there is a unique and symmetric equilibrium, i.e., $x_1^* = x_2^* = 1$ only if $g \geq \overline{g}$. The reason is the reward scheme designed by the funding agency. Note that universities, while competing for research funds, just have one device to get the maximum amount of the research grant -and hence maximizing excellence-. That is, its recruitment standard. In other words, each university can only take advantage by setting a higher recruitment standard than its competitor. In this setting, universities fully devote their efforts to attract as many faculty candidates as possible unless the research is highly rewarded. Hence the unique equilibrium emerge when the amount devoted to finance research is very high, that is, if $g \geq \overline{g}$. Observe that then, in equilibrium the excellence level of both universities coincide:

$$E_1^* = E_2^* = \frac{g}{2} - a. \tag{16}$$

Hence, it is immediate that the equilibrium aggregate excellence achieved in the competing setting, E_c, is equal to $g - 2a$. It is then easy to check that $E_m > E_c$ if $a_m < 2a$. That is, whenever there are synergy gains among competing institutions, the process of association among those established universities does result in a new institution with a higher aggregate excellence. This may simply be the result of exploiting the efficiency gains that arise by making a better use of joint resources and the elimination of duplication. In other words, this merging process can also be interpreted as a kind of reorganization procedure to reduce operational costs.

5 Concluding Remarks

Recently, universities around the world are encouraged to form "strategic alliances" that make them more visible and reputable internationally to better compete for talent and knowledge-related investment. In this paper we analyze whether or not such mergers are optimal in terms of aggregate excellence. In particular, we try to address whether the assumed synergy gains caused by a merger induce higher excellence than competition between those universities. A crucial point here is the ceasing of competition for resources and faculty candidates between universities.

We find that the interrelation between universities' ex-ante reputation, the amount of research funds and universities' strategic recruitment standard choice plays a key role in determining the success or failure of mergers. Our main finding is that the higher the heterogeneity between merging institutions the higher the amount of funds needed to make the merger profitable. We also find that the higher the heterogeneity between the competing universities the higher the aggregate excellence in equilibrium in this setting. The reason for this is that higher heterogeneity induces tougher competition between universities resulting in an increase in excellence for the most reputable university and a reduction in excellence for the least reputable one.

In this analysis we have taken a relatively conservative approach regarding the channels through which mergers enhance universities' rents. In particular, we have just considered their effects on local higher education markets. On the one hand, this assumption allows an intuitive discussion of the comparison between mergers and competition and on the other hand, it is the based on empirical facts regarding the proportion of both research funds and academics coming from abroad (see the Introduction). Thus, removing the specification proposed in this paper by considering the effects of merging on global markets will only reinforce our main results without adding further insights.

There are several extensions that can be considered here. The first one refers to study the role of the type of higher education institution, research versus teaching oriented, in the comparison between competing and merged universities. Second, we could incorporate the universities' initial reputation parameter as an additional factor influencing the proportion of research funds received by each university, p_i. Finally, we could also be analyzed the case where the funding agency finances universities both inside and outside its own region. It could be interesting to check which would be the universities' optimal strategy compete or merge, in this situation.

Finally we think the results presented here are relevant to several recent debates in the literature on university governance. This is especially relevant for Europe where some governments are implementing policies, and creating incentives for joint proposals among different universities, with the aim of changing the position of their higher education institutions in the current international hierarchy. Our results therefore provide support for policies that promote greater competition among universities whenever the heterogeneity between them is sufficiently high as long as the amount of resources is not very large. In addition our theoretical results yield two hypotheses to be tested empirically: the impact of the ex-ante reputation differences between universities and role of the amount of research resources in the success of eventual merging process.

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