The role of networks on the creation of graduate schools

Elena Del Rey*and Xavier Wauthy†

Work in progress. October 2003.

Abstract

This paper considers the problem of two competing universities having to choose how to launch a new program at the graduate level. There are two options with respect to the organization of the program, as the university can (i) "extend" the existing structure by adapting the teaching load of the teaching staff or (ii) create a doctoral school, which essentially requires the set up of a research center and the attraction of specific professors exhibiting serious publication records. The cost of hiring one such professor is decreasing in the number of professors of her type that the school is able to attract. This, in turn, depends on the ability to enrol a sufficiently large number of students, since only if the size of the program is large enough will the school be able to attract and retain a sufficiently large number of researchers of the required quality.

*Universitat de Girona, Spain.

†Facultés universitaires de Saint-Louis and CORE, Belgium.

Institutional support from the Spanish Science and Technology Ministry (Project SEC 2002-02606) and the IAP program of the Federal Government, under contract IAP 5/26 is gratefully acknowledged.

1 Introduction

Certain parties of the global budget to finance universities (in particular those relative to the aid for mobility of students and professors at the graduate level) may be subject in Spain to the previous concession of a hallmark certifying the high quality of the program taught by the institution.[1] The design of a program that deserves the hallmark is likely to entail higher costs. Indeed, the most relevant input to a doctoral program is a group of research professors of recognized prestige. In order to attract such professors, the university must be able not only to pay a sufficiently high wage, but also to offer a good research environment, i.e. the possibility to interact with colleagues who share similar interests.

The literature has identified the positive effects of creating social networks (links with other professionals) in discovering and applying innovations in firms (see, for instance Cooke and Wills, 1999; Erickson and Jacoby, 2003; Liebeskind, 1995). The existence of networks of this type within universities allows us to assess that the wage a university has to pay for a research professor is inversely related to the number of such professors that she is able to attract. On the other hand, hiring a large number of professors is only justified by the existence of a sufficiently large number of students. Hence, the potential size of the program becomes crucial when it comes to deciding whether to launch a doctoral school.

Alternatively, the university may choose to offer a graduate program that does not have the aforementioned quality hallmark. It is a less costly and less risky option. Graduate courses may be taught by simply adapting the teaching load of the existing undergraduate professors so that they can use part of their time to prepare the courses.

Under what circumstances will a university choose to incur the costs required to receive a quality hallmark? Before studying this issue we address a previous and important one: how many graduate programs must coexist in a unique jurisdiction? The answer to this question will allow us to shed some light on the real role of the quality hallmark as a way to optimize the use of resources devoted to higher education.

We first present the model in section 2. Then, in section 3, we identify the First Best student allocation given technology. Section 4 identifies possible equilibrium market partitions, i.e. student allocations such that no student has an incentive to change school. A problem of equilibrium multiplicity arises. In order to select an equilibrium when we have more than one we propose, in section 5, to select the one in which every student is better off. As we will see, this is not enough to eliminate the multiplicity problem. Section 6 provides preliminary conclusions.

2 The Model

We consider two universities A and B of quality q with $q_A > q_B$.[2] They both operate in the undergraduate market. At some point, they have to choose how to launch (if any) a new program at the graduate level.

There are two options with respect to the organization of such a program:

(i) "extend" the existing structure by adapting the teaching load of existing lecturers. The required lecturer/student ratio is given. We assume that it is always possible

[1] See BOE 12/17/2002.

[2] We could argue that such difference is due to a difference in sunk costs.

to hire these lecturers at wage w_g. Hence, the cost of giving this graduate diploma to n students is $C_g(n) = n\ w_g$ where g stands for graduate program.

(ii) create a doctoral school, which essentially requires the set up of a research center, with specific professors (exhibiting serious publication records). We assume the following preferences of a research professor:

$$U(w, n) = w + \Phi n$$

The key idea is that the willingness to accept a position is positively related to the size of the graduate program because of research spillovers with the students, other professors, etc. Assuming, that professors have reservation utility u we can solve the participation constraint $U(w, n) \geq u$ and obtain

$$w_d = u - \Phi n$$

The corresponding cost structure is $C_d(n) = n\ w_d$ where d stands for doctoral school, and w_d is the minimum wage a research professor will demand when the number of students is n.

There is a continuum of graduate students of mass N and ability a uniformly distributed in (a^-, a^+) with $a^- > 0$. We assume for simplicity that $a^+ - a^- = 1$. Their utility depends on the productivity gained through the program, which is a function of own ability, a, the quality of the university q_i and the number of fellow-students n_i. We therefore assume that graduate students benefit from size for the same reason professors do: interaction and research spillovers. The parameter $\beta \geq 0$ measures the size of this effect. We associate β with the doctoral school, thus assuming that spillovers are particularly relevant here. In contrast, $\beta = 0$ at the graduate school. Finally, if the university charges some tuition fee this enters negatively in the students utility function:

$$U = aq_i + \beta n_i - t_i \text{ for} i = A, B$$

3 First Best

In this Section we identify the first best allocation of students to graduate programs given the technologies. For this matter we assume that tuition fees, being only transfers from students to universities, have no effect on welfare.

Clearly, given $q_A > q_B$ university A has an advantage. Due to the specification of individual utility, welfare is maximized when higher ability students attend the higher quality program. The number of students attending A at the First Best is then $n_A = (a^+ - a^A)$. Similarly, $n_B = (a^A - a^B)$ is the number of students attending B.

3.1 Neither university chooses to have the doctoral school ($\beta = 0$)

The maximization of

$$W = \int_{a^A}^{a^+} aq_A da + \int_{a^B}^{a^A} aq_B da - (a^+ - a^A)\ w_g - (a^A - a^B)\ w_g$$

shows that $a^A = \frac{w_g}{q_A} < \frac{w_g}{q_B} = a^B$. Hence, if there is no doctoral school, the only graduate program is offered by A at the first best.

3.2 Only one school chooses to launch the doctoral program

Suppose now that only one of the universities has the doctoral school. From a welfare point of view, this should be A, since it generates a higher surplus.

We then assume that A has the β technology and check whether it will enroll every student or share the market with B.

Global welfare is now given by

$$\begin{array}{l} W = \int_{a^A}^{a^+} aq_A da + \beta(a^+ - a^A)^2 da + \int_{a^B}^{a^A} aq_B da \\ -(a^+ - a^A)w_d\left[a^+ - a^A\right] - (a^A - a^B)w_g \end{array}$$

We first study the shape of this welfare function.

$$foc(a^A) : -a^A\Delta q - (a^+ - a^A)2\beta + u - 2\Phi(a^+ - a^A) - w_g = 0$$

1. $\Delta q - 2(\beta + \Phi) > 0 : W$ concave

$$a^A_{FB} = \frac{u - w_g - 2a^+(\Phi + \beta)}{\Delta q - 2(\beta + \Phi)} < a^+ \Leftrightarrow u - w_g < a^+\Delta q$$

$$a^A_{FB} = \frac{u - w_g - 2a^+(\Phi + \beta)}{\Delta q - 2(\beta + \Phi)} > a^- \Leftrightarrow u - w_g > a^-\Delta q + 2(\Phi + \beta)$$

In this case, $a^B_{FB} = \frac{w_g}{q_B} > a^A_{FB}$, in which case, only the doctoral program is in the market iff

$$\begin{aligned} \frac{u - w_g - 2a^+(\Phi + \beta)}{\Delta q - 2(\beta + \Phi)} &< \frac{w_g}{q_B} \Leftrightarrow \\ q_B\left(u - w_g - 2a^+(\Phi + \beta)\right) &< w_g\left(q_A - q_B - 2(\beta + \Phi)\right) \\ \frac{uq_B - w_g q_A}{a^+ q_B - w_g} &< 2(\beta + \Phi) \end{aligned}$$

otherwise, **both programs are in the market.**

Without the network effect, the condition for A to be alone in this market is

$$\frac{u}{w_g} < \frac{q_A}{q_B}$$

the difference in costs must be smaller than the difference in quality. This condition is still sufficient since $a^+q_B - w_g > 0$ (otherwise B would not be in the market for sure). Still, this condition is no longer necessary, since $\frac{u}{w_g} > \frac{q_A}{q_B}$ can be compensated by a higher network effect.

2. $\Delta q - 2(\beta + \Phi) < 0 : W$ **convex**. If

$$\frac{w_g + 2a^+(\Phi + \beta) - u}{2(\beta + \Phi) - \Delta q} > a^+$$

W is decreasing over the domain (a^-, a^+) and the payoff is maximized at $a = a^-$: A will enroll all students (sufficient condition). This is the case if

$$\begin{aligned} u - w_g &< a^+ \Delta q \\ u - a^+ q_A &< w_g - a^+ q_B \end{aligned}$$

If, on the other hand

$$\frac{w_g + 2a^+ (\Phi + \beta) - u}{2(\beta + \Phi) - \Delta q} < a^- \Leftrightarrow u - w_g > a^- \Delta q + 2(\Phi + \beta)$$

Then A will not enter the market
In between, we need to compare the payoff at $a^A = a^+$ and $a^A = a^-$ to see what is best:

$$\begin{aligned} a^A &= a^+ : W_B = (a^+ - a^B)\left(\frac{a^+ + a^B}{2} q_B - w_g\right) \\ a^A &= a^- : W_A = \left(\frac{a^+ + a^-}{2} q_A + \beta - u + \Phi\right) \end{aligned}$$

$w_g > u - \Phi$ sufficient for doctoral school alone.

3.3 Both schools choose to launch a doctoral school

From a welfare point of view, both costs and networks effects are identical independently of who generates them. Still, A generates higher welfare due to her quality advantage. Hence, the payoff is always larger if A alone produces the doctoral program.

4 Candidate equilibria without tuition fees

Without tuition fees, universities are publicly financed and compete through the limiting admission grade. In other words, students agree on which school is best and they all apply there. This preferred university chooses who to accept or reject by setting a limiting admission ability below which students cannot enrol. Rejected students then apply to the second school since, at zero tuition, a worse school is better than no school.

Before analyzing the optimal choices of the universities, we rule out possible partitions of demand which are not compatible with student preferences. We consider the following 4 possible alternatives:

- competition between two doctoral schools (both universities choose technology β)
- competition between one doctoral school and a university offering some graduate program (we need to differentiate two subcases depending on whether A or B is the graduate school)
- competition between two universities offering graduate courses (none of them chooses the β technology)

4.1 Two doctoral schools

In this section we search for equilibrium partitions of demand among schools when both incur the cost to install the β technology (doctoral school).

4.1.1 A enrols the best, then B chooses among leftovers

This candidate partition implies that A enrols every $a \in (a^A, a^+)$ and B every $a \in (a^B, a^A)$. It must hence be the case that $a^A > a^B$ (otherwise B has a negative share). All admitted in A have to be willing to attend, otherwise $(a^+ - a^A)$ is not the real size of A. For this we need that the utility of the last admitted (student who derives less utility from attending A) is larger at A than B:

$$a^A q_A + \beta(a^+ - a^A)N > a^A q_B + \beta(a^A - a^B)N$$

$$a^A > \frac{-\beta(a^B + a^+)N}{(\Delta q - 2\beta N)}$$

which is always the case if $\Delta q - 2\beta N > 0$.

If $\Delta q - 2\beta N < 0$, the condition becomes

$$a^A < \frac{\beta(a^B + a^+)N}{2\beta N - \Delta q}.$$

This condition could in principle be violated for some a^B. Then it would not be true that all admitted at A prefer to attend there. Define

$$f(a^B) = \frac{\beta(a^B + a^+)N}{2\beta N - \Delta q}$$

if $a^A < f(a^B)$ the two schools share the market (S). On the other hand if $a^A > f(a^-)$ then it is for all a^B and partition S cannot take place.

$$f(a^-) = \frac{(a^+ + a^-)\,\beta N}{2\beta N - \Delta q} < a^+ \Leftrightarrow a^-\beta N < a^+\,(\beta N - \Delta q)$$

Never true if $\Delta q - \beta N > 0$ which is then a sufficient condition for $a^+ - a^A$, $a^A - a^B$ being an equilibrium partition.

Let us draw $f(a^B)$ when $\Delta q - \beta N < 0$. Whenever $a^A < f(a^B)$ S will be an equilibrium.

$$f(a^+) = \frac{2\beta a^+ N}{2\beta N - \Delta q} > a^+ \Leftrightarrow 0 > \Delta q$$

which is always the case. Then the constraint hits the 45 degree line above a^+. The slope of $f(a^B) > 1/2$.

If $a^A < f(a^B)$ not satisfied, then

$$a^A > \frac{\beta(a^B + a^+)N}{2\beta N - \Delta q}$$

$$a^A q_B + (a^A - a^B)\beta N > a^A q_A + \beta(a^+ - a^A)N$$

which is also satisfied for all $a > a^A$: school B faces all demand.

4.1.2 B takes the best and leaves no room to A

The admission requirements of B are so lax that the disadvantage in quality is overcome by size. There is no room for A. $a^+ - a^B, 0$

$a^A > a^B$. No-one has to have an incentive to deviate. In particular, the most able individual who would be the one to derive a larger benefit from leaving B in favor of A:

$$a^+ q_B + \beta(a^+ - a^B)N > a^+ q_A$$

$$a^B < \frac{a^+ (\beta N - \Delta q)}{\beta N} = cte$$

Note that $f\left(\frac{a^+(\beta N - \Delta q)}{\beta N}\right) = a^+$ (this helps for the drawing).

4.1.3 B takes the best then A chooses among leftovers

The partition of the market is then $a^+ - a^B, a^B - a^A$ and hence we need that $a^B > a^A$.

All admitted in B have to be willing to attend. This will be true if the individual who would most gain from moving to A prefers B:

$$a^+ q_B + \beta(a^+ - a^B)N > a^+ q_A + \beta(a^B - a^A)N$$

$$(a^A - 2a^B)\beta N > a^+ (\Delta q - \beta N)$$

$$g(a^A) = \frac{a^A \beta N - a^+ (\Delta q - \beta N)}{2\beta N} > a^B$$

This equilibrium is then possible if $g(a^A) > a^B$ (slope 1/2)

$$g(a^-) = \frac{a^+(\beta N - \Delta q)}{2\beta N} > a^-$$

so once again if $\beta N - \Delta q < 0$ it is never binding. When it is, the line $g(a^A)$ hits the 45 degree line at

$$\begin{aligned} \frac{a^A \beta N - a^+ (\Delta q - \beta N)}{2\beta N} &= a^A \\ g(a^A) &= \frac{a^+ (\beta N - \Delta q)}{\beta N} = a^A \end{aligned}$$

4.1.4 A takes the best and leaves no room for B

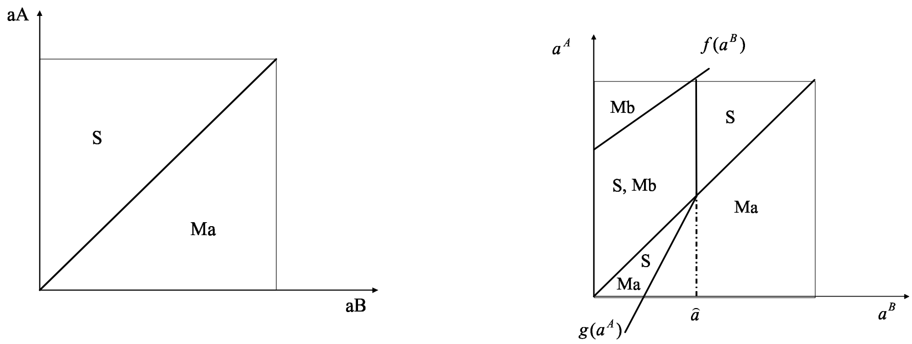
Finally it could be that A accepted so many applications that there were no room for B to make up for her quality disadvantage. In this case $a^A < a^B$. For this configuration to be stable we need that no student who would be able to enrol at B be willing to do so.

$$a^B q_B < a^B q_A + (a^+ - a^A)\beta N$$

$$0 < a^B\Delta q + (a^+ - a^A)\beta N$$

which is always the case for $a^A < a^B$. In this case A has both the quality and network advantage.

The following figure summarizes this subsection:



$\Delta q - \beta > 0$ $\Delta q - \beta < 0$

Figure 1

4.2 Only B chooses to launch the doctoral school

$$\begin{aligned} U_A &= aq_A \\ U_B &= aq_B + \beta n_B \end{aligned}$$

4.2.1 A takes the best and B chooses among leftovers

$a^A > a^B$. The last admitted at A has to be willing to attend A.

$$\begin{aligned} a^A q_A &\geq a^A q_B + \beta(a^A - a^B) \\ a^A(\Delta q - \beta N) &\geq -\beta N a^B \end{aligned}$$

always if $(\Delta q - \beta N) \geq 0$. If $(\Delta q - \beta N) < 0$ then we need that

$$\begin{aligned} a^A(\beta N - \Delta q) &\leq \beta N a^B \\ a^A &\leq \frac{\beta N a^B}{(\beta N - \Delta q)} = f'(a^B) \text{ iff } a^B \geq a^A \frac{\beta N - \Delta q}{\beta N} \end{aligned}$$

slope larger than 1, if $\dfrac{\beta N a^-}{(\beta N - \Delta q)} > a^+$ then not relevant.

4.2.2 B takes the best and leaves no room to A

partition $(0, a^+ - a^B)$ we need

$$\begin{aligned} a^+ q_A &\leq a^+ q_B + \beta(a^+ - a^B)N \\ a^+ (\Delta q - \beta N) &\leq -\beta a^B N \end{aligned}$$

impossible if $(\Delta q - \beta N) > 0$. Otherwise we need

$$a^+ \geq \frac{\beta a^B N}{\beta N - \Delta q} \text{ iff } a^B \leq a^+ \frac{\beta N - \Delta q}{\beta N}$$

4.2.3 A takes the best and leaves no room to B

$a^A < a^B$: partition $(a^+ - a^A, 0)$

$$a^A q_A \geq a^A q_B$$

is always possible

4.2.4 B takes the best and A chooses among leftovers

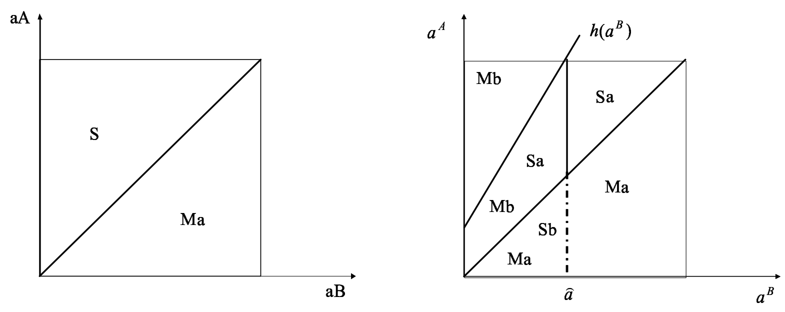
partition $(a^+ - a^B, a^B - a^A)$

$$\begin{aligned} a^+ q_A &\leq a^+ q_B + \beta(a^+ - a^B)N \\ a^+ \Delta q &\leq \beta(a^+ - a^B)N \\ a^+(\Delta q - \beta N) &\leq -\beta N a^B \end{aligned}$$

not possible if $\Delta q - \beta N > 0$, otherwise

$$a^+ \geq \frac{\beta N a^B}{\beta N - \Delta q}$$

The figure summarizes this subsection:



$\Delta q - \beta > 0$ $\Delta q - \beta < 0$

Figure 2

4.3 Only A chooses to launch the doctoral school

$a^A > a^B$

$$a^A q_A + \beta(a^+ - a^A)N \geq a^B q_B$$

partition $(a^+ - a^A, a^A - a^B)$ always possible

$a^A < a^B$

$$a^A q_A + \beta(a^+ - a^A)N \geq a^B q_B$$

same condition since B has the same technology as before (it doesn't matter how many admitted). Then partition $(a^+ - a^A, 0)$ always possible.

On the contrary, $(a^+ - a^B, a^B - a^A)$ and monopoly of B never possible.

4.4 Neither school launches the doctoral school

$U_A = aq_A$ and $U_B = aq_B$. Then $a^A > a^B$ always possible implies that they share the market and $a^A < a^B$ always possible implies that A is alone.

5 Selecting an equilibrium when there is multiplicity

What we want to do is "select" an equilibrium when two different ones can occur. The justification will be that a group of students is better off under one of the equilibria rather than the other so that a coalition can be formed that will destroy the latter.

There are two cases in which we have two equilibria, when there are two doctoral schools and when school B alone has a doctoral school (i.e. whenever B has a doctoral school).

5.1 Only B chooses to launch the doctoral school

The equilibrium market partitions are in this case summarized by Figure 2, where $h(a^B) = \dfrac{\beta a^B}{\beta - \Delta q}$ and $\hat{a} = \dfrac{a^+ \beta}{\beta - \Delta q}$.

5.1.1 A more selective

$a^A > a^B$

When $a^A < h(a^B)$ and $a^B < \hat{a}$ we can have two equilibrium configurations: either M^b or S^a(the schools share the market with A taking the best students). This implies that in any case students of ability $a \in (a^B, a^A)$ enrol at school B. The question is whether students with ability $a \in (a^A, a^+)$ are better off at B with the students that in any case attend this school or at A forming a selected group

$$\text{if } a\ q_A < a\ q_B + \beta(a^+ - a^B) \text{ for all } a \in (a^A, a^+)$$

then M^b is better. For this to be the case it is sufficient that it is true for $a = a^+$:

$$\frac{a^+\ (\beta - \Delta q)}{\beta} > a^B$$

which is the case in the relevant area. Then M^b *is* better.

5.1.2 B more selective

$a^B > a^A$

The two possible configurations are now M^a and S^b(schools share the market and school B has the best students). This implies that students of ability $a \in (a^A, a^B)$ enrol in any case school A. As for students with $a \in (a^B, a^+)$, if

$$aq_A < aq_B + \beta(a^+ - a^B)$$

they will be better off at S^b. Once again it is enough that B preferred by a^+. The condition is the same as before and it is again sufficient for it to be satisfied that $a^B < \dfrac{a^+ \ (\beta - \Delta q)}{\beta}$ which is indeed the case.

The right hand side of Figure 1 becomes then:

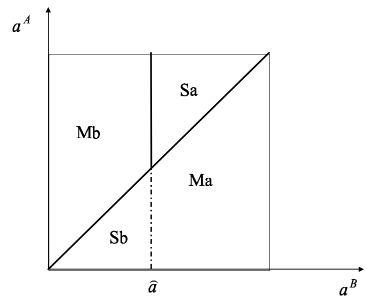


Figure 3

5.2 Two doctoral schools

Recall the equilibrium partitions in this case, summarized in Figure 1, where $\hat{a} = \dfrac{a^+(\beta - \Delta q)}{\beta}$, $f(a^B) = \dfrac{\beta(a^B + a^+)}{2\beta - \Delta q}$ and $g(a^A) = \dfrac{a^A\beta - a^+ (\Delta q - \beta)}{2\beta}$.

5.2.1 B more selective

$a^B > a^A$

The two possible configurations are now M^a and S^b(schools share the market and school B has the best students). This implies that students of ability $a \in (a^A, a^B)$ enrol in any case school A. As for students with $a \in (a^B, a^+)$, if

$$aq_A + \beta(a^+ - a^A) > aq_B + \beta(a^+ - a^B)$$

they will be better off at M^a. Since $q_A > q_B$ and $a^A < a^B$ this is always the case. Therefore, "below the diagonal" the (strong Nash?) equilibrium is unique (M^a).

5.2.2 A more selective

$a^A > a^B$

When $a^A < f(a^B)$ and $a^B < \frac{a^+ (\beta - \Delta q)}{\beta}$ we can have, as before, two equilibrium configurations: either M^b or S^a(the schools share the market with A taking the best students). This implies that in any case students of ability $a \in (a^B, a^A)$ enrol at school B. The question is whether students with ability $a \in (a^A, a^+)$ are better off at B with the others or at A alone (not alone, the group) when both schools have the *technology* β:

$$a\ q_A + \beta(a^+ - a^A) > a\ q_B + \beta(a^+ - a^B) \text{ for all } a \in (a^A, a^+)$$

then S^a is better. Sufficient that true for a^A :

$$a^A\ \Delta q + \beta(a^B - a^A) > 0 \Leftrightarrow a^A < \frac{a^B \beta}{\beta - \Delta q}$$

However, $\frac{a^B \beta}{\beta - \Delta q} < f(a^B)$:

$$\frac{a^B \beta}{\beta - \Delta q} < \frac{\beta(a^B + a^+)}{2\beta - \Delta q} \Leftrightarrow a^B < \frac{a^+ (\beta - \Delta q)}{\beta}$$

which is the case in the relevant area. Note also that the line $a^A = \frac{a^B \beta}{\beta - \Delta q}$ has slope larger than 1. At $a^B = \frac{a^+ (\beta - \Delta q)}{\beta}$, it equals a^+. Then, there is an area between $f(a^B)$, of slope smaller than1 and also with $f(\hat{a}) = a^+$, and $a^A = \frac{a^B \beta}{\beta - \Delta q}$ in which S^a nay not be the preferred configuration.

Let us see what is sufficient for M^b to be preferred:

$$\begin{aligned} a^+ \Delta\ q &< \beta(a^A - a^B) \\ a^A &> \frac{a^+ \Delta q + \beta a^B}{\beta} \end{aligned}$$

This line is once again equal to a^+ at $a^B = \hat{a}$. Its slope, 1, is larger than that of $f(a^B)$, although smaller than that of $a^A < \frac{a^B \beta}{\beta - \Delta q}$. As a result, there is an area in which either configuration may be preferred.

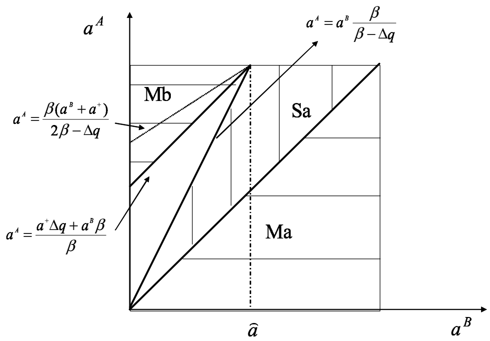


Figure 4

Using a more restrictive concept of equilibrium does not allow to eliminate the possibility of multiple equilibria when both schools launch the doctoral program.

6 Concluding comments

We have seen that, at the first best, if there is a doctoral school, it is in the highest quality university. We have identified conditions for two different kinds of graduate programs to share the market. If only one of the programs is optimal (either the doctoral program or the master program but not both) then the highest quality university should be in charge of it.

Decentralized equilibria may differ from the first best in several aspects. Although we need to address this issue rigorously, we can anticipate the following deviations from the first best at the decentralized equilibrium as preliminary results.

First, when the high quality university holds the monopoly of graduate education it can be that in fact the program is not socially profitable or that, being socially profitable, it is actually not in place. Second, the low quality university may hold the monopoly of graduate education. In this case, there is clearly room for a Pareto improvement by moving every student to the high quality university.

Notice that the differentiation, by means of a quality hallmark, of the university enjoying a quality advantage may compel the realization of all the deviations just mentioned. Thus, it may induce an equilibrium type that, given the assumptions of our model, we have identified as first best. Among such assumptions, the complementarity among individual ability and educational quality in the generation of social surplus and the role played by network effects deserve to be mentioned.

References

[1] BOE 17-12-2002. Orden 18 de noviembre de 2002. Ministerio de Educación, Cultura y Deportes.

[2] Cooke, P.; Wills, D. (1999): Small Firms, Social Capital and the Enhancement of Business Performance through Innovation Programmes. Small Business Economics, Nov 01, Vol. 13, Issue 3, p 219.

[3] Erickson, C.L. and Jacoby, S.M. (2003): The Effect of Employer Networks on Workplace Innovation and Training. Industrial and Labor Relations Review, vol 56 no2 pp 203-224.

[4] Liebeskind, J.P. (1995): Social Networks, Learning, and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms; National Bureau of Economic Research Working Paper: 5320.