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Why business schools do so much research: A signaling explanation

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ABSTRACT

Criticism is mounting on business schools for their excessive focus on research and the relative neglect of teaching quality. This paper shows that if students have imperfect information about teaching quality and if business schools differ in their research productivity, the least productive schools would do as much research as the top-tier ones only to manipulate students' expectations. In turn, the most productive schools might resort to excess research in order to signal their type in the eyes of prospective students. Since resources are limited, they also tend to neglect teaching quality. Such a situation is socially inefficient as compared to the perfect information case.

1. Introduction

The ongoing development of the service sector in the Western economies and the increased competition between firms in a globalized world brought about a substantial demand for high quality managerial skills. This transformation helped Business Schools [B-Schools, thereafter] to become important players in the education sector. While in the 1950s their main purpose was to provide basic, professionally oriented education, these days scholarship and research become essential dimensions of their mission such as understood by society and by themselves. Furthermore, with the deeper programme standardization and the reduced mobility costs for students, the market for business education itself became global. Since a school's reputation is connected to its research performance (Armstrong, 1995; Becker et al., 2003), B-Schools have no other choice than to compete on this dimension too (Kwok and Arpan, 2002). In the last few years, B-Schools seem to have engaged in a genuine academic reputation race (Van Vught, 2007).

The growing enthusiasm of B-Schools for theoretical advances has recently been subject to criticism. This is not a surprise: such a strategic orientation towards maximizing academic prestige requires substantial investment in traditional research inputs (human capital, physical capital, data and information) and the returns are difficult to measure. A recent report of the Association to Advance Collegiate Schools of Business (AACSB) – an influential US accreditation agency for B-Schools – summarizes well the widespread popular grief: "business schools have recently been criticized for placing too much emphasis on research relative to teaching, and for producing research that is to narrow, irrelevant and impractical" (AACSB, 2008, p. 10). The criticism sounds louder with respect to the top institutions. For instance, Bennis and O'Toole (2005, p. 98) claim that: "many leading B-Schools have quietly adopted an inappropriate – and ultimately self-defeating – model of academic excellence. Instead of measuring themselves in terms of the competence of their graduates, or by how well their faculty understand important drivers of business performance, they measure themselves almost solely by the rigor of their scientific research".

This criticism is twofold. On the one hand comes the issue of social utility or relevance of research. On the other hand, comes the idea that too much research drains resources from the other essential activity of B-Schools that is business education. It is beyond the scope of this paper to address the important topic of the relevance for practitioners and firms of the research carried out by B-Schools. We just can notice that, as highly ranked academic papers present more generally a fundamental than an applied nature, the reputation race probably will stimulate a type

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of research that might be considered as poorly relevant from a professional point of view. This does not mean that this type of research is necessarily socially inefficient, insofar it could nourish future applied research.[1]

With respect to the second type of criticism, Laband and Tollison (2003) have pointed out that the huge increase of the investment in academic research is carried out to the expense of time and effort that could have been devoted to providing education. If there is such a thing as a socially optimal level of research and education, any form of over-investment in research should come with some form of under-investment in education. Some authors have argued that excess research can be a Nash equilibrium strategy in a game where each dean pushes his faculty to target the top-tier journals, although such a strategy generalized across schools harms the quality of the top-tier journals and pushes down the return from publishing (Besancenot and Vranceanu, 2008; Besancenot et al., 2009). Other explanations put forward some form of deans' irrationality, who, being fascinated by rankings, would become unable to perceive what firms and students really need (e.g., Pfeffer and Fong, 2002; Bennis and O'Toole, 2005).

Without aiming at answering whether business research is excessive indeed, in this paper we put forward a set of necessary conditions for such a configuration to emerge. Our model builds on a traditional signaling game with imperfect information.[2] The business education sector features two types of schools that differ only in the publication productivity of the representative professor. Teaching productivity is similar, and so is the number of professors. We refer to the highly efficient ones as *H*-schools, and to the less efficient ones as *L*-schools. Students, who value both teaching quality and faculty publications, cannot directly assess the quality of education. In a perfect information set-up, *H*-schools would deliver better research and education than *L*-schools and could command higher fees. In an imperfect information set-up, publication can be used by schools strategically. In particular, a *L*-school could choose to deliver as much research as the *H*-schools, only to appear in the eyes of the prospective students as a *H*-school. By so doing, they neglect teaching quality. This situation can prove to be extremely detrimental not only to students, but also to *H*-schools that can get smaller fees than in a perfect information framework. Depending on parameter values, it may become interesting for *H*-schools to provide such a high level of research that *L*-schools cannot give suit. It will be shown that, in a static framework with a predetermined distribution of schools, the game presents several equilibria, most of them characterized by an excessive amount of research as compared to the perfect information case. An equilibrium is defined as a situation where schools implement their optimal research strategies given students' beliefs and students' beliefs are correct given the optimal strategies of the schools.

While plausible, our assumptions are not innocuous and deserve further scrutiny. A crucial assumption is that teaching quality cannot be observed by prospective students. Diamond (1993) notices that the debate on whether teaching quality is observable or not can be traced back at least to Adam Smith, who suggested to modulate teachers' pay according to their performance in the classroom. Nowadays, B-Schools all have implemented systems of student evaluations aiming to survey students' satisfaction about a course, and deans tend to assign them substantial weight when deciding on bonuses or promotions (Forbes and Paul, 1991). However, it is not clear what student evaluation really measure. Probably, they do capture the communication skills of the professor, whether he starts on time, is nice, open-minded, has humor, etc. but might not measure the relevance or the intrinsic value of the transmitted knowledge. To quote Paul and Rubin (1984, p. 143), "in most disciplines, students are, by definition, incapable of judging the 'state of the art' or of determining the 'usefulness' of the material presented in class". More recently, Weinberg et al. (2008) use data from economics courses at Ohio State University, and conclude that students cannot gauge the amount of human capital produced in class. True, many formal aspects of teaching can be observed (textbooks, cases, teaching material), but less so the quality of the curriculum, i.e. whether it is really adapted to the new challenges for tomorrow managers, whether it takes into account the most relevant theories, whether it uses the most efficient teaching methods. Even if prospective students have access to several sources (Internet, newspapers, magazines) providing information about the teaching quality of Business Schools such as assessed by alumni or recruiters, one cannot discard the fact that "faculties often have better information about what students will find useful than the students themselves, or even recruiters" (Demski and Zymmerman, 2000, p. 343).

The assumption according to which the publication record of a given school is public information is also quite plausible. Many bibliometric measures are available and media, researchers and administrations use them to compile annual rankings and evaluations of various schools and departments. Schools themselves advertise loudly about their research credentials and achievements. Some empirical studies have put forward that a school's research performance has an impact on the prospective students decision to joint that school and pay high tuition fees (Siow, 1997; Becker et al., 2003). Such correlation suggests that information conveyed by standard measure of research performance reaches future students.

Paul and Rubin (1984) argued that publishing one paper in a refereed journal allows to signal that a professor keeps the pace with the latest advances of the field, and therefore can serve deans as a signal for teaching quality. In turn, this would explain why the first publication is in general associated to a high increase in a professor wage than subsequent publication. This argument does hold only if research and teaching were positively correlated, and this whatever the level of teaching: undergraduate, graduate and doctoral. The belief that research and teaching are complements is strong among professors themselves and was at the heart of the reform of the Prussian University undertaken by W. Von Humboldt at the beginning of the 19th century. Yet the debate on whether research and teaching are substitutes, complements or orthogonal activities is far from being been closed (Marsh and Hattie, 2002). Hattie and Marsh (1996) surveyed the empirical literature on this subject (58 papers and 498 correlations) and show that the overall correlation is as small as 0.06. Our model builds on the simplifying assumption according to which at the school's production level, research and teaching are orthogonal activities, i.e. the time spend on research does not affect teaching quality and vice versa. If we further assume that production of publications and teaching quality is realized with constant marginal returns to working hours, the production frontier between teaching quality and research is a straight line, with a negative slope that illustrates that faculty total hours is a scarce (predetermined) resource. Yet the structure of our model would not be altered if we allow for a more sophisticated technology, including one where research and teaching are complements.[3] In this case the production frontier would be concave; this would not alter the

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[1] Starting with the pioneering work by Hamilton (1990, 1991), a vast strand of research discusses the social efficiency of scientific research. See Laband and Tollison (2003) or Van Dalen and Klamer (2005) for an analysis of this topic as applied to economics.

[2] This analytical framwork can be traced back to Spence (1973). See also Spence (2002) and Vickers (1986).

[3] See Becker (1975) for a static model with a flexible research-teaching technology and El-Ouardhighi and Vranceanu (2008) or Besancenot and Faria (2008) for a dynamic approach.

incentive for a less research efficient school to imitate the research strategy of the more productive school.

The model is highly stylized, and its conclusions are not independent of our assumptions. In particular, the model is static, hence its strongest policy implications are meaningful in the short run. In the long run some of the one-period equilibria might not exist. Indeed, it seems reasonable to assume that scholars with a high research productivity are entitled to a better wage than the less productive one; they are thus more expensive for the schools who hire them.[4] Yet in all the short-run equilibria of this game but the signaling one, *L*-schools and *H*-schools get identical tuition fees. In a competitive market this might push schools to modify their hiring strategies, and the differences between them could finally disappear. For sure, this outcome should be qualified, since the education market is not purely competitive and the tie between tuition fees and a school resources is sometimes very loose.

It should also be noticed that in business education, interactions within students matter as much as interactions between students and professors. Hence, selectivity is a key determinant of the quality of a programme. In order to focus on the signaling issue, we will not address this important issue in this paper and consider that the number of students per school is exogenously given.

Finally, in this paper we have focused on the consequences of using research as a signal for teaching quality. Several other signals can help to overcome the informational asymmetries in the higher education sector. Tuition fees, the average income of the graduates, the value-for-money rating, strong branding activities can be used as indirect signals for teaching quality. It would be difficult to build a model where all these signals are brought into the picture. Yet our methodology could be applied to analyze the impact of any other such a signal.

The paper is organized as follows. The next section introduces the basic assumptions and presents the benchmark perfect information case. The equilibria of the game are analyzed in Section 3, first in the large productivity gap and then in the small productivity gap case. The last section presents the conclusion.

2. Main assumptions

In the short run the number of B-Schools is predetermined and will be normalized to one. The number of students that a school can recruit is given, and is equal across schools. All schools deliver a standardized degree, for instance an MBA; the curricula contains a fixed number of hours. All schools dispose of a identical, fixed endowment in faculty work hours, l. Faculty members can use their working time either to do research, l_R, or to improve the teaching quality, l_T. The measure of quality in teaching is a continuous variable T. The teaching quality depends on the hours l_T, spent by the faculty on pedagogical innovation and programme development. In the simplest framework, getting one teaching quality unit requires a_T hours of work, i.e. $a_T T = l_T$. When it comes to research, let R be the amount of research produced by a school.[5] The production of research is also assumed to be a linear function of the time devoted to this activity: $a_R R = l_R$, with a_R a fixed production coefficient representing the number of hours needed to produce one research unit.

We assume that scholars differ in their research productivity. Let a_R^τ denote the number of hours needed to produce one research unit by a type τ scholar. There are two types of scholars, H and L, with $a_R^H < a_R^L$, the H-scholar is more productive (i.e. needs less time to produce one research unit).

Over the relevant time period (short-run), the schools' endowment or wealth is predetermined. To keep the model as simple as possible, we consider that the population of schools may split into *H*-schools characterized by a high wealth and *L*-schools characterized by a low wealth. *H*-schools are able to recruit the more expensive *H*-type scholars and *L*-schools recruit only *L*-type scholars. Hence, we have two types of schools either, the *H*-school, with a high research potential and the *L*-school, with a low research potential. The type τ is thus representative of both the school and its faculty. We denote by q the frequency of *H*-schools in the population of schools.

Remark that in this paper schools differ only in the faculty research productivity, if all their writing hours were used for improving teaching quality, all schools would perform identically. To the contrary, if all their working time l is used for research, the total volume of research is bigger for *H*-schools than for *L*-schools: $l/a_R^H > l/a_R^L$.

Under these assumptions, for a type τ school, the hour constraint is:

$$a_R^\tau R + a_T T = l, \quad \text{with} \tau \in \{L, H\}. \tag{1}$$

To this constraint corresponds a "production frontier" made up of possible bundles (T, R) to be obtained with the amount of hours l. To further simplify notation, we set $a_T = 1$ and $l = 1$. We represent in Fig. 1 two production frontiers (one for each type of school τ) in the plane $\{OT, OR\}$ as straight lines of slope $-(1/a_R^\tau)$. When all resources are used to improve education quality, the latter is $l/a_T = 1$; when all resources are used for research, *H*-schools produce $1/a_R^H$ research units and L schools produce $1/a_R^L$ research units. Notice that along the production frontier of a school τ, a given level of research R implies a level of education $T^\tau(R)$, with $\tau = H$ or L.

As already mentioned in Section 1, the structure of the model would not change should we allow for a more sophisticated technology. In particular, if research and teaching are complementary activities and/or the marginal return to hours invested in each activity is decreasing, production frontiers would be quasi-concave; nevertheless, the production set of the more efficient school would still encompass the production set of the less efficient one, which is the only analytical element required for our demonstration.

There is no need to argue long that students value top quality teaching, since their human capital is directly related to this variable. When choosing their schools, students take into account a wide range of criteria. Many factors such as the geographical proximity, cultural ties or first-rate athletic programmes may bear on

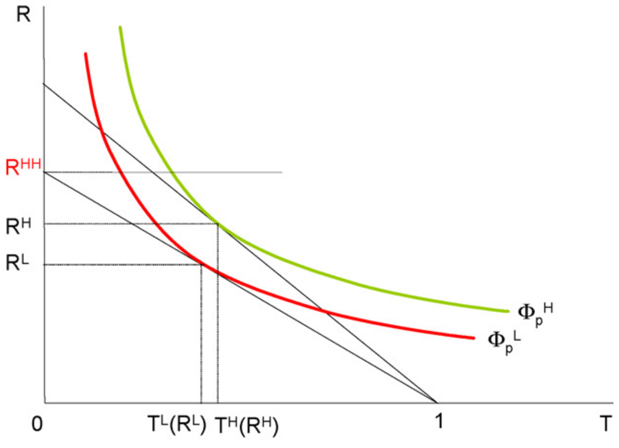

Fig. 1. The perfect information case.

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[4] These scholars probably have better outside opportunities (Faria, 2001; Coupé, 2004; Besancenot and Vranceanu, 2008).

[5] There is no need to be very specific about how this measure is obtained; in general research is assessed by the contribution of the school to the intellectual debate, which may take the form of papers, books and other publications, interviews, etc.

their decision. Yet among the many factors that attracts students to a school, the most important one is institutional prestige or reputation. As pointed out by Bok (1986), best students are drawn to the institutions characterized by a high faculty reputation, a high quality of the group of students, or the most successful graduates' career. Academic research contributes then to a school reputation trough its positive effects on the perception of business schools by recruiters, media and applicants. Mitra and Golder (2008), analyzing a panel of 57 B-Schools over 18 years, have put forward that, in the long run, an increase of the schools scientific production affects significantly both the selectivity of admission and the graduates' average starting salary. Even when research is of limited direct value for them, students are attracted by B-Schools with a high research performance.

To keep the model as simple as possible, our analysis abstracts from the second-order motives and assumes that the arguments of the students' utility function are only the quality of teaching and the level of research (Armstrong, 1995; Becker et al., 2003; Demski and Zimmerman, 2000; AACSB, 2008). Students' utility is thus $U(R, T)$, with $(\partial U(,)/\partial T) > 0$, $(\partial U(,)/\partial R) > 0$ and entailing convex indifference curves.[6] Schools can charge tuition fees such that the expected surplus of the students is zero. So tuition fees are $\Phi(R) = E[U(R, T^{\tau}(R))]$ with $\tau = H$ or L. Under these assumptions, in a perfect information set-up, schools would simply choose the bundle (R^{τ}, T^{τ}) that maximizes tuition fees given their hour constraint, such as indicated in Fig. 1.

More precisely, the optimal amount of research under perfect information are R^L (for the L-school) and R^H (for the H-school). The connected teaching qualities are $T^L(R^L)$ and respectively $T^H(R^H)$. Tuition fees are equal to student's willingness-to-pay for the observed service levels, $\Phi_p^L = U(R^L, T^L(R^L))$ for the L-school and $\Phi_p^H = U(R^H, T^H(R^H))$ for the H-school, where the p subscript indicates the perfect information case. In Fig. 1, we represented a situation where $T^L(R^L) < T^H(R^H)$. This is not a necessary condition and our analysis also holds in the opposite case, $T^L(R^L) > T^H(R^H)$. However, the former case, where teaching is a "normal" good and the income effect offsets the substitution effect seems to be the most plausible.

The assumption of perfect information – useful for introducing the basic notation – is not very realistic given that an education programme can be seen as a very complex commodity. So, in order to build our model on a logic of imperfect information, we need several additional assumptions. We will assume that research is an observable variable, that can be measured by standard indicators (quality adjusted number of publication, number of citations, etc.). Students can also assess the formal aspect of education (classes' sizes, teaching material, library facilities, etc.) however they have no means to assess whether the content is relevant, up-to-date, original, innovative, etc. In other words, the quality of teaching is private information to the school. Furthermore, students know the distribution of types of schools.

In an imperfect information set-up, the set of strategies is more sophisticated. A L-school may deliver its perfect information research level R^L; it can also play R^H, the perfect information research level of the H-school. A H-school can produce its perfect information research level R^H; if they want to make sure that L-schools do not imitate them, they should produce a so high amount of research that a L-school cannot deliver it (recall that L-schools have a lower research productivity). Let us denote by R^{HH} this lowest level of research unattainable by a L-school (see Fig. 1), R^{HH} is the second research strategy available for a H-school. Notice that a H-school would never play R^L, because it has no interest to go for a L-school.[7]

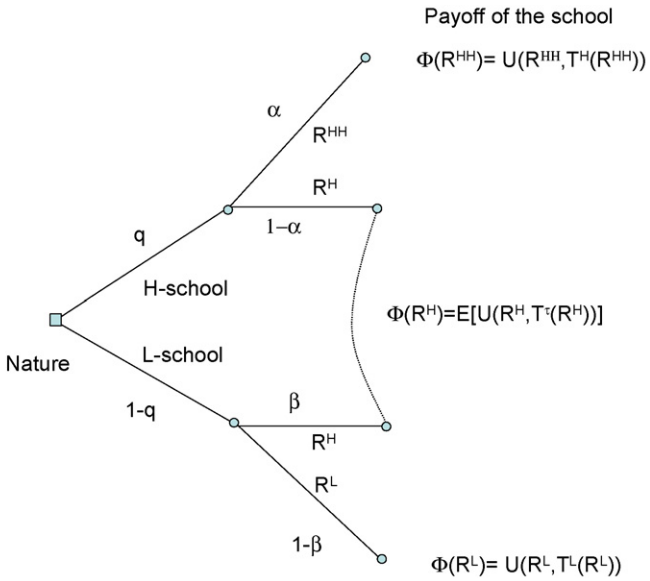

Fig. 2. The decision tree.

For a research level $j \in \{L, H, HH\}$, a school's payoff is $\Phi(R^j) = E[U(R^j, T^{\tau}(R^j))]$. Notice that research levels R^{HH} and R^L reveal perfectly a school's type. Thus $\Phi(R^{HH}) = U(R^{HH}, T^H(R^{HH}))$ and $\Phi(R^L) = U(R^L, T^L(R^L))$. Students' expected payoff given the school's research strategy R^j are $E[U(R^j, T^{\tau}(R^j))] - \Phi(R^j) = 0$.

Fig. 2 presents the decision tree. The typical *sequence of decisions* goes like this:

- Step 0, Nature chooses the type of school, either L or H.
- Step 1, depending on their type, schools chose their research strategy.
- Step 2, students make their opinion about the type of school given the observed level of research and pay a tuition fee equal to their expected utility.

The curve that relates the dots for a strategy R^H indicates that the student who observe this strategy cannot infer without ambiguity whether the strategy was implemented by a H- or a L-school.

3. Equilibria

3.1. Definition and types

An equilibrium of this game is defined as a situation where schools research strategies are optimal (allow them to charge the largest fees) given students's beliefs about the type of school, and students' beliefs are correct given schools' optimal strategies. As is often the case with these games, we may distinguish between a separating equilibrium, where the strategy of the schools perfectly reveals their type, a pooling equilibrium where all schools implement the same strategy and thus no information about the type of school can be inferred from the observed research strategy, and hybrid equilibria wherein schools play Nash mixed strategies and their strategy carry some but not full information about their type.

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[6] A specific utility function featuring these two arguments can be worked out if students care about their discounted flow of income. School's reputation or research should have a strong impact on the first period wage (with decreasing weights on next periods) and education, by enhancing student's productivity, has a substantial impact on lifetime wages.

[7] It could be shown that all other strategies are dominated.

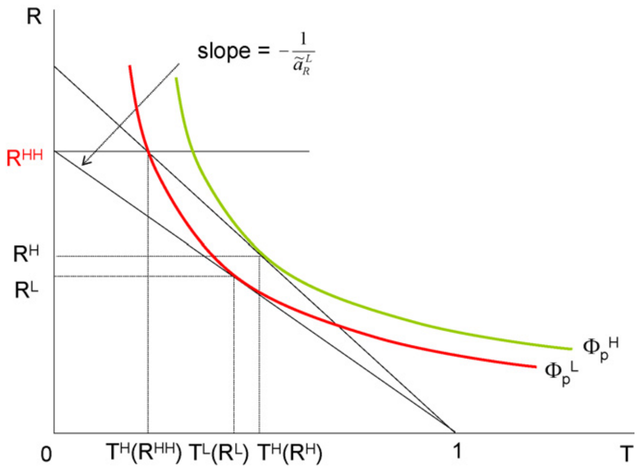

Fig. 3. The critical threshold.

Before turning to analyzing the various equilibria, we would first notice that if the *L*-school cannot implement the perfect information optimal research level of the *H*-school, the prevailing equilibrium is of the separating type: each school is delivering its perfect information optimal amounts of research and education quality. In order to rule out this trivial case, we assume that *L*-schools have the resources to deliver the amount of research R^H, or, with former notations, that $R^{HH} > R^H$ (see Appendix A—case 1 for the formal proof).

We also must call attention on a critical value of a_R^L, denoted by $\tilde{a}_R^L$ and implicitly defined by the equation $U(R^{HH}, T^H(R^{HH})) = U(R^L, T^L(R^L))$, such as represented in Fig. 3. In other words, there is a value of a_R^L such that *H*-schools that implement the signaling strategy get the same payoff as *L*-schools that signals themselves by implementing the perfect information optimum of research (see Appendix B for the formal proof).

Furthermore, for $a_R^L > \tilde{a}_R^L$, what we refer to as the "strong productivity gap" case, we have $U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH}))$, or:

$$U(R^H, T^L(R^H)) < U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH})) < U(R^H, T^H(R^H)). \quad (2)$$

In the opposite case of "moderate productivity gap", which occurs if the two type of scholars do not differ too much in their research productivity, that is if $\tilde{a}_R^L > a_R^L > a_R^H$, we check that $U(R^L, T^L(R^L)) > U(R^{HH}, T^H(R^{HH}))$, or:

$$U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L)) < U(R^H, T^H(R^H)). \quad (3)$$

We recall that $U(R^H, T^L(R^H)) < U(R^L, T^L(R^L))$.

The range of possible equilibria depends to a large extent on this research productivity gap. We study firstly the strong productivity gap case, then turn to the moderate productivity gap case.

3.2. *The strong productivity gap case: $\tilde{a}_R^L < a_R^L$*

The strong productivity case corresponds to a situation where faculty research productivity in the *L*-schools is low enough, that is the time to produce one paper is larger than the critical value: $a_R^L > \tilde{a}_R^L$. We have shown that in this case the critical utilities can be ranked: $U(R^H, T^L(R^H)) < U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH})) < U(R^H, T^H(R^H))$.

3.2.1. *Pooling equilibrium: all schools do R^H*

We first can put forward the existence of a pooling equilibrium where all schools play R^H. The *L*-school does R^H (it imitates the efficient production of research of a *H*-school) and the *H*-school decides not to signal itself by doing R^{HH} (it chooses the amount R^H). Denoting a school's strategy as a function of its type by $s(\tau)$, in this equilibrium schools' optimal strategies are $s(\tau) = R^H, \forall \tau \in \{H, L\}$.

Let us denote by $Pr[\tau|R^j]$ the probability students assign to the event that a school is of type τ (with $\tau \in \{H, L\}$) if the research strategy is R^j, with $j \in \{HH, H, L\}$. Students' equilibrium beliefs can be written as

$$\begin{cases} Pr[H|R^{HH}] = 1 \\ Pr[H|R^H] = q \quad , \\ Pr[H|R^L] = 0 \end{cases} \quad (4)$$

with probabilities $Pr[L|R^j]$ being complements to $Pr[H|R^j]$.

Necessary conditions for this equilibrium are:

$$\begin{cases} \Phi(R^{HH}) < \Phi(R^H) & \text{for the } H\text{-school} \\ \Phi(R^L) < \Phi(R^H) & \text{for the } L\text{-school} \end{cases} . \quad (5)$$

Since $\Phi(R^L) < \Phi(R^{HH})$ because $U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH}))$, the equilibrium exists under the single condition $\Phi(R^{HH}) < \Phi(R^H)$. In turn, this implies that the frequency of *H*-schools is high enough:

$$\begin{aligned} &\Phi(R^{HH}) < \Phi(R^H) \\ &\Leftrightarrow U(R^{HH}, T^H(R^{HH})) < E[U(R^H, T^\tau(R^H))] \\ &\Leftrightarrow U(R^{HH}, T^H(R^{HH})) < qU(R^H, T^H(R^H)) + (1-q)U(R^H, T^L(R^H)) \\ &\Leftrightarrow q > q_1 \equiv \frac{U(R^{HH}, T^H(R^{HH})) - U(R^H, T^L(R^H))}{U(R^H, T^H(R^H)) - U(R^H, T^L(R^H))}. \end{aligned} \quad (6)$$

Given that $U(R^H, T^L(R^H)) < U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH})) < U(R^H, T^H(R^H))$, we know that $q_1 \in [0, 1]$. So this equilibrium exists if the frequency of *H*-schools is large enough. If there are not too many *L*-schools, they become "invisible" in the mass of *H*-schools by implementing the same research strategy, to the expense of their teaching performance; furthermore *H*-schools have no incentive to signal themselves by increasing the amount of research, this strategy is too expensive.

3.2.2. *Signaling equilibrium: L-schools do R^L and H-schools do R^{HH}*

We can show that a separating equilibrium with signaling, where *H*-schools deliver the "signaling" level of research R^{HH} and *L*-schools produce their efficient level, is always possible. In this equilibrium, schools' strategies are:

$$\begin{cases} s(H) = R^{HH} \\ s(L) = R^L \end{cases} . \quad (7)$$

Equilibrium beliefs:

$$\begin{cases} Pr[H|R^{HH}] = 1 \\ Pr[H|R^H] = 0 \quad . \\ Pr[H|R^L] = 0 \end{cases} \quad (8)$$

This equilibrium is feasible under the necessary conditions:

(a) For the *L*-school, the condition $\Phi(R^L) > \Phi(R^H)$ is always true, given that $\Phi(R^H) = Pr[H|R^H]U(R^H, T^H(R^H)) + Pr[L|R^H]U(R^H, T^L(R^H))$ and $U(R^L, T^L(R^L)) > U(R^H, T^L(R^H))$.
(b) For the *H*-school, the condition $\Phi(R^{HH}) > \Phi(R^H)$ is equivalent to $U(R^{HH}, T^H(R^{HH})) > U(R^H, T^L(R^H))$. Because in the case under scrutiny $U(R^H, T^L(R^H)) < U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH})) < U(R^H, T^H(R^H))$, this last condition is true.

In this case, the excessive research strategy implemented by the H-school implies that their education falls below their efficient education level, $T^H(R^{HH}) < T^H(R^H)$. Their education quality level may even be lower than the education level of L-schools.

3.2.3. Hybrid equilibrium 1: high excess research

In this equilibrium, some H-schools decide to signal themselves by playing R^{HH}, and the other H-schools do not (they play R^H). In this case, L-schools may want to copy them and play R^H.

Denoting by $\sigma()$ a Nash mixed strategy, schools' equilibrium strategies can be written as

$$\begin{cases} \sigma(H) = \{\alpha R^{HH} + (1-\alpha)R^H \mid \alpha \in [0, 1]\} \\ s(L) = R^H \end{cases}. \tag{9}$$

where α is the fraction of H-schools playing R^{HH}.

Using Bayes rule, and denoting by $Pr[R^j|\tau]$ the probability that a school of type τ plays strategy R^j, equilibrium beliefs can be written as

$$\begin{cases} Pr[H|R^{HH}] = 1 \\ Pr[H|R^H] = \dfrac{Pr[R^H|H]Pr[H]}{Pr[R^H]} = \dfrac{(1-\alpha)q}{(1-\alpha)q + (1-q)} \\ Pr[L|R^L] = 1 \end{cases}. \tag{10}$$

In equilibrium, a H-school must be indifferent between strategy R^H and R^{HH}:

$$\begin{aligned} \Phi(R^{HH}) &= \Phi(R^H) \\ &\Leftrightarrow U(R^{HH}, T^H(R^{HH})) = Pr[H|R^H]U(R^H, T^H(R^H)) + Pr[L|R^H]U(R^H, T^L(R^H)) \\ &\Leftrightarrow U(R^{HH}, T^H(R^{HH})) = \frac{(1-\alpha)q}{(1-\alpha)q + (1-q)}U(R^H, T^H(R^H)) + \frac{(1-q)}{(1-\alpha)q + (1-q)}U(R^H, T^L(R^H)). \end{aligned} \tag{11}$$

The later equation allows us to determine α with respect to the predetermined variables:

$$\alpha = \frac{\begin{array}{c}\{q[U(R^H, T^H(R^H)) - U(R^{HH}, T^H(R^{HH}))] \\ -(1-q)[U(R^{HH}, T^H(R^{HH})) - U(R^H, T^L(R^H))]\}\end{array}}{q(U(R^H, T^H(R^H))) - U(R^{HH}, T^H(R^{HH}))}. \tag{12}$$

Obviously, $\alpha < 1$. On the other hand, $\alpha > 0$ if:

$$q > q_1 \equiv \frac{U(R^{HH}, T^H(R^{HH})) - U(R^H, T^L(R^H))}{U(R^H, T^H(R^H)) - U(R^H, T^L(R^H))}. \tag{13}$$

Recall that q_1 was previously defined as the threshold for which the pooling equilibrium can occur (Eq. (6)). Here α can be seen as a monotonously increasing function in q, with $\alpha = 0$ for $q = q_1 < 1$ and $\alpha = 1$ for $q = 1$.

We can also check that the condition for a L-school always holds; indeed, $\Phi(R^L) < \Phi(R^H) = \Phi(R^{HH})$ given that $U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH}))$.

The frequency of H-schools who decide to signal themselves by implementing the R^{HH} strategy depends on the proportion q of H-schools in the population of schools. The larger this proportion, less H-schools would implement the over-signaling strategy. Clearly this equilibrium comes with some form of abnormal proliferation of research as compared to the perfect information case. All L-schools imitate the H ones and adopt the research level R^H; as a reaction to this imitation strategy, some H-schools decide to signal their type by providing excessive research. In particular, for $q = q_1$, all H-schools do R^{HH}, and all L-schools do R^H, the overall volume of abnormal research is at its highest level.

In the large productivity gap case, if $q < q_1$, only the signaling equilibrium exists. For $q > q_1$ the game presents multiple equilibria: the signaling, pooling and hybrid equilibrium are all feasible. Whatever the prevailing equilibrium, an abnormal level of research is delivered (as compared to the perfect information case), at the expense of quality in education.

We turn now to the analysis of the moderate productivity gap case.

3.3. Moderate productivity gap: $\tilde{a}_R^L > a_R^L > a_R^H$

When $\tilde{a}_R^L > a_R^L > a_R^H$, we have shown that $U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L)) < U(R^H, T^H(R^H))$.

3.3.1. Pooling equilibrium: all schools do R^H

In this case too, an equilibrium where all schools play R^H is feasible. H-schools does not signal themselves by doing R^{HH}, and the L-schools mimic the H-schools. Schools' strategies are $s(\tau) = R^H, \forall\tau$.

We write the equilibrium beliefs:

$$\begin{cases} Pr[H|R^{HH}] = 1 \\ Pr[H|R^H] = q \\ Pr[H|R^L] = 0 \end{cases}. \tag{14}$$

Necessary existence conditions are:

(a) For the H-school:

$$\begin{aligned} \Phi(R^{HH}) = U(R^{HH}, T^H(R^{HH})) &< Pr[H|R^H]U(R^H, T^H(R^H)) \\ &+ Pr[L|R^H]U(R^H, T^L(R^H)) = \Phi(R^H). \end{aligned} \tag{15}$$

(b) For the L-school:

$$\begin{aligned} \Phi(R^L) = U(R^L, T^L(R^L)) &< Pr[H|R^H]U(R^H, T^H(R^H)) \\ &+ Pr[L|R^H]U(R^H, T^L(R^H)) = \Phi(R^H). \end{aligned} \tag{16}$$

Given that $U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L))$, a sufficient condition is:

$$U(R^L, T^L(R^L)) < qU(R^H, T^H(R^H)) + (1-q)U(R^H, T^L(R^H)), \tag{17}$$

equivalent to:

$$q > q_2 \equiv \frac{U(R^L, T^L(R^L)) - U(R^H, T^L(R^H))}{U(R^H, T^H(R^H)) - U(R^H, T^L(R^H))}. \tag{18}$$

Because $U(R^H, T^L(R^H)) < U(R^L, T^L(R^L)) < U(R^H, T^H(R^H))$, we have $q_2 \in [0, 1]$.

So this equilibrium where the research level is substantial, given that L-schools do as much research as H-schools in perfect information, can occur for $q > q_2$. Because all L-schools do more research than their efficient level, the quality of their teaching is hampered.

3.3.2. Hybrid equilibrium 2: low excess research

In this equilibrium, H-schools play R^H and a only a fraction β of the L-schools do the same:

$$\begin{cases} s(H) = R^H \\ \sigma(L) = \{\beta R^H + (1-\beta)R^L \mid \beta \in [0, 1]\}. \end{cases} \tag{19}$$

Equilibrium beliefs are:

$$\begin{cases} Pr[H|R^H] = \dfrac{Pr[R^H|H]Pr[H]}{Pr[R^H]} = \dfrac{q}{q + (1-q)\beta} \\ Pr[L|R^L] = 1 \end{cases}. \tag{20}$$

Table 1
Types of equilibria.

Equilibria	Strong gap, $a_R^L > \tilde{a}_R^L$	Moderate gap, $a_R^L < \tilde{a}_R^L$
Pooling: all schools play R^H, $\forall\tau$	$q \geq q_1 \in [0, 1]$	$q \geq q_2 \in [0, 1]$
Signaling: all H schools play R^{HH} and all L schools play R^L	Always possible	Impossible
Hybrid 1: all L and some H play R^H, the other H play R^{HH}	$q > q_1 \in [0, 1]$	Impossible
Hybrid 2: all H and some L play R^H, the other L play R^L	Impossible	$q < q_2 \in [0, 1]$

In equilibrium an L-school must be indifferent between playing R^L or R^H, that is $\Phi(R^L) = \Phi(R^H)$. This condition leads to the equilibrium frequency of L-schools doing R^H:

$$U(R^L, T^L(R^L)) = Pr[H|R^H]U(R^H, T^H(R^H)) + Pr[L|R^H]U(R^H, T^L(R^H))$$

$$= \frac{qU(R^H, T^H(R^H)) + \beta(1-q)U(R^H, T^L(R^H))}{q + (1-q)\beta}$$

$$\Leftrightarrow \beta = \frac{q}{(1-q)} \frac{[U(R^H, T^H(R^H)) - U(R^L, T^L(R^L))]}{[U(R^L, T^L(R^L)) - U(R^H, T^L(R^H))]}. \qquad (21)$$

We remark that β is an increasing function in q. For $q = 0$ we have $\beta = 0$ and for $q = q_2$, such as defined in Eq. (18), we get $\beta = 1$. So this equilibrium prevails whenever $q < q_2$. Some L-schools do too much research; their frequency increases if the proportion of H-schools goes up.

We can also check that for a H-school, the condition $\Phi(R^{HH}) < \Phi(R^H) = \Phi(R^L)$ always holds given that $U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L))$.

If we want to sum up the conclusions of this section, we have shown that, in a single period framework, depending on a_R^L and q, one of the equilibria presented in Table 1 can occur.

It should be emphasized that in the "strong productivity gap" case, for $q > q_1$ we have a standard multiple equilibria setting: the pooling, the signaling and the Hybrid equilibrium 1 are all feasible, and which one will actually materialize depends on students' equilibrium beliefs. In the "moderate productivity gap" case, either the pooling or the Hybrid equilibrium 2 can prevail.

3.4. From the short-run to the long-run perspective

So far we have analyzed the equilibria in a short-run perspective. In particular, the number of schools, their budgets (resources) and their research–education technology were taken as given. A more powerful model would analyze the relationship between the school's status, the tuitions they can obtain and their investment strategies in faculty development. A dynamic approach would allow to introduce into the picture the possibility to change either the number of schools or their type. Such a methodological change would require additional complexity, and might interfere with the basic message of our short paper. Hence, on a Occam razor principle, we will only sketch in this subsection some dynamic implications of the static model.

The signaling equilibrium has an interesting property: H-schools get higher tuition fees than L-schools. This is not a trivial outcome. Because this gap in resources is stable, H-schools can continue to hire the more efficient and more expensive H-professors and L-schools can hire only the less expensive L-professors. In this configuration, the gap between H-schools and L-schools should last.[8]

In all the other equilibria (pooling and hybrids), H-schools get the same tuition fees as L-schools. Yet wage costs are larger for H-schools than for L-schools. If tuitions represent the main source of founding a school's development, in a purely competitive set-up H-schools will end up by meeting financial difficulties, while L-schools situation will make nice profits. One possible adjustment for H-schools is to fire some productive researchers and hire less productive and less expensive ones. If we allow for the faculty to be made up of both very productive and less productive scholars (in proportions that vary from one school to another), then the average research productivity can vary. Over time, the average research productivity of the H-school $(1/a_R^H)$ should decline.[9]

At the end of the adjustment, the differences between the two types of schools will have vanished, and so will vanish all the static equilibria except the separating one. However, for many schools tuitions have only a marginal impact on their fortunes. Models of financing business schools based on foundation grants, huge privately founded endowments, firms' and even public sponsoring are quite frequent (and somehow surprising for schools who aim at teaching us how to create and manage private businesses). If the tie between tuitions and schools' resource is weak, then many of the equilibria put forward in the short-run perspective could survive in the long run.

4. Conclusion

These days, criticism is mounting on B-Schools about doing too much and not always relevant research. In particular, some critics point out that the excessive emphasis on research comes at the expense of teaching quality. This paper works out a simple signaling model that allows to put forward a set of necessary conditions for such scenarios to become possible. The crucial condition is some form of students' inability to gauge teaching quality. In this context, we have shown that if there is a large research productivity gap between top and normal schools, the latter would implement the same level of research as the top-tier schools only in order to manipulate student's expectations. The rational response of leading schools is to implement excessive research strategies only to differentiate themselves from the normal schools and signal their quality to future students. In a static set-up, as long as information is imperfect, there is little chance to obtain an efficient separation between the two types of schools.

Following the EU Lisbon Summit of 2000, European policymakers have adopted a more activist strategy of supporting research and innovation, seen as important engines of employment and output growth. In this context, the fact that B-Schools tend to invest massively in research might be interpreted as a good news. However, when employment and growth are at stake, the investment in human capital through education should matter at least as much as the advance in technology or management brought about by research. Hence, if the investment in research is achieved to the expenses of the investment in education quality, the final outcome can be socially sub-optimal.

Furthermore, if we agree with the idea according to which it is necessary to preserve at the European level a group of top-tier

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[8] To be more specific, if the cost of employing the highly productive researchers is CH and the cost of employing the less productive researchers is CL, a H-school has no incentive to transform into a L-school if $\Phi(R^{HH}) - \Phi(R^L) > (CH - CL)$.

[9] Starting from the pooling equilibrium in the strong productivity gap, this productivity gap narrows. When $\tilde{a}_R^L = a_R^L$, the thresholds q_1 and q_2 become equal. Hence, the pooling equilibrium in the strong productivity gap (possible for $q > q_1$) becomes the pooling equilibrium in the moderate productivity gap (possible for $q > q_2$).

schools that deliver both top research and train the future intellectual elites, than it may be useful to block the long-run convergence process between schools. This recommendation is consistent with the going EU research and superior education policy of supporting the creation of pan-European centres of excellence "competitive at a global scale" (EU, 2007). In the same line, everything that helps suppressing the informational asymmetry for students with respect to teaching quality would be beneficial. One possible measures can be the development of schools' rankings that set a high weight on pedagogical achievements or career developments (based on human capital) instead of first-job wages (essentially based on a school's reputation). One contribution of this paper to existing literature has been to point out the scope for multiple equilibria; since policmakers might not be able to detect the type of the prevailing equilibrium, this should complicate the task of designing the most efficient policies.

It is beyond the scope of this paper to address in an exhaustive way the complex issue of reforming the business education sector. The only important point we would emphasize is that in an activity characterized by strong asymmetries of information, some form of inefficiencies are unavoidable. In this context, signaling strategies are not a panacea, to the contrary, they may contribute to the emergence of socially sub-optimal outcomes, such as a relative neglect of teaching quality and a connected excessive focus on publication.

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Appendix A. Trivial and impossible equilibria

Case 1. Trivial separating equilibrium: each school delivers the perfect information (or efficient) amount of research.

In a separating equilibrium, schools' strategies are $s(\tau) = R^{\tau}$ with $\tau \in \{H, L\}$. The probability that the school is of type τ if the research strategy is R^j was denoted by $Pr[\tau|R^j]$. The equilibrium beliefs are: $Pr[H|R^H] = 1$ and $Pr[L|R^L] = 1$. In this equilibrium, research strategies reveal the type of the school. Students make no assessment error, tuition fees are $\Phi(R^H) = U(R^H, T^H(R^H))$ and $\Phi(R^L) = U(R^L, T^L(R^L))$. A necessary condition of existence for this equilibrium is that a type L-school prefers $\Phi(R^L)$ to $\Phi(R^H)$. Given that $U(R^L, T^L(R^L)) < U(R^H, T^H(R^H))$, a L-school always find more profitable to play R^H than R^L, i.e. $\Phi(R^L) < \Phi(R^H)$. Hence, this equilibrium can appear only if the strategy R^H is not possible for the L-school, because its resources are too small, i.e. if $R^{HH} \leq R^H$.

Case 2. In the "high research gap" case, the Hybrid equilibrium 2 is impossible.

We recall that $U(R^H, T^L(R^H)) < U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH})) < U(R^H, T^H(R^H))$. Schools' strategies can be written as $s(H) = R^H$ and $\sigma(L) = \{\beta R^H + (1-\beta)R^L | \beta \in [0, 1]\}$. The equilibrium beliefs are $Pr[H|R^H] = (Pr[R^H|H]Pr[H]/Pr[R^H]) = q/(q + (1-q)\beta)$ and $Pr[L|R^L] = 1$. Necessary and sufficient conditions are $\Phi(R^L) = \Phi(R^H)$. For a L-school and $\Phi(R^{HH}) < \Phi(R^H)$ for a H-school. But $\Phi(R^{HH}) < \Phi(R^H) = \Phi(R^L)$ is tantamount to $U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L))$ which is false in our case.

Case 3. In the "moderate research gap" case, the signaling equilibrium where the L-school does R^L and the H-school does R^{HH} is impossible.

Recall that in this case $U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L)) < U(R^H, T^H(R^H))$.

Schools' strategies are $s(H) = R^{HH}$ and $s(L) = R^L$. Equilibrium beliefs $Pr[H|R^{HH}] = 1$ and $Pr[H|R^H] = Pr[H|R^L] = 0$. This equilibrium is feasible if $\Phi(R^{HH}) > \Phi(R^H)$. But this condition implies $U(R^{HH}, T^H(R^{HH})) > U(R^H, T^L(R^H))$. In the case of a moderate gap this inequality is false.

Case 4. In the "moderate research gap" case, the Hybrid equilibrium 1 (partial over signaling by H-schools; high excess research equilibrium) is impossible.

This case implies $U(R^{HH}, T^H(R^{HH})) < U(R^L, T^L(R^L)) < U(R^H, T^H(R^H))$.

Strategies are $\sigma(H) = \{\alpha R^{HH} + (1-\alpha)R^H | \alpha \in [0, 1]\}$ and $s(L) = R^H$. Beliefs can be written as $Pr[H|R^{HH}] = 1$, $Pr[H|R^H] = (Pr[R^H|H]Pr[H]/Pr[R^H]) = (1-\alpha)q/((1-\alpha)q + (1-q))$ and $Pr[H|R^L] = 0$. The necessary and sufficient condition for a L-school: $\Phi(R^L) < \Phi(R^H) = \Phi(R^{HH})$ or $U(R^L, T^L(R^L)) < U(R^{HH}, T^H(R^{HH}))$, which is false.

Appendix B. Existence of $\tilde{a}_R^L$

In order to verify that a value such as $\tilde{a}_R^L$ does exist, we must study how $U(R^{HH}, T^H(R^{HH}))$ and $U(R^L, T^L(R^L))$ vary with respect to a_R^L. On the one hand, it can be shown that the efficient utility level $\Phi(R^{HH}) = U(R^{HH}, T^H(R^{HH}))$ is an increasing function in $a_R^L : d\Phi(R^{HH})/da_R^L > 0$.

The proof begins with the remark that $\Phi(R^{HH})$ is a decreasing function of R^{HH} for any R^{HH} in the interval $[R^H, 1/a_R^H]$. Indeed, $d\Phi(R^{HH}) = U'_R dR^{HH} + U'_T((dT^H(R^{HH})/dR^{HH}))dR^{HH}$ where $T^H(R^{HH}) = 1 - a_R^H R^{HH}$. It turns out that $d\Phi(R^{HH}) = (U'_R - a_R^H U'_T)dR^{HH}$. But $R^{HH} = (1/a_R^L)$ so $dR^{HH} = -(1/(a_R^L)^2)da_R^L$. Thus $d\Phi(R^{HH}) = -(1/(a_R^L)^2)(U'_R - a_R^H U'_T)da_R^L$ or, in an equivalent way, $d\Phi(R^{HH})/da_R^L = -(a_R^H U'_R/(a_R^L)^2)((1/a_R^H) - (U'_T/U'_R))$. Given that $-(U'_T/U'_R) = (dR/dT)_{U=Ct}$ and because $(1/a_R^H) - (U'_T/U'_R) < 0$ for $R^{HH} > R^H$, we get $(d\Phi(R^{HH})/da_R^L) > 0$.

On the other hand, the efficient utility level $\Phi(R^L) = U(R^L, T^L(R^L))$ is a decreasing function of a_R^L: $d\Phi(R^L)/da_R^L < 0$.

In the limit case $a_R^L = a_R^H$, we check $\Phi(R^L) = U(R^H, T^H(R^H)) > U(R^{HH}, T^H(R^{HH})) = \Phi(R^{HH})$ and, in the opposite case, $a_R^L = 1/R^H$ (i.e. $R^H = R^{HH}$) we verify $\Phi(R^L) < \Phi(R^{HH}) = U(R^H, T^H(R^H))$. So there is a $\tilde{a}_R^L$ in the interval $[a_R^H, 1/R^H]$ for which $\Phi(R^L) = \Phi(R^{HH})$.

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