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QUALITY AND VARIETY COMPETITION IN HIGHER EDUCATION*

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Abstract: In this paper, we analyze a bidimensional quality competition between two higher education sectors characterised by different preferences (academic vs. vocational) as well as cost structures, and its impact on curriculum's provision (type and quality), both in decentralised and social welfare maximisation settings. The students are heterogenous in terms of their valuation of quality and their intellectual type. We try to illustrate in this abstract setting some stylized facts as academic drift of vocational institutions as well as addressing more normative issue as the relative merits of binary or unitary models of higher education

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1. INTRODUCTION

The design of the optimal organisation of higher education systems is a complex issue. Such an optimal system should ensure that the interaction between the behaviour of educational sectors and the demands emanating from students will give rise to a supply of human capital that matches the skilled manpower requirements of the economy. The purpose of this paper is to investigate the effects of competition between two different educational sectors[1] (university and a more vocationally oriented sector) facing heterogeneous students on the provision of curricula.

This analysis is an attempt to evaluate the degree of optimality of a traditional "binary structure" of higher education (one key characteristics of many Continental higher education systems). We assume a priori the existence of two types of higher education sectors, with clearly divergent educational preferences, i.e. one sector with academic (theoretical) preferences called "university" (and suffering a disutility when deviating from this preferred curriculum's position) and a "non-university" sector with no such preferences and ready to fill any gap in the market, inter alia by providing more vocational curricula. In this sense we assume a binary system and consider the unitary one as a possible end-product of the competition between the two types of higher education sectors. In addition, the initial situation is characterised by the provision of a higher quality curriculum by the university[2] sector which might be explained by the fact that the universities entered the higher education market a long time ago, and have built a reputation of providing high quality curriculum.

[1]The model could also be interpreted in terms of orientations within a field (e.g. applied or business economics versus pure economics).

[2]Our model could be adapted to a situation where the non-university sector is delivering the higher quality curriculum. However, our specification covers a broader range of existing institutional configuration and is based on previous institutional and historical analysis (De Meleumesteer and Debande (1995)).

Quality should be understood as the mere pedagogical[3] (internal) quality of the courses provided by each higher education sector and is related to reputational assets.

Students are characterised by their two-dimensional type: (i) their valuation of the level of quality per se ("quality" dimension, i.e. the vertical dimension of competition) and (ii) their taste for a more theoretical or vocational curriculum expressed by their disutility from deviating from their preferred "ideal" position on the curriculum spectrum corresponding to their intellectual type ("variety" dimension, i.e. the horizontal dimension of competition).

We consider exogenous prices, i.e. higher education sectors only choose quality and variety while public authorities set the level of tuition fees. In this sense we model a kind of quasi-market (Le Grand and Bartlett, 1993). We compare the optimal levels of variety and quality which maximize the utility function of the higher education sectors with the socially optimal ones. In this analysis, we focus on the more realistic case of moderate relative tuitions fees allowing us to characterise the equilibrium when one dimension (i.e., quality or variety) is more important for the students. In horizontal dominance (HD), the student gives so much importance to her/his intellectual preferences that (s)he will accept to depart slightly from them only if largely compensated in terms of valuation for quality. In vertical dominance (VD), on the contrary, the quality dimension is so overvalued that the student will concede to value it a little bit less only if it gives him the opportunity to radically alter his preferences for curriculum. In our model, the underlying psychology of the students is completely determined by the level of relative tuition fees as determined by policy-makers and the parameters characterizing the behaviour of higher education sectors (i.e. the institutional setting).

[3]One can speak here of internal quality, as it is not judged by any external characteristics (as the performance of the graduates on the labour market, for example). However, it is true that the two types of quality might be positively related (see Card and Krueger (1992) on the link between school quality and rate of returns to education). In this sense, our model could be viewed as indirectly embodying labour market considerations.

The analysis entails two steps: in the first step, we compute the decentralized equilibria and in the next step we compare these equilibria with the social welfare equilibria, where the social welfare function corresponds to the maximisation of the students surplus[4].

We obtain multiple equilibria and for the given range of (exogenous) prices, both vertical and horizontal dominance cases occur. In vertical dominance, in the decentralised setting, given the exogeneity of tuition fees, both sectors have a higher incentive to locate themselves nearer to the centre (*1/2*) in order to benefit from the market share effect. This is why in all equilibrium configurations in VD, we obtain that the optimal location for the non-university education sector is always *1/2*. For the university sector, the market share effect is counterbalanced by the disutility incurred when deviating from its preferred location on the curriculum spectrum. As the two higher education sectors tend to be moderately horizontally differentiated, they will try to increase their level of differentiation along the other dimension, i.e. in terms of quality. The university sector will have an incentive to provide a high quality curriculum which compensates its location closest to a perfectly theoretical curriculum. Being located at the centre in order to maximize its market share, the non-university sector has an incentive to provide minimum level of quality since its lower efficiency increases the cost of providing a given level of quality. As far as horizontal dominance equilibria are concerned , the higher education sectors tend to overweight the variety aspect in order to account for students' preferences. A slight shift of the higher education sector towards a more vocational curriculum has to be compensated by a large increase in the level of quality. The optimal level of curriculum's variety will be affected by the extent of quality differentiation and will depend on the relative price-cost margin of both sectors. A higher level of quality differentiation will allow, by the same token, a higher level of variety differentiation.

[4]We indeed consider higher education sectors as instruments used in the promotion of social welfare (i.e. citizens, students).

When we turn to the social welfare maximisation setting, we cannot exclude either horizontal dominance or vertical dominance cases. When we compare the decentralized vertical dominance equilibria with the corresponding optimal social ones, we prove that the location of the non-university sector is nearly first-best (even if the level of quality it provides in the decentralized setting is generally lower than the socially optimal one), while this is not the case for the university sector. When the decentralized horizontal dominance equilibria are compared with the socially optimal ones, it appears that the level of quality chosen by the university is socially optimal, while on the horizontal dimension the degree of compatibility between the decentralized and socially optimal equilibria is function of the price-cost margin.

To our knowledge there are no models of the higher education markets of this kind in the literature. There is no extensive formalised literature dealing with this issue of provision of quality in higher education in relation with the overall organisation of the system (i.e. the nature of competition). More qualitative studies and surveys have recognized that higher education (as education by large) may not be a sector where market forces necessarily lead to a socially optimal level of quality (Cave and al., 1995). A more formalized analysis has been presented by Beitia (1996) but her analysis mainly focuses on the interaction between incentive effects and product quality and she does not integrate the whole dimension of vertical and horizontal quality differentiation in the competition between higher education sectors. More recently Effinger and Polborn (1997) have analysed the impact of the interaction between peer group effects and school reputation on the optimal allocation of students in the case of higher education [see also Boadway, Marceau and Marchand (1996)) for an analysis of competition between schools in a location setting with peer-group effects]. In our paper, we make an attempt to explicitly introduce the dual characteristic of quality (horizontal, i.e. type of curriculum, and vertical, i.e. level of quality) in a model of

competition between two types of higher education. Finally, we have to mention the recent paper of Del Rey (2001) considering competition between two universities that teach and research in the same jurisdiction. She characterises different equilibria with a different mix of research and teaching activities.

Our approach is in line with the literature dealing with the interplay between horizontal and vertical differentiation within the growing industrial organisation literature. Besides a vast literature about multi-dimensional vertical differentiation models (Vandenbosch and Weinberg, 1995) and multi-dimensional horizontal differentiation models (Ansari and al., 1998; Irmen and Thisse, 1998), there is also a limited but growing body of literature considering the interplay between horizontal and vertical differenciation (Neven and Thisse, 1990; Economides, 1989; Dos Santos Ferreira and Thisse, 1996; Degryse and Irmen, 1997; Canoy and Peitz, 1997). One can identify a basic result in this literature: when prices are endogenous and firms compete on several dimensions, maximal differentiation occurs on one dimension only. More precisely, firms differentiate themselves along the dimension consumers value the most or for which they have a cost advantage. The underlying forces are a strategic one inducing firms to differentiate from the others in order to reduce price competition and a demand one related to the maximisation of market share.

In contrast with these papers, our model does not contain price competition, the public authorities setting them exogenously. Hence, the incentive to differentiate products decreases as both sectors cease to compete in prices. We can expect that higher education sectors will choose an intermediate level of differentiation on both dimensions given their preferences in terms of location. The optimal choices of variety and quality will be affected by asymmetries in the cost functions of both sectors. As the university sector has a cost advantage

(disadvantage) in terms of quality (variety) relative to the other sector, maximal (minimal) differentiation in quality (variety) could be an equilibrium.

2. THE MODEL

In this section, we present a model of two-dimensional competition in variety and quality applied to higher education. We describe the utility function of both sets of players, i.e. the higher education sectors and the students, and the underlying assumptions on the game structure.

Higher education sectors

We assume that each higher education sector can choose its location anywhere between the two extremes of a straight line running from *0* to *1*, where *0* corresponds to a fully abstract or theoretical curriculum and *1* to a purely vocational curriculum. We call x_i and x_j the respective curricula of each higher education sector *i* and *j*, where x_i and x_j are assumed to lie on the support *[0,1]*. Students are heterogeneous in terms of their intellectual type, and they therefore value differently the curriculum provided by the two higher education sectors, depending on the distance between the preferred curriculum corresponding to their intellectual type and the curricula actually delivered by the two sectors. This characteristic corresponds to horizontal differentiation. Due to its academic tradition, the university sector has a preferred location corresponding to *0*, while the non-university sector has no such a preferred location on the curriculum spectrum. To capture this assumption, we assume that the university sector incurs a quadratic cost when deviating from its ideal curriculum, i.e. $-x_u^2$ if the university's preferred location is *0* (abstract curriculum). The non-university sector is not embedded in such a tradition of delivering a specific curriculum. These two assumptions have been retained for their historical relevance (see Dedande and De Meulemeester, 2003).

Moreover, the higher education sectors have also to choose the level of quality of the curriculum they deliver. Let us define q_i the level of quality chosen by sector i where $q_i \in [\underline{q}, \overline{q}]$ and all students prefer a high quality to a low quality. This second characteristic corresponds to vertical differentiation. We assume that $q_u > q_e$, i.e. the curriculum's quality of the university sector is higher than the one of the other sector. Hence, each higher education sector's curriculum i, is characterized by its variety x_i, and its quality q_i, with $(x_i, q_i) \in [0,1] x [\underline{q}, \overline{q}]$.

The university sector is assumed to have constant returns to scale in the production of quality and as incurring variable costs. The total cost for the university sector of producing a specific type of curriculum with a given quality is defined as follows:

$$C_u = (c_u + q_u)D_u + x_u^2 \tag{1}$$

where c_u is a constant marginal cost, D_u the market share of the university sector, q_u the quality choice and x_u the location choice.

The total cost function of the non-university sector is:

$$C_e = (c_e + \beta q_e)D_e \quad \beta > 1 \tag{2}$$

The newly established sector also faces constant marginal cost times the market share. At the difference of the university sector, the cost of delivering one additional unit of quality increases more sharply ($\beta > 1$). β can be interpreted as an efficiency parameter, where higher values of β correspond to the non-university sector less efficient in delivering a curriculum of a given quality. This assumption corresponds to the fact that the university sector has always lower production costs as it operates in the education market since a long time.

The net utility of the university sector (if its optimal point is zero) is equal to its profits net of disutility:

$$U_u = (P_u - c_u - q_u)D_u - x_u^2 \tag{3}$$

where D_u is the university sector demand function and P_u the exogenous university sector fee. For the non-university sector we have the following net utility function:

$$U_e = (P_e - c_e - \beta q_e)D_e \tag{4}$$

The two educational sectors interact with students who compare the type of curriculum delivered (its more or less abstract nature) with its intrinsic level of quality (low or high)

Students

Students choose the educational institution according to two characteristics. First, each student has a preferred curriculum location x, corresponding to his intellectual type, i.e. his location on the abstract versus vocational dimension. Second, each student "values" the quality of the curriculum by $\theta, \theta \in [0,1]$. It can be implicitly interpreted as the importance given to the reputation of the higher education sector, the reputation signalling the level of quality of the sector. Students tend to internalise this by giving a weigh to the quality aspect of the educational products delivered by the two higher education sectors, reflecting indirectly their underlying evaluation of the likely labour market attractiveness of their degree (see Card and Krueger (1992) on the link between quality of education and labour market performance). A student of type (x, θ) derives the following (indirect) utility from studying in sector i :

$$V_i = R - (x_i - x)^2 + \theta q_i - P_i \tag{5}$$

where R is a positive constant, the same for all students and assumed to be high enough to ensure that all students choose a curriculum, and P_i is the exogenous fee.

We assume that each student faces a quadratic cost $(x_i\text{-}x)^2$ of consuming the type i curriculum due to intellectual and motivational distance from his intellectual type x. We

suppose that students described by (x, θ) are uniformly distributed over the unit square, with a total mass equal to one. Hence, the product's aggregate demand can be described as the measure of a subset of $[0,1]x[0,1]$.

Game structure

First, we derive the aggregate demand for each higher education sector. Then, we analyse a simultaneous game where both sectors choose simultaneously their location, i.e. an abstract versus a vocational curriculum, and the level of quality, for a given level of price. We make this assumption of simultaneous quality and variety choice because the provision of a curriculum will often require the joint specification of these two characteristics. As we only consider a simultaneous game, the choice of quality or variety by one higher education sector has no strategic effect. We suppose that public authorities determine the fee of both higher education sectors. As the level of the fees is specified by regulatory authorities, the optimal strategy of both sectors in terms of differentiation will not be directly affected by the purpose of softening price competition.

3. EQUILIBRIUM IN THE SIMULTANEOUS QUALITY AND VARIETY GAME

In this section, we study the higher education sector's location choice in the curriculum dimension and the quality choice. First, we derive the demands for both higher education sectors for given levels of price and then, we analyse the simultaneous equilibrium in variety and quality.

3.1. Demand analysis

Given the assumptions set out in section 2, we can derive the set of students who are just indifferent between entering the university or the non-university sector. The set of indifferent students is located in a position such that

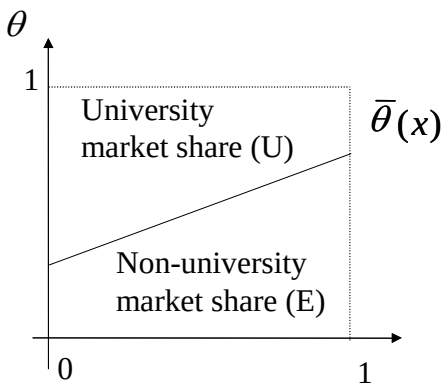
$$R-(x_u-x)^2+\theta q_u-P_u=R-(x_e-x)^2+\theta q_e-P_e \tag{6}$$

Hence, we obtain

$$\bar{\theta}(x)=-\frac{(x_e^2-x_u^2)+(P_e-P_u)}{(q_u-q_e)}+\frac{2(x_e-x_u)}{(q_u-q_e)}x \tag{7}$$

Students prefer the university sector if their "x" is low or if their "θ" is high, so the indifference line in the *(x, θ)* space must be increasing. The set of students is partitioned in two groups as described in Figure 1.

Figure 1: Partition of students in the two-dimensional curriculum space

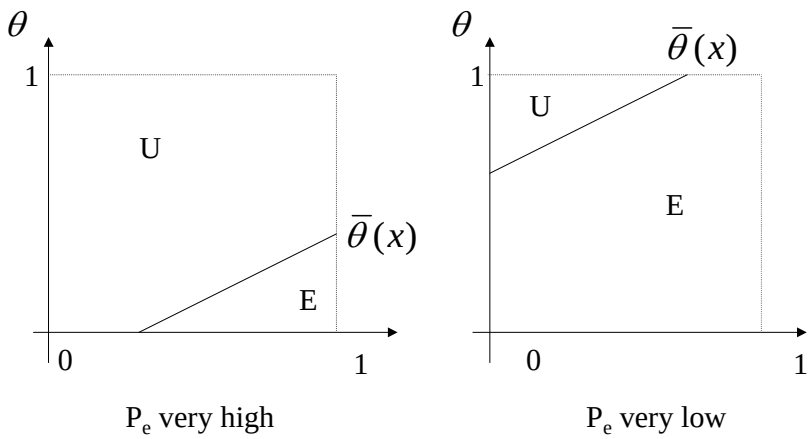


Students in the interval $\theta \in [0,\bar{\theta}(x)]$ decide to go to the non-university sector while students belonging to the interval $\theta \in]\bar{\theta}(x),1]$ choose the university sector.

We now derive the demand function by integrating the function $\bar{\theta}(x)$ over [0,1], taking into account the different position of the $\bar{\theta}(x)$ line. For P_e very high (low) compared to P_u, the $\bar{\theta}(x)$ line crosses the bottom (top) and right (left) sides of the unit square. In Figure 2, we

have represented the partition of the space for high and low value of the non-university sector's fee.

Figure 2: Partition of the space for high and low value of P_e



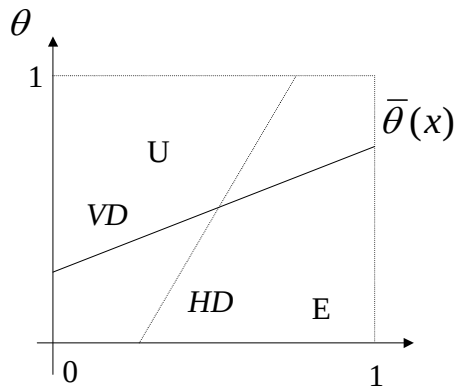
For intermediate value of P_e, the $\bar{\theta}(x)$ line may cross either the vertical sides of the unit square or the horizontal sides of the unit square. To discuss this intermediate case, we have to introduce the notion of horizontal and vertical dominance[5]. If $\frac{\partial\bar{\theta}}{\partial x} < 1$, i.e. $\frac{2(x_e - x_u)}{(q_u - q_e)} < 1$ or $2(x_e - x_u) < q_u - q_e$, we have a vertical dominance situation (VD) where the quality difference dominates the variety difference. In vertical dominance, the taste for quality is so strong that the student has a low sensitivity in regard to its evaluation of the type of curriculum. If $\frac{\partial\bar{\theta}}{\partial x} > 1$, i.e. $\frac{2(x_e - x_u)}{(q_u - q_e)} > 1$ or $2(x_e - x_u) > q_u - q_e$, we have a horizontal dominance situation (HD) where the variety difference dominates the quality difference. In horizontal dominance, students' preferences for a given type of curriculum have an important impact on the quality evaluation: when he infinitesimally moves towards more vocational

[5]See Neven and Thisse (1990).

preferences, the student has to be much more compensated in terms of quality. Finally, if $\frac{\partial \overline{\theta}}{\partial x} = 1$, no dimension is predominant.

We describe the space's partition for intermediate level P_e in the Figure 3.

Figure 3: Partition of the space for intermediate value of P_e



For each cases, we can compute the demand for the non-university sector assuming that the university sector's fee is fixed.

We summarize our result as follows

$$\text{If } P_e > P_e^{'} \text{ where } P_e^{'} = (x_e - x_u)(2 - x_e - x_u) + \overline{P_u}, \quad D_e = 0 \tag{8}$$

If $P_e \in \left[P_e^{''}, P_e^{'}\right]$ where $P_e^{''} = \overline{P_u} - (x_e^2 - x_u^2)$,

$$D_e^{'} = \frac{\left[(x_e - x_u)(1 - x_e - x_u) - (P_e - P_u)\right]}{(q_u - q_e)} + \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u)\right]^2}{4(x_e - x_u)(q_u - q_e)} \tag{9}$$

In the vertical dominance situation, we have:

If $P_e \in \left[P_e^{'''}, P_e^{''}\right]$ where $P_e^{'''} = \overline{P_u} + 2(x_e - x_u) - (x_e^2 - x_u^2) - (q_u - q_e)$,

$$D_e^{''} = \frac{(x_e - x_u)}{(q_u - q_e)} - \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u)\right]}{(q_u - q_e)} \tag{10}$$

If $P_e \in \left[P_e^{''''}, P_e^{'''}\right]$ where $P_e^{''''} = \overline{P_u} - (x_e^2 - x_u^2) - (q_u - q_e)$,

$$D_e^{'''} = \frac{\left[2(x_e - x_u)(2 - x_e - x_u) - (q_u - q_e) - 2(P_e - P_u)\right]}{4(x_e - x_u)(q_u - q_e)} - \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u)\right]^2}{4(x_e - x_u)(q_u - q_e)} \quad (11)$$

In the horizontal dominance situation, we have:

If $P_e \in \left[\hat{P}_e^{'''}, \hat{P}_e^{''}\right]$ where $\hat{P}_e^{'''} = P_e^{''}$ *et* $\hat{P}_e^{''} = P_e^{'''}$,

$$\hat{D}_e^{''} = \frac{(2 - x_e - x_u)}{2} - \frac{\left[(q_u - q_e) + 2(P_e - P_u)\right]}{4(x_e - x_u)} \quad (12)$$

If $P_e \in \left[\hat{P}_e^{''''}, \hat{P}_e^{'''}\right]$ where $\hat{P}_e^{''''} = P_e^{''''}$,

$$\hat{D}_e^{'''} = \frac{\left[2(x_e - x_u)(2 - x_e - x_u) - (q_u - q_e) - 2(P_e - P_u)\right]}{4(x_e - x_u)(q_u - q_e)} - \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u)\right]^2}{4(x_e - x_u)(q_u - q_e)} \quad (13)$$

If $P_e < P_e^{''''} = \hat{P}_e^{''''}, \quad D_e = 1$ (14)

At each kink, the demand is continuous. The most interesting parts of the demand function are the intermediate case where we can distinguish between vertical and horizontal dominance. This segment of the demand function corresponds to the more realistic case (with respect to the European institutional realities) where the difference between the fee of the two types of higher education sector is not too high. The aggregate demand for the university sector can be directly computed since students always go to one of the two higher education sectors: $D_u=1-D_e$.

We can now analyze the simultaneous game in variety and quality. This structure of the game rests on the assumption that when higher education sectors have to decide over the characteristics of their curriculum, they simultaneously decide over an associated level of quality.

3.2 Variety and quality equilibrium in a decentralised setting

In what follows, we focus our analysis on the most interesting cases, i.e. the middle piece of the demand function corresponding to moderate relative tuition fees charged by the two higher education sectors and giving rise to two possible set of equilibria, corresponding either to a vertical dominance case or to a horizontal dominance. For facility of exposition, we distinguish the maximisation process in, first, vertical dominance case, and then in a horizontal dominance setting (because the expression of the demand function differ), while keeping in mind that for the selected range of (exogenous) prices (Pe between Pe" and Pe"') one cannot exclude either type of situation.

3.2.1 Vertical dominance

Consider first the vertical dominance situation. In the simultaneous game, the non-university sector's maximization problem is given by:

$$L_e = (P_e - c_e - \beta q_e)D_e^{''} + \lambda_{\overline{q_e}}(\overline{q} - q_e) + \lambda_{\underline{q_e}}(q_e - \overline{q}) + \lambda_{x_e}(1 - x_e) \qquad (15),$$

subject to non-negativity and inequality constraints (q_e and $x_e > 0$)).

In a similar way, we can consider the university sector 's maximization problem:

$$L_u = (P_u - c_u - q_u)D_u^{''} - x_u^2 + \lambda_{\overline{q_u}}(\overline{q} - q_u) + \lambda_{\underline{q_u}}(q_u - \overline{q}) + \lambda_{x_u}(1 - x_u) \qquad (16),$$

subject to non-negativity and inequality constraints (q_u and $x_u > 0$).

After substitution by the expression for the demand segment, we can derive L_i with respect to q_i and x_i with $i=e,u$. We obtain the equilibria in vertical dominance (see below).

3.2.2 Horizontal dominance

Consider now the horizontal dominance situation. In the simultaneous game, the non-university sector's maximization problem is given by:

$$L_e = (P_e - c_e - \beta q_e)\hat{D}_e^{''} + \lambda_{\overline{q_e}}(\overline{q} - q_e) + \lambda_{\underline{q_e}}(q_e - \overline{q}) + \lambda_{x_e}(1 - x_e) \qquad (29),$$

subject to non-negativity and inequality constraints (q_e et $x_e > 0$).

In a similar way, we can consider the university sector's maximization problem:

$$L_u = (P_u - c_u - q_u)\hat{D}_u^{''} - x_u^2 + \lambda_{\overline{q_u}}(\overline{q} - q_u) + \lambda_{\underline{q_u}}(q_u - \overline{q}) + \lambda_{x_u}(1 - x_u) \qquad (30),$$

subject to non-negativity and inequality constraints (q_u et $x_u > 0$).

After substitution by the expression for the demand segment, we can derive L_i with respect to q_i and x_i with $i=e,u$. We obtain the equilibria in horizontal dominance.

We summarise our findings in a decentralised setting in the following proposition:

Proposition 1[6] : for (exogenous) levels of price Pe

$$P_e \in \left[\overline{P_u} + 2.(x_e - x_u) - (x_e^2 - x_u^2) - (q_u - q_e); P_u - (\overline{x_e^2} - x_u^2) \right]$$

we obtain 5 equilibria, 3 corresponding to a VD setting and 2 to a HD setting.

In vertical dominance, there exist the following location and quality equilibria:

1. $$x_u^* = \frac{1+2K}{3} + \frac{(1+12DP-8K+16K^2)}{6A} + \frac{A}{6} \qquad (17)$$

where $K = P_u - c_u - \dfrac{P_e - c_e}{\beta}$ (> 0) , $DP = P_e - P_u$ (<0)

[6]Proofs available upon request.

and

$$A = (4K-1)^3 + 36DP(1+2K) + 2*3^{3/2}*\sqrt{DP(4K-1)^3 + 8DP^2*(1-2DP+10K-2K^2)}$$

$$x_e^* = \frac{1}{2} \qquad (18)$$

$$q_u^* = \frac{P_e - c_e}{\beta} \qquad (19)$$

$$q_e^* = P_u - c_u - \frac{(P_u - c_u - (\frac{P_e - c_e}{\beta}))}{\frac{2+4K}{3} + \frac{(1+12DP-8K+16K^2)}{3A} + \frac{A}{3}} \qquad (20)$$

2. $$x_u^* = \frac{(P_u - c_u - \overline{q})}{2(P_u - c_u - \underline{q})} \quad (< \frac{1}{2}) \qquad (21)$$

$$x_e^* = \frac{1}{2} \qquad (22)$$

$$q_u^* = \overline{q} \qquad (23)$$

$$q_e^* = \underline{q} \qquad (24)$$

3. $$x_u^* = \frac{(P_u - c_u - \overline{q})}{2(P_u - c_u - \underline{q})} \quad (< \frac{1}{2}) \qquad (25)$$

$$x_e^* = \frac{1}{2} \qquad (26)$$

$$q_u^* = \underline{q} + \frac{2*\sqrt{16(1-4(P_u - c_u - \underline{q}))(P_u - c_u - \underline{q})(P_e - P_u)}}{(1-4(P_u - c_u - \underline{q}))} \qquad (27)$$

$$q_e^* = \underline{q} \qquad (28)$$

In horizontal dominance, there exist the following location and quality equilibria:

1. $$x_u^* = \frac{(P_u - c_u - \overline{q})}{2} \qquad (31)$$

$$x_e^* = \frac{(P_u - c_u - \bar{q})}{2} + \frac{\sqrt{2(\bar{q} - \underline{q}) + 4(P_e - P_u)}}{2} \quad (32)$$

$$q_u^* = \bar{q} \quad (33)$$

$$q_e^* = \underline{q} \quad (34)$$

2. $$x_u^* = \frac{(P_u - c_u - \bar{q})}{2} \quad (35)$$

$$x_e^* = \frac{(P_u - c_u - \bar{q} + 1)}{3} +$$

$$\frac{1}{6}\sqrt{4(P_u - c_u - \bar{q} + 1)^2 - 6(\frac{(P_u - c_u - \bar{q})^2}{2} + 2(P_u - c_u - \bar{q}) + \frac{P_e - c_e}{\beta} - \bar{q} - 2(P_e - P_u))^2} \quad (36)$$

$$q_u^* = \bar{q} \quad (37)$$

$$q_e^* = \bar{q} + 2(P_e - P_u) - 2(-\frac{(P_u - c_u - \bar{q})}{6} + \frac{1}{3} \pm$$

$$\frac{1}{6}\sqrt{4(P_u - c_u - \bar{q} + 1)^2 - 6(\frac{(P_u - c_u - \bar{q})^2}{2} + 2(P_u - c_u - \bar{q}) + \frac{P_e - c_e}{\beta} - \bar{q} - 2(P_e - P_u))^2} \quad (38$$

In the decentralised setting, multiple equilibria in location and variety occur. The intuition of the vertical dominance case is the following. As there is no price competition, both higher education sectors have a higher incentive to be located near the center in order to benefit from the "market share effect". This effect explains the optimal location of the non-university sector in ½. For the university sector, the market share effect is counterbalanced by the disutility it incurred when deviating from its preferred location on the curriculum spectrum. As the two higher education sectors tend to be moderately horizontally differentiated, they will try to increase their level of differentiation along the other dimension, i.e. in terms of quality. We can see directly from the demand function that the university sector 's demand increases with q_u. As a consequence, the university sector will have an incentive to provide a high quality

curriculum which compensates its location closest to a perfectly theoretical curriculum. Being located at the center in order to maximize its market share, the non-university sector has an incentive to provide minimum level of quality as its lower efficiency increases the cost of providing a given level of quality. Moreover, if the level of quality differentiation is high enough, it favors a location closer to a perfectly theoretical curriculum as students give more weight to the difference in the quality level of the curriculum (vertical dominance framework).

The first equilibrium described in Proposition 1 corresponds to an interior solution. We observe that the optimal location on the curriculum support for the non-university sector is at the centre, i.e. to deliver a curriculum halfway between a purely theoretical and vocational curriculum. This location choice is independent from the model's parameters. The university sector will choose to deliver a rather theoretical curriculum as its location will be in the interval *[0, 0.2]*, depending on the parameters' value. A higher fee per student increases the incentive of the university sector to be more horizontally differentiated as it weakens the demand effect. The two higher education sectors tend to be more vertically differentiated when the cost asymmetries between the two higher education sectors are limited and the difference in the fee charged not too high.

When the level of efficiency of the non-university sector (net of the production cost of quality) is relatively high compared to the one of the university sector, the latter has an incentive to be more vertically differentiated to compensate for its lower efficiency of providing a given level of curriculum quality. However, maximal vertical differentiation never occurs. A higher level of university sector's efficiency reduces its need to be vertically differentiated in order to maximize its utility function. Hence, this equilibrium is characterized by intermediate differentiation in terms of type of curriculum and quality.

In the second equilibrium, we have maximal vertical differentiation and intermediate horizontal differentiation. Maximal differentiation occurs along the dimension which is the most valuable for the students, i.e. the level of quality. As explained before, the lower quality of the non-university sector is compensated by a location at the centre of the curriculum support. Let us define $\overline{q} = \underline{q} + \varepsilon$. When $\varepsilon \to 0$, i.e. when higher education sectors are unable to differentiate themselves in terms of quality, they choose to be located in a central position. Hence, even if the university bears a disutility from deviating from its preferred location on the curriculum spectrum, it has an incentive to be the closest as possible to the centre in order to increase its market share as differentiation on the most salient characteristic for the students is ineffective. We have a minimal differentiation along the two dimensions. When $\varepsilon \to \infty$, the equilibrium is characterised by a maximal differentiation in terms of quality and a minimal differentation in terms of variety.

In the third equilibrium, if $P_u \to P_e$, the equilibrium is characterized by a minimal differentiation along the two dimensions. If $P_u > P_e$, then $P_u - c_u - \underline{q} > 0.25$ and the two higher education sectors become more horizontally and vertically differentiated. Indeed, the university sector chooses a location closer to a perfectly theoretical curriculum and the spread between q_u^* and $q_e^*(= \underline{q})$ becomes larger. A higher price reduces the need to be located in a central position in order to maximize market share. Moreover, by increasing the level of differentiation in terms of quality along the most valuable dimension for students, the university sector is able to counterbalance the loss in terms of demand from choosing a curriculum which is closer to its preferred curriculum's type, i.e. a theoretical curriculum. The reverse is true when $P_u < P_e$: higher education sectors tend to be less differentiated on both dimensions.

The basic intuition of the results in the horizontal dominance framework is the following. In horizontal dominance, students give a very high importance to their intellectual preferences and therefore tend to drastically increase their valuation for quality when moving towards more vocational preferences. Given this type of students' preferences, the two higher education sectors have an incentive to be maximally vertically differentiated to relax the constraint on the admissible level of horizontal differentiation. A higher level of quality differentiation will allow, ceteris paribus, a higher level of variety differentiation. The optimal level of curriculum's variety will be affected by the extent of quality differentiation and will depend on the relative price-cost margin of both higher education sectors.

In the first HD possible equilibrium, when $P_u \to P_e$ and $\bar{q} \to \underline{q}$, i.e. the curriculum of the two higher education sectors has similar quality, we have minimal horizontal differentiation. When $\bar{q} - \underline{q} \to \infty$, i.e. the difference in the quality of the curriculum is very high, the two higher education sectors are maximally differentiated in terms of variety. Ceteris paribus, when the spread between the low and high level of curriculum's quality increases, the two sectors choose to deliver more differentiated type of curriculum, i.e. the university sector provides a more theoretical curriculum while the non-university sector delivers a more vocationally-oriented curriculum.

In the second HD possible equilibrium, we observe an intermediate the level of differentiation on both dimensions. In terms of vertical differentiation, the university sector will choose to deliver a high quality curriculum, the level of vertical differentiation depending on the model's parameters. The extent of vertical differentiation is mainly affected by the spread in the fee charged by the two higher education sectors, by the relative efficiency of the non-university sector and by the spread between the lower and the upper bound of the quality support.

4. SOCIAL WELFARE ANALYSIS

In this section, we analyse the socially optimal quality and location equilibria. The welfare maximisation process is defined as the maximization of the surplus of students without taking into account the surplus of the higher education sectors (the latter being more instrument serving the student's welfare maximization[7]). As for the preceding analysis, for the aforementioned range of price, we can obtain results corresponding to both HD and VD settings. The formal expression for the social welfare function depends indeed on the expression of the demand function that differs in HD and VD setting, and no situation can be excluded a priori. The program to be taken into account is therefore either 4.1 or 4.2.

4.1. Vertical Dominance

The social welfare function is equal to the students' surplus, i.e. the sum of the utility of students choosing to go to the university sector and of students going to the non-university sector. In order to derive the share of the students, who are going, respectively to the university and to the non-university sector, we refer to Figure 3 describing the partition of the space in vertical dominance. The social welfare function boils down to:

$$W^{vd} = \int_{x=0}^{x=1} \left[\int_{\theta(x)}^{1} \left[R - (x_u - x)^2 + \theta(x) q_u - P_u \right] d\theta \right] dx + \int_{x=0}^{x=1} \left[\int_{0}^{\theta(x)} \left[R - (x_e - x)^2 + \theta(x) q_e - P_e \right] d\theta \right] dx \quad (39)$$

where $\theta(x) = -\dfrac{(x_e{}^2 - x_u{}^2) + (P_e - P_u)}{(q_u - q_e)} + \dfrac{2(x_e - x_u)}{(q_u - q_e)} x$

The first term corresponds to the surplus each student enjoys from choosing the curriculum of the university sector, the second term corresponding to the surplus derived from "consuming" the non-university sector's curriculum.

[7]Anyway, the computations tend to become very rapidly utterly tedious and cumbersome, leaving no room for interpretation, when increasing the number of arguments in the social welfare maximisation function.

Solving this double integral, we obtain the explicit expression for the social welfare function in vertical dominance:

$$\begin{aligned} W^{vd} = & R - x_u^2 + x_u - P_u + \frac{q_u}{2} - \frac{1}{3} + \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u)\right]^2}{2(q_u - q_e)} \\ & - \frac{(x_e - x_u)}{(q_u - q_e)}\left[(x_e^2 - x_u^2) + (P_e - P_u) - \frac{2}{3}(x_e - x_u)\right] \end{aligned} \tag{40}$$

The socially optimum level of variety and quality corresponds to the maximization of the social welfare function subject to non-negativity constraints and inequality constraints:

$$\begin{aligned} Max_{x_u, x_e, q_u, q_e} W^{vd} = & R - x_u^2 + x_u - P_u + \frac{q_u}{2} - \frac{1}{3} + \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u)\right]^2}{2(q_u - q_e)} \\ & - \frac{(x_e - x_u)}{(q_u - q_e)}\left[(x_e^2 - x_u^2) + (P_e - P_u) - \frac{2}{3}(x_e - x_u)\right] + \lambda_{\bar{q}_u}(\bar{q} - q_u) \\ & + \lambda_{\underline{q}_u}(q_u - \underline{q}) + \lambda_{\bar{q}_e}(\bar{q} - q_e) + \lambda_{\underline{q}_e}(q_e - \underline{q}) \\ & + \lambda_{x_u}(1 - x_u) + \lambda_{x_e}(1 - x_e) \end{aligned}$$

4.2. Horizontal Dominance

To obtain the social welfare function in horizontal dominance, we proceed as in vertical dominance. In order to derive the share of the students going respectively to the university and to the non-university sector, we refer to Figure 3 describing the partition of the space. The function $\theta(x)$, which divides the space in two parts, has the derivative $d\theta/dx = 2(x_e - x_u)/(q_u - q_e)$ which is positive, regardless of the value of x. Hence, this function is monotonic and an inverse function exists. Solving $\theta(x)$, we obtain the inverse function $x(\theta) = \left[(x_e^2 - x_u^2) + (P_e - P_u)/2(x_u - x_e)\right] + \left[(q_e - q_u)/2(x_u - x_e)\right]\theta$.

The social welfare function in horizontal dominance is equal to:

$$W^{hd} = \int_{\theta=0}^{\theta=1} \left[\int_{0}^{x(\theta)} \left[R - (x_u - x)^2 + \theta(x) q_u - P_u \right] dx \right] . d\theta + \int_{\theta=0}^{\theta=1} \left[\int_{x(\theta)}^{1} \left[R - (x_e - x)^2 + \theta(x) q_e - P_e \right] dx \right] . d\theta \tag{41}$$

$$where \;\; x(\theta) = \left[(x_e^2 - x_u^2) + (P_e - P_u)/2(x_u - x_e) \right] + \left[(q_e - q_u)/2(x_u - x_e) \right] \theta$$

The first term corresponds to the surplus each student enjoys from choosing the curriculum of the university sector, the second term corresponding to the surplus derived from "consuming" the non-university sector's curriculum. Solving this double integral, we obtain the explicit expression for the social welfare function in horizontal dominance:

$$W_{x_u, x_e, q_u, q_e}{}^{hd} = R - x_e^2 + x_e - P_e + \frac{q_e}{2} - \frac{1}{3} + \frac{(q_u - q_e)^2}{12(x_e - x_u)} + \frac{\left[(x_e^2 - x_u^2) + (P_e - P_u) \right]^2}{4.(x_u - x_e)} \left[(x_e^2 - x_u^2) + (P_e - P_u) + (q_u - q_e) \right] \tag{42}$$

Maximizing this social welfare function subject to non-negativity constraints and inequality constraints, we obtain the socially optimal level of variety and quality for a given level of fees *(P_u, P_e)*.

In proposition 3, we summarize the socially optimal level of variety and quality for a given level of fees *(P_e, P_u)* in vertical dominance and in horizontal dominance:

Proposition 3[8]*:*

3.a. In vertical dominance, the social welfare equilibrium is characterized by:

$$x_u^* = 0.46 \tag{43}$$

$$x_e^* = 0.50 \tag{44}$$

[8]The proof of Proposition 3 follows the proof of Proposition 1. For numerical computation, we have used Matlab.

$$q_u^* = \bar{q} \tag{45}$$

$$q_e^* = \bar{q} - 2.68 \tag{46}$$

$$P_e - P_u = -2.5 \tag{47}$$

3.b. *In horizontal dominance, the social welfare equilibrium is characterized by:*

$$x_u^* = 0.47 \tag{48}$$

$$x_e^* = 0.83 \tag{49}$$

$$q_u^* = \bar{q} \tag{50}$$

$$q_e^* = \bar{q} - 0.37 \tag{51}$$

$$P_e = P_u \tag{52}$$

In vertical dominance, the socially optimal level of variety corresponds to an interior location on the curriculum support for the two higher education sectors. We observe some convergence to an identical location where both higher education sectors deliver a curriculum halfway between a purely theoretical and purely vocational curriculum. In terms of the choice of a socially optimal level of quality, the quality of the university sector's curriculum is equal to the maximum feasible level of quality. The spread between the quality delivered by the two higher education sectors is relatively large.

Hence, we can reinterpret this result as follows. The socially optimal location and quality levels in *vertical dominance* is characterized by the convergence to a unitary system, where both sectors propose the same type of curriculum, with a relatively high level of vertical differentiation between the sectors inside the educational system.

When compared with the decentralized equilibria, the location choice by the non-university sector appears very close to the first best, at least on the curriculum support. Concerning the university sector's location choice, the spread between the decentralized location and the socially optimal one will partially depend on the level of vertical differentiation between the two higher education sectors, i.e. the distance between q_u^* and q_e^*. In terms of quality, the comparison between the decentralized and socially optimal equilibrium is less obvious. For the second decentralized equilibrium, we observe that the socially optimal level of quality corresponds to the decentralized one. However, we can notice that the level of quality of the non-university sector achieved in the decentralized set-up will be in general lower than the socially optimal one since $q_e^{*,sw} > \underline{q}$.

In horizontal dominance, the social welfare equilibrium is characterised by a relatively high level of horizontal differentiation, a low level of vertical differentiation and the same fee for the two higher education sectors.

Hence, Proposition 3.b. shows that in horizontal dominance, a binary system with one institution providing a vocational curriculum and the other one delivering a more abstract curriculum is optimal. As far as vertical differentiation is concerned, the university sector will provide a curriculum of the highest feasible quality level as the utility of the students increases with the level of quality of the curriculum of the two higher education sectors.

The comparison between the decentralized and the socially optimal equilibria shows that the quality level chosen by the university sector in the decentralized set-up is the similar to the socially optimal level, i.e.. $q_u^* = \overline{q}$. Moreover, in the decentralized equilibria, the level of vertical differentiation between the two sectors is too high compared to the socially optimal one. For the horizontal dimension, the adequation between the decentralized and socially optimal equilibria for the university sector will depend on its price-cost margin: if

$P_u - c_u - \bar{q} \to 1$, then the decentralized equilibrium (+ /- 0.5) is nearest to the socially optimal one (0.46). Depending on the model's parameters, the distance on the curriculum support between the two higher education sectors in the decentralized equilibria may be relatively close to the socially optimal distance.

5. CONCLUSION

In this paper, we have developed an analytical framework in order to evaluate the effects of competition on variety and quality of curricula provided by two different types of higher education sectors (an academically-oriented one versus a new one less embedded in a tradition and therefore a priori more likely to offer a more vocational curriculum) in a system where fees are exogenously set by public authorities. Many European countries have indeed implemented major reforms (see e.g. the British reform of the late eighties or the 1999 Bologna declaration) of their higher education systems in order to improve their responsiveness to market and social needs. They aim at reducing the degree of both horizontal (by reducing variety and favouring more vocationally-oriented curricula even within the traditional university sector) and vertical (by stressing quality everywhere in the system) differentiation. The model has been carefully designed in order to provide a sound analytical basis for discussing such important policy issues.

We have tried to account for the bi-dimensional character of the curricula supplied by the higher education institutions (the horizontal one, i.e. the academic-versus-vocational character of the curriculum, and the vertical one, i.e. the mere level of pedagogical quality) as well as the concomitant bi-dimensional character of the students' types (heterogeneous students characterised by different intellectual types, i.e. more academic versus more vocationally-oriented ones, and different valuations for quality). The paper also embodies a careful specification of the institutional cost functions and of the students' preferences. The model

has been designed as a simultaneous duopoly game between an (initially) academically-oriented sector and a more opportunist new one. We concentrate on the case of moderate relative tuition fees between the two higher education sectors. In this case we have to distinguish two possible expressions for the demand function, one corresponding to vertical-dominance situation (VD) and the other to a horizontal-dominance (HD) one. In the VD case, the quality dimension is so overvalued that the student will concede to value it a little bit less only if this allows him to radically alter his curriculum preferences. In HD, the student gives so much importance to the latter element that he will accept to slightly change his valuation for a curriculum only if this allows him to radically modify his valuation for quality. This distinction makes sense as we observe countries like UK, Japan or USA where the choice is heavily biased towards the institution as a signal for quality rather than towards the subject, the reverse being true for countries like Belgium or Germany (this behaviour being influenced by the overall institutional framework).

Cournot competition in the decentralised setting produces multiple equilibria, some of them corresponding to a VD situation, the others to a HD one. In *vertical dominance*, given the exogeneity of tuition fees (i.e. no price competition), both sectors have a higher incentive to locate near the centre (1/2) on the curriculum spectrum in order to benefit from the market share effect. This is why in all equilibrium configurations in VD we obtain that the optimal location for the non-university sector is 1/2. As far as the university sector is concerned, it tends to compensate for its disutility from providing a less theoretical curriculum by increasing its level of quality while the non-university sector, located at the centre, has an incentive to offer minimum quality in order to reduce the costs of providing a given level of quality. When we compare the decentralized equilibria with the optimal social ones, we prove that the location of the non-university sector is nearly first-best (even if the level of quality it

provides in decentralized setting is generally lower than the socially optimal one), while this is not the case for the university sector. Concerning the university sector's location choice, the spread between the decentralized location and the socially optimal one will partially depend on the level of vertical differentiation between the two higher education sectors.

In *horizontal dominance*, students tend to overweight the variety aspect (horizontal differentiation). In order to increase their market share, higher education sectors will give a higher weight to the level of variety differentiation. The optimal level of curriculum's variety will be affected by the extent of quality differentiation and will depend on the relative price-cost margin of both higher education sectors. We also prove that a higher level of differentiations in terms of quality will allow for a greater degree of horizontal (variety) differentiation. When the decentralized equilibria are compared with the socially optimal ones, it appears that the level of quality chosen by the university is socially optimal, while on the horizontal dimension the degree of compatibility between the decentralized and socially optima equilibria will depend on the price-cost margin. Last, in the decentralized setting, the level of vertical differentiation between the two sectors proves to be too high compared to the socially desirable level.

This theoretical framework is interesting as it helps us in understanding some recurrent key "stylised facts" concerning the evolution of higher education systems. Among these "stylised facts", there is on the one hand the "academic drift" characterising higher technical education sectors, initially designed as vocational higher education sector, and on the other hand the "vocational drift" of the university sector. The two latter phenomena can be explained by the competition between the two types of sectors, of which our model presents the end-result. "Academic drift" has been mainly put forward in order to explain the evolution of the German "Technische Hochschulen" at the turn of the 19th century (see Gispen, 1989) and the English

Polytechnics after 1945 (Pratt and Burgess, 1974), i.e. within systems more related to the VD framework where students tend to value more the quality dimension as signalled by the higher education sector. This observed situation resulting from such an evolution is quite consistent with a possible interpretation of the results of our formal analysis[9]: in VD, in decentralized equilibrium, the optimal location for the non-university sector is indeed always 1/2 (i.e. far away from a purely vocational curriculum). Moreover we have proved that in VD the non-university sector has an incentive to offer minimum quality (lower than the socially optimal one). This finding can be related with the widespread scepticism against the quality of Polytechnics in UK after 1945 (in Germany before 1933, in a more controlled environment, no such criticism were levelled against the Technische Hochschulen). The results of our simulations tend to suggest that in VD a low level of horizontal differentiation (i.e. nearly a unitary system centred around 1/2) is socially optimal, with quite large differences in terms of quality (the university sector providing the highest possible level of quality). This situation might not be too dissimilar from the current American situation characterised by a large spectrum of quality and with higher education sectors providing a large array of curricula (from MBA to theoretical physics, from music to engineering), on average at the middle of the curriculum spectrum.

On the other hand, HD systems are more similar to higher education systems prevailing in Continental Europe today, where students tend to give the priority to the subject rather than the quality of the higher education sectors (the latter being relatively homogenous). In our theoretical approach, we have distinguished two main situations in the decentralized setting: one with maximum vertical differentiation (with the university sector offering the highest level of quality) and the level of horizontal differentiation depending on the model's

[9]Our model could be viewed as a kind of comparative static exercise providing the end-result of the competition without describing the dynamics leading from the initial situation towards the current state.

parameters (the higher the level of vertical differentiation, the higher the level of horizontal differentiation); the other situation being characterised by an intermediate level of differentiation on both dimensions. In countries like Belgium, the higher education technical sector was considered as of lower quality than university sector[10], and at the same time the level of horizontal differentiation between the two systems was quite important.

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[10]For example, to teach in an university, a PhD is a prerequisite, which is not the case for non-university institutions. Moreover, the worries of the Belgian French-speaking ministry of Higher Education to promote higher technical institutions by changing their name is also an indicator that these institutions were considered as of lower quality.

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