Why Academic Quality in Higher Education Declines

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CESIFO WORKING PAPER NO. 5480
CATEGORY 2: PUBLIC CHOICE
AUGUST 2015

ISSN 2364-1428

CESifo *Working Paper No. 5480*

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Abstract

We investigate the choice of quality, or academic content, in higher education in a two-sector model. Individuals are differentiated according to their cost of acquiring human capital. A higher academic quality increases productivity upon training, but is also associated with higher cost of acquiring skill. We consider both a differentiated university system in which quality is tailored to the individual need, and a uniform quality system being politically determined. The former yields a higher income dispersion. Average quality decreases under both systems when the skill premium increases. Moving from a single stage to a two-stage scheme reduces quality in the first stage and increases quality in the second stage. Increasing differentiation in higher education can decrease student effort and skill of medium ability types.

JEL-Code: I210, I230, I280, J240.

Keywords: higher education, enrollment, quality, higher education systems.

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1 Introduction

Is academic quality in higher education declining, and if so, why? The expansion of higher education in the last decades has triggered a concern for declining skill of students and teaching standards. Some pieces of evidence suggest a trend of declining quality in higher education. For instance, the National Adult Literacy Survey (NALS) reveals that the average skill level of adults holding a bachelor degree in the US has gone down substantially. The percentage of college-educated adults with command of so-called proficient document literacy - defined as being able to integrate, synthesize, and analyze multiple pieces of information located in complex documents - decreased from 37 percent in 1992 to 25 percent in 2003 (Kutner et al., 2007). On the input side, Babcock and Marks (2010) document a decline in the amount of time that full-time college students spent studying from 40 hours per week in 1961 to about 27 hours per week in 2003. A decline in academic quality comes at a substantial cost, as the empirical literature acknowledges considerable positive effects of college quality on earnings (Black and Smith, 2004, 2006, Long, 2008, 2010, Dale and Krueger, 2011, Dillon and Smith, 2015). For example, Dillon and Smith (2015) find that for a student of median ability, each 10 percentile point increase in the quality of the first college is associated with an additional $1,400 of annual earnings.

The most obvious candidate for explaining changes in academic quality lies in the tremendous worldwide increase in enrollment rates in tertiary education over the last decades, which comes along with an increase in the college wage premium. The average college premium has increased over the last decades in many parts of the developed world (Acemoglu, 2002, Mitchell, 2005). In the U.S., Autor et al. (2008) report a change in college/high school log wage premium from 0.4 at the end of the 70s to more than 0.65 in 2005. The OECD average entry rate into tertiary theory-based programs with usual length of at least three years (5A programs) has increased from 48 percent to 61 percent over the period 2000-2012 (OECD, 2014, Table C3.2a).

There are different approaches to deal with the strong increase in enrollment. In the US, there is a great deal of quality differentiation among universities, ranging from open admission to highly selective institutions. While the top universities remain as selective as ever or even increase their resulting admission standards (Hoxby, 2009), the enrollment increase is mainly driven by the expansion of the non-elite institutions targeting the needs of the bulk of students. The number of students in the US enrolling at the for-profit higher education institutions, generally perceived as being of lower quality, has gone up from 111,714 to 2,018,397 over the period 1980-2010, an 18-fold increase (Snyder and Dillow, 2013, Table 303.10). In Europe, concerns of policy are centered around enhancing the international mobility of students and graduates. This has led, among others, to the Bologna initiative (Bologna declaration, 1999), aiming at standardizing academic curricula across the European Union, making exams of different universities roughly comparable. Moreover, those countries traditionally using a single-stage diploma system subsequently implemented two-stage schemes with bachelor and master degrees. The evidence on the effects of Bologna reform on student outcomes is still scant. Several studies have found increased enrollment post-reform in Portugal (Cardoso et al., 2008) and Italy (Cappellari and Lucifora, 2009). Lower drop-out rates despite the enrollment expansion (Cappellari and Lucifora, 2009; Horstschräer and Sprietsma, 2015) also indicate lower standards.

In this paper we explain changes in academic quality and skills of graduates under different higher education systems. We model two stylized systems: a system offering a uniform quality which is politically determined (closer to the European concept), and a differentiated system that resembles the US type in which colleges offer different qualities, tailored to the ability of their student population. In our two-sector model with agents being heterogenous in ability, there is endogenous sorting. The wage of a higher education graduate depends on her ability and the quality of the university attended. As more talented individuals display a smaller cost of acquiring education in response to increasing academic quality, the most preferred quality of higher education increases in ability. While the differentiated system with its tailored programs will lead to higher enrollment and higher dispersion of income, the uniform quality system reflects a compromise of the interests of the student population. Academic quality is higher in the differentiated system at the top universites than in the uniform system, while the opposite holds for the lowest quality colleges in the market. In our benchmark model, the tailored system Pareto dominates the uniform system. We proceed by identifying three channels of change in quality and resulting skill levels.

First, increasing the skill premium reduces average quality in both systems, though through different mechanisms. Under the tailored framework, additional enrollment will be met by an increase of comparatively low quality colleges, while higher quality universities will not adapt their curriculum. In the uniform system, the interest of the new marginal group within higher education induces a pressure to cut quality for all students.

Second, a decline in academic quality also occurs when introducing vertically differentiated degrees in a uniform quality system. As in the Bologna reform. we consider replacing one-stage (diploma) systems by two-stage schemes with consecutive bachelor and master degrees. Compared to the single-stage uniform scheme, this reform will bring about higher quality in the second (master) stage as medium ability students have already completed their studies. At the same time, it reduces quality in the first stage, allowing for a higher overall enrollment.

Third, moving from a uniform system to a differentiated system tends to be associated with losses in human capital for medium ability students when student effort is endogenized. In an incomplete information environment, firms determine individual wages according to a collective signal of skill from the student body of a university of given academic quality and an individual signal. Since the accuracy of the collective signal increases with a more differentiated university system, the weight employers attach to the individual signal declines, aggravating the positive externality of individual study effort. This induces students to exert lower effort. As a result, students in the middle of the ability spectrum will enroll in programs being similar in quality under both uniform and differentiated systems, while their effort and welfare is higher under the uniform system.

Our paper is related to the literature on educational standards (Costrell, 1994, 1997; Betts 1998) in which the early contributions focused on alternative political objectives when determining standards and competition in standards across jurisdictions with mobile workers. Centralizing standards in an asymmetric information environment with student mobility can be welfare-enhancing as higher local standards are associated with a positive externality, thus reducing equilibrium standards in a competitive market (Costrell, 1997) - which could be interpreted as argument in favor of the uniform system. According to Mechtenberg and Strausz (2008), improving international mobility through the Bologna initiative increases quality, here measured as expenditure per student, due to more intense competition, while a free-rider effect works in the opposite direction. Analyzing the market for universities, Epple et al. (2003, 2006) argue that stratified qualities will be an equilibrium outcome, where universities with a higher endowment choose a higher quality so as to exert market power. If peer effects are important in educational production, a market outcome will generate stratification in ability and income. In the absence of market imperfections, perfect sorting can be achieved also by just relying on tuition fees (Gary-Bobo and Trannoy, 2008). Most closely related to our paper are MacLeod and Urquiola (2012) and Kaganovich and Su (2015), the former stressing that competition between universities will induce an anti-lemons effect, resulting in a segmented university market delivering low student effort. While their focus lies on dynamic competition issues, we are systematically comparing different university systems from a political economy perspective. Kaganovich and Su (2015) argue that an increase in enrollment will lead private elite colleges to increase their quality, while public colleges decrease their standard to allow for more students. By contrast, our contribution allows for a continnum of suppliers, offering an alternative explanation why increasing differentiation can be less beneficial or even detrimental for student ability types in the middle of the spectrum.

The remainder of the paper is organized as follows. Section 2 introduces the model, and Section 3 discusses the consequences of uniform quality. Section 4 is concerned with a comparison of the uniform and the differentiated system, while Section 5 analyzes the move from a one-stage to a two-stage scheme within a uniform framework. In Section 6 we extend the model to include endogenous student effort in an asymmetric information environment. The final Section 7 concludes and indicates directions for future research.

2 The Basic Model

2.1 Costs and returns of quality

Each individual lives for one period. Upon learning her ability type, she chooses whether or not to enroll in higher education. All university students graduate and work in the skilled sector, the other individuals work in the unskilled sector. Individuals are heterogeneous in ability a. For simplicity, let the log ability be normally distributed, $log(a) \sim N(0, \sigma^2(a))$. Wages reflect productivity differences proportionally. In the unskilled sector, the income of an individual of ability level a is given by $y_u(a) = w_u a$, where w_u is a standard wage in the unskilled sector that would be paid to an individual with the highest ability $a = \infty$. In the skilled sector, a worker of ability a having completed higher education of quality $q \in [0, \overline{q}]$ earns $y_s(a, q) = w_s a g(q)$. Higher quality increases productivity in the skilled sector, though at a diminishing rate, $g_q(q) > 0 > g_{qq}(q)$, and $\underset{q \to 0}{lim} g(q) > 0$.

To keep the analysis tractable, utility is assumed to be logarithmic in income, $U(y) = \log(y)$. Acquiring skills is associated with a utility cost $C(q, a) = \log h(q, a)$. Utility cost is increasing and convex in quality, $h_q(q, a) > 0$, $h_{qq}(q, a) > 0$ and decreasing in ability, $h_a(q, a) < 0$. While also marginal cost of quality decreases in ability, $h_{qa}(q, a) < 0$, it is less responsive than quality itself, $h_a/h < h_{qa}/h_q < 0$. In order to ensure that enrollment in higher education is always positive but never universal, we assume $\underset{a \to 0}{lim} h(q, a) = \infty$ and $\underset{a \to \infty}{lim} h(q, a) < w_s g(q)/w_u$ for any $q \in [0, \overline{q}]$. This ensures that the endogenous ability threshold that separates the skilled workers from the unskilled is interior for any $q \in [0, \overline{q}]$. Individuals with the lowest ability level will face an infinite utility cost while very high ability types always find it optimal to enroll. In order to guarantee existence of optimal qualities as interior solutions, we impose $\underset{q \to 0}{lim} g_q(q) = \infty, \underset{q \to \overline{q}}{lim} g_q(q) = 0, \underset{q \to 0}{lim} h_q(q, a) = 0, \underset{q \to \overline{q}}{lim} h_q(q, a) = \infty$. Individuals possess perfect foresight with respect to their prospective wage. An individual of ability a enrolls in education of quality q when net utility from doing so exceeds utility from remaining unskilled, that is, if $\log(w_s a g(q)) - \log h(q, a) > \log(w_u a)$ holds. This implies that an agent will enroll if ability a exceeds the threshold level

a^*, which satisfies

$$h(q, a^*) = \frac{w_s g(q)}{w_u}. \tag{1}$$

2.2 Individual optimal quality

Optimum quality at the level of the individual is determined by maximizing utility as skilled with respect to quality, that is to maximize

$$X = \log [w_s g(q) a] - \log h(q, a) \tag{2}$$

This yields as first-order condition

$$X_q = \frac{g_q(q^*)}{g(q^*)} - \frac{h_q(q^*, a)}{h(q^*, a)} = 0 \tag{3}$$

The first-order condition reveals that optimum quality is independent of standard wage rate in the skilled sector. This is a consequence of the specification of the utility function where substitution and income effects cancel out. On the one hand, a higher return on quality calls for a higher quality. At the same time, any target utility level can then be achieved by cutting quality.

Proposition 1 is concerned with the pattern of ability-specific optimal qualities.

Proposition 1 *A sufficient condition for uniqueness of optimal quality at the individual level is $h_{qq}h - (h_q)^2 > 0$, or $h_{qq/}/h_q > h_q/h$. Given that uniqueness holds, most preferred quality levels increase with rising ability if $h_{qa}/h_q > h_a/h$.*

Proof. See Appendix A. □

Figure 1 illustrates the proposition where, given our assumptions, optimal quality increases in ability. This property is due to the fact that marginal cost of quality is less sensitive to a change in ability that the cost itself. Should the function h be independent of ability a, as in Meier and Schiopu (2015), all types would share the same most preferred optimal quality.

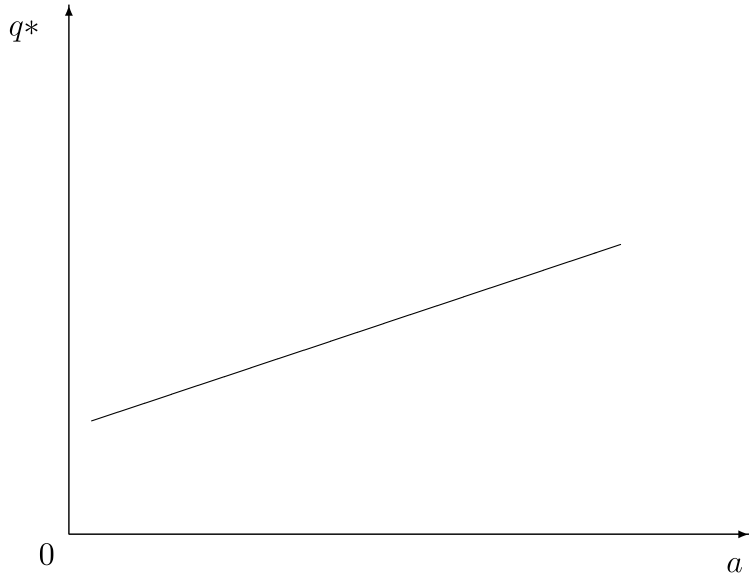

Fig. 1. Type-specific optimal qualities

Notice that $X_q > 0$ ($g_q/g > h_q/h$) below the type-specific optimal quality and $X_q < 0$ ($g_q/g < h_q/h$) above that level.

In the following analysis, we consider two systems of higher education. In the differentiated (American-style) framework, quality is tailored according to individual need. Prospective students can choose between a continuum of qualities. By contrast, in the (European-style) uniform system quality is determined through some political process. As the process balances the interests of high ability students and students from the middle of the ability distribution, chosen quality will typically exceed optimal quality of the marginal student who is just indifferent between enrolling and not enrolling.

3 Uniform quality

With uniform quality for all students enrolling in higher education, an interior equilibrium is defined by a market enrollment threshold $a_m = a^*$ satisfying equation (1).

Our assumptions ensure existence and uniqueness of an interior market enrollment threshold at any given quality.

Proposition 2 *An interior market enrollment threshold* $a_m(q) \in (0, \infty)$ *at any given quality level* $q \in [0, \overline{q}]$ *always exists and is unique.*

Proof. See Appendix B. □

When the most able student has a sufficiently small utility cost, she is always willing to enroll. As the least able type never enrolls and enrollment incentives are increasing in ability, an interior enrollment threshold exists. The same line of reasoning applies to the differentiated framework with variable qualities.

Proposition 3 deals with the impact of changing the uniform quality level on enrollment.

Proposition 3 *A higher quality* q *increases the market enrollment threshold* a^* *if the quality lies weakly above the optimal quality of the marginal student. Should quality lie below optimal quality of the ability type at the enrollment threshold, increasing that quality marginally reduces the market enrollment threshold.*

Proof. See Appendix C □

As it will be shown, the relevant case in any uniform model is the first, in which the chosen quality level is optimal for some medium skilled. At the same time, it exceeds the optimal quality of the marginal ability type being indifferent between enrolling or staying unskilled. Since a higher quality would make becoming skilled less attractive for this marginal type, increasing quality reduces enrollment. If, for some reason, the chosen quality would be set below the optimum of the marginal individual, increasing quality has a positive impact on utility of the marginal individual, inducing a further increase in enrollment by ability types slightly below the previous margin.

Proposition 4 shows that a rising relative wage per skilled efficiency unit, w_s/w_u, increases enrollment.

Proposition 4 *An increase in* w_s/w_u *reduces the market enrollment threshold at any given quality.*

Proof. See Appendix D. □

The comparative static properties are easily understood. Raising the skill premium through a higher w_s/w_u increases the enrollment incentives. This in turn leads to a lower enrollment threshold a_m and a higher enrollment rate. Unsurprisingly, this result carries over to the differentiated system.

Corollary. *Increasing the skill premium reduces the market enrollment threshold in the differentiated system.*

Proof. See Appendix E. □

In principle, changing the skill premium could have an impact on individual optimal quality. In our framework, there is no such effect. However, a higher skill premium makes becoming skilled more attractive. This will induce more individuals to become skilled in the differentiated system.

4 Optimal uniform quality

Suppose that the uniform quality in the European-style framework is chosen so as to maximize welfare. Welfare W is represented by a Benthamite utilitarian welfare function, aggregating utility from wage income minus utility losses due to acquiring human capital:

$$W = \int_0^{a^*(q)} \log(w_u a) f(a) da + \int_{a^*(q)}^{\infty} \log(w_s a g(q)) f(a) da - \int_{a^*(q)}^{\infty} \log h(q,a) f(a) da \quad (4)$$

Thus, aggregate welfare is derived by adding utility from income of the unskilled, $\int_0^{a^*(q)} \log(w_u a) f(a) da$, to utility from income of the skilled, $\int_{a^*(q)}^{\infty} \log(w_s a g(q)) f(a) da$, net of the aggregate utility cost of acquiring higher education, $\int_{a^*(q)}^{\infty} \log h(q,a) f(a) da$.

The social planner maximizes welfare with respect to the choice of a uniform quality standard. This can be interpreted as representing the outcome of a probabilistic voting process with two parties choosing a political platform and voters whose choice is governed additionally by ideological concerns. Considering the standard scenario in which all voters have identical political power, this framework has a unique equilibrium in which both parties converge to the same platform - the one that maximizes the Benthamite social welfare function (Coughlin and Nitzan, 1981, Persson and Tabellini, 2000).

The derivative of the welfare function with respect to q is:

$$\frac{\partial W}{\partial q} = \frac{\partial a^*(q)}{\partial q} \log\left(w_u a^*(q)\right) f(a^*(q)) + \int_{a^*(q)}^{\infty} \frac{g_q}{g} f(a)da - \frac{\partial a^*(q)}{\partial q} \log(w_s a^*(q) g(q)) f(a^*(q))$$
$$- \int_{a^*(q)}^{\infty} \frac{h_q}{h} f(a)da + \frac{\partial a^*(q)}{\partial q} \log(h(q, a^*(q))) f(a^*(q)) \tag{5}$$

Taking into account the market equilibrium condition (1), $\partial W / \partial q$ can be simplified as follows:

$$\frac{\partial W}{\partial q} = \int_{a^*(q)}^{\infty} \left(\frac{g_q(q)}{g(q)} - \frac{h_q(q,a)}{h(q,a)} \right) f(a)da \tag{6}$$

The uniform quality q^u is the solution of the $\frac{\partial W}{\partial q}(a^*(q^u)) = 0$. Recalling the structurally similar condition determining ability-specific optimal qualities (3), the last line shows that uniform quality reflects a compromise. Top ability individual will consider the uniform quality level as being too low, while marginal students are to some extent deterred by a quality that looks too high from their vantage point.

The second-order condition reads

$$\frac{\partial^2 W}{\partial q^2} = \int_{a^*(q)}^{\infty} \left[\frac{g_{qq} g - (g_q)^2}{g^2} - \frac{h_{qq} h - (h_q)^2}{h^2} \right] f(a)da \tag{7}$$
$$+ \left(\frac{h_q(q, a^*(q))}{h(q, a^*(q))} - \frac{g_q(q)}{g(q)} \right) \frac{\partial a^*(q)}{\partial q}.$$

The first term in (7) is negative under the assumptions taken so far, but the second term is positive (see the proof of Proposition 3). In principle it could make sense to have multiple solutions. Increasing quality leads to a smaller enrollment rate, which in itself yields a welfare loss. At the same time, those remaining enrolled are served better on average by the higher quality as gains of the highly talented outweigh losses for the now smaller group of medium ability types. However, as we would like to conduct comparative statics, we exclude multiple solutions.

Proposition 5 compares the differentiated to the uniform system in terms of enrollment, quality, and income dispersion.

Proposition 5 *The differentiated (tailored) system exhibits a higher quality at the top and a lower quality at the bottom than the uniform system. Moreover, it displays a higher enrollment and a wider dispersion of income.*

Proof. Recalling Proposition 1 stating that most preferred quality increases in ability, a higher quality at the top in the differentiated system is immediate from comparing (3) and (6). Since utility as skilled worker is at least as high in the differentiated system as in the uniform system, enrollment in the differentiated system must be weakly higher than under the uniform frame. As condition (6) together with type-specific most preferred quality increasing in ability ensures that the marginal student under the uniform frame is not at his or her optimal quality level, utility in the differentiated system is higher at the uniform system's marginal type. This in turn ensures that some types slightly below the uniform margin find it optimal to enroll in the differentiated system. Thus, total enrollment is higher with the differentiated frame. Since quality in the uniform system is already higher than in the differentiated scheme at the uniform system's margin, quality at the bottom of the differentiated system is even lower. Higher quality at the top ability type translates into higher income at the top of the differentiated system than in the uniform system. Since at the same time lowest incomes of unskilled individuals are identical, income dispersion in the differentiated system is higher. □

Notice that the uniform scheme is not efficient. This can be demonstrated as follows. Consider any optimal allocation under a uniform framework. The chosen quality will lie above the optimum of the marginal individual being indifferent whether or not to enroll. Offering some tailored lower quality to an individual with lower ability may induce this individual to enroll without harming anybody.

Since the differentiated system simply Pareto dominates the uniform system, the issue arises why the uniform scheme is nevertheless chosen by many countries. One possibility lies in egalitarian preferences. If an income inequality measure enters the choice of the social planner between the differentiated system and the uniform system, the latter will be preferred given a sufficiently high weight on the inequality measure. From a political economy point of view, this can be supported by ability types from the middle of the spectrum who achieve a higher income under the uniform frame due to higher quality and potentially suffer from relative deprivation. With such preferences, they are interested in limiting quality of high ability types if no other instrument of redistribution is available. Section 6 pursues a different explanation, arguing that the uniform system will be associated with lower student effort, resulting in lower welfare for students who would obtain similar qualities under both systems.

Proposition 6 completes the explanation of a decline in quality due to an increasing college wage premium.

Proposition 6 *Increasing the skill premium reduces quality under the uniform scheme and reduces average quality under the differentiated scheme.*

Proof. See Appendix F. □

The proposition is easily understood. While quality choice in our model does not directly depend on wages, uniform quality will decrease with higher enrollment as the interest of medium ability students now entering the university system has to be taken into account. In the differentiated scheme, average quality declines due to marginal ability types enrolling at low quality colleges while there is no change at the other universities.

5 Two-stage higher education

One main feature of higher education reform following the Bologna initiative in many European countries in the early 2000s has been moving to a two-stage higher education scheme with bachelor and master, replacing the older one-stage diploma. As stylized fact from the reformed system, a bachelor degree is a prerequisite of enrolling into the master stage. We show that this reform leads to higher enrollment as it allows to reduce quality at the first (bachelor) stage. At the same time, quality in the second stage can be increased as only a fraction of all students - and less than the share of the students under the diploma system – is expected to enroll into master studies. Master students are harmed relative to a system in which two quality types were employed already at the outset.

This can be formalized as follows. While the returns to quality are not altered, the cost function changes such that $h(q, a)$ stays relevant for students completing only the first stage, while it is replaced by $\phi(q_1, q_2, a)$ for students obtaining both grades, with q_1 denoting quality at the first stage and q_2 representing quality at the second stage, which will typically exceed the former. As there may be a jump in quality, an adaptation cost can arise such that $\phi(q_1, q_2, a) \geq h(q_2, a)$ where $\partial\phi/\partial q_1 < 0$ for any $q_1 < q_2$. Should, for whatever reason, quality in the first stage be higher than in the second, we would have $\phi(q_1, q_2, a) \geq h(q_2, a)$ with $\partial\phi/\partial q_1 > 0$ for any $q_1 > q_2$. In that event, the effort demanded at the first stage is too high given the ultimate target quality. Put differently, considering a variation in q_1, the cost function $\phi(q_1, q_2, a)$ assumes a miminum at $q_1 = q_2$ for any a. Assume moreover identical marginal cost terms at the ultimate quality, $\partial\phi(q_1, q_2, a)/\partial q_2 = h_{q_2}(q_2, a)$. This ensures that the only modification of the cost term is an adaptation cost, which will be zero at $q_1 = q_2$, thus $\phi(q_1, q_1, a) = h(q_1, a)$. We also assume that function $\phi(q_1, q_1, a)$ is less elastic to a change in ability than function $h(q_1, a)$, that is $|\phi_a/\phi| < |h_a/h|$. Finally, let the adaptation cost be sufficiently small, that is $\left|\frac{\partial\phi}{\partial q_1}\right| / \frac{\partial\phi}{\partial q_2}$ remains close to zero.

The problem of the social planner is then modified as follows:

$$\max_{q_1,q_2} W = \int_0^{a_1^*(q_1)} \log(w_u a) f(a)da + \int_{a_1^*(q_1)}^{a_2^*(q_2,q_1)} \log(w_s a g(q_1)) f(a)da \tag{8}$$
$$+ \int_{a_2^*(q_2,q_1)}^{\infty} \log(w_s a g(q_2)) f(a)da$$
$$- \int_{a_1^*(q_1)}^{a_2^*(q_2,q_1)} \log(h(q_1,a)) f(a)da - \int_{a_2^*(q_2,q_1)}^{\infty} \log(\phi(q_1,q_2,a)) f(a)da$$

In this problem, the social planner chooses qualities in the first stage q_1 and in the second stage, q_2, where $a^*(q_1)$ is the overall enrollment threshold and $a^*(q_2, q_1)$ denotes the ability threshold for the second stage.

With qualities q_1 and q_2 given, the related market enrollment thresholds a_1 and a_2 then satisfy

$$h(q_1, a_1^*) = \frac{w_s g(q_1)}{w_u}, \tag{9}$$
$$\frac{\phi(q_1, q_2, a_2^*)}{h(q_1, a_2^*)} = \frac{g(q_2)}{g(q_1)}. \tag{10}$$

The latter condition refers to the ability level a_2 at which an individual is indifferent between entering the second stage and completing studies after the first stage. Proposition 7 shows that a unique interior enrollment threshold for the second stage at given quality exists under mild conditions.

Proposition 7 *If* $\lim_{a\to\infty} \frac{\phi(q_1,q_2,a)}{h(q_1,a)} < \frac{g(q_2)}{g(q_1)} < \lim_{a\to 0} \frac{\phi(q_1,q_2,a)}{h(q_1,a)}$ *and* $q_2 > q_1$, *the enrollment threshold* a_2 *is interior and unique and satifies (10).*

Proof. See Appendix G. □

Rewriting welfare as

$$W = \log(w_u) \int_{0}^{a_1^*(q_1)} f(a)da + \log(w_s) \int_{a_1^*(q_1)}^{\infty} f(a)da + \int_{a_1^*(q_1)}^{a_2^*(q_2,q_1)} \log(g(q_1)) f(a)da \quad (11)$$

$$+ \int_{0}^{\infty} \log(a) f(a)da + \int_{a_2^*(q_2,q_1)}^{\infty} \log(g(q_2)) f(a)da$$

$$- \int_{a_1^*(q_1)}^{a_2^*(q_2,q_1)} \log(h(q_1,a)) f(a)da - \int_{a_2^*(q_2,q_1)}^{\infty} \log(\phi(q_1,q_2,a)) f(a)da$$

the first-order conditions to the optimization problem of the social planner are

$$\frac{\partial W}{\partial q_1} = \int_{a_1^*(q_1)}^{a_2^*(q_2,q_1)} \left[\frac{g_{q_1}(q)}{g(q)} - \frac{h_{q_1}(q_1,a)}{h(q_1,a)} \right] f(a)da - \int_{a_2^*(q_2,q_1)}^{\infty} \frac{\phi_{q_1}(q_1,q_2,a)}{\phi(q_1,q_2,a)} f(a)da \quad (12)$$

$$+ \frac{\partial W}{\partial a_1^*} \frac{a_1^*(q_1)}{\partial q_1} + \frac{\partial W}{\partial a_2^*} \frac{\partial a_2^*(q_2,q_1)}{\partial q_1}$$

$$= \int_{a_1^*(q_1)}^{a_2^*(q_2,q_1)} \left[\frac{g_{q_1}(q_1)}{g(q_1)} - \frac{h_q(q_1,a)}{h(q_1,a)} \right] f(a)da - \int_{a_2^*(q_2,q_1)}^{\infty} \frac{\phi_{q_1}(q_1,q_2,a)}{\phi(q_1,q_2,a)} f(a)da$$

$$= 0,$$

$$\frac{\partial W}{\partial q_2} = \int_{a_2^*(q_2,q_1)}^{\infty} \left[\frac{g_{q_2}(q_2)}{g(q_2)} - \frac{\phi_{q_2}(q_1,q_2,a)}{\phi(q_1,q_2,a)} \right] f(a)da + \frac{\partial W}{\partial a_2^*} \frac{\partial a_2^*(q_2,q_1)}{\partial q_2} \quad (13)$$

$$= \int_{a_2^*(q_2,q_1)}^{\infty} \left[\frac{g_{q_2}(q_2)}{g(q_2)} - \frac{\phi_{q_2}(q_1,q_2,a)}{\phi(q_1,q_2,a)} \right] f(a)da$$

$$= 0.$$

because $\partial W / \partial a_1^* = 0$ owing to the market equilibrium condition (9) and $\partial W / \partial a_2^* = 0$ due to the other market equilibrium condition (10). The first-order conditions can be interpreted as follows. While (13) again indicates that the chosen quality level at the second stage is a compromise between optimal quality levels of high ability individuals and marginal ability types entering the second stage, the optimality condition for the first stage (12) shows according to the second line that the compromise quality of those leaving the university system after their bachelor is distorted upward to dampen the negative impact on costs of aquiring education of the high ability types going through both stages.

Similar to the analysis of quality choice for single-stage studies above, multiple solutions to the welfare optimization problem may exist. We assume uniqueness also here, enabling us to compare the two-stage system to the uniform single-stage scheme, where Proposition 8 summarizes the outcomes.

Proposition 8 *Compared to the uniform single-stage system, the two-stage scheme yields (i) higher overall enrollment, (ii) lower quality at the first stage, (iii) higher quality at the second stage.*

Proof. See Appendix H. □

Proposition 8 can be interpreted as follows. Unsurprisingly, the additional political option to differentiate academic qualities will be employed. This is true because the differentiated scheme can be implemented in a Pareto improving fashion. As nobody would enroll in the second stage otherwise, quality in the master program will exceed quality of the bachelor stage. The second stage exhibits a higher quality than the uniform program because the adjustment cost calls for a higher marginal benefit of the compromise quality at the second stage. This can only be achieved by raising the quality above the level of the single-stage system. As high ability students proceed to the second stage, quality at the first stage can be reduced below the level from the uniform system to adapt to the preferences of students completing studies after the first stage. Since marginal students are now served better, this in turn also induces a higher overall enrollment.

It is obvious that even the optimal two-stage system is dominated by a one-stage system employing a differentiation with the same two qualities q_1 and q_2. Such a reform to a tracked single-stage system would leave overall enrollment unchanged. However, all people taking the higher track benefit, either due to saving the adaptation cost $[\phi(q_1, q_2, a) - h(q_2, a)]$ if they would opt for the higher quality anyway, or by being offered a more attractive higher track, allowing to switch away from just completing a bachelor-type degree.

6 Quality and effort

A possible objection against the Pareto dominance of the differentiated system over the uniform one lies in the possiblity that differentiated schemes may reduce effort in a incomplete information framework. We augment the human capital production function to include an effort component, besides ability and the quality of the university. The skill or human capital of an agent with ability a is given by $s(a, q, e) = ag(q)\chi(e)$, where $e \geq 0$ is the effort. We impose $\chi(0) = 0$, $\lim_{e\to 0} \chi_e(e) = \infty$, $\lim_{e\to\infty} \chi_e(e) = 0$, and $\frac{d\,[\chi_e(e)/\chi(e)]}{de} \leq 0$. Marginal utility from effort is decreasing in effort. Disutility of acquiring higher education at quality q and effort e is given by $\log(h(q, a)\psi(e))$ with $\psi_e > 0$, $\psi_{ee} > 0$, $\lim_{e\to 0} \psi(e) > 0$, $\lim_{e\to 0} \psi_e(e) = 0$, and $\lim_{e\to\infty} \psi_e(e) = \infty$ $\frac{d\,[\psi_e(e)/\psi(e)]}{de} > 0$. Thus, the relative marginal disutility of providing effort increases in effort. In order to insure uniqueness of optimal effort, we need the marginal disutility of effort $\psi_e(e)$ to be more responsive to effort than $\psi(e)$.

To preserve tractability, we take the log of $s(a, q, e)$. Letting $\widetilde{s} = \log(s)$, $\widetilde{a} = \log(a)$, $\widetilde{q} = \log(g(q))$ and $\widetilde{e} = \log(\chi(e))$, the true skill of a student i from university of quality q is given by $\widetilde{s}_i = \widetilde{a}_i + \widetilde{q} + \widetilde{e}_i$. For simplicity, the ranking of universities and hence the quality measure is common knowledge. The true ability $\widetilde{a}_i$ is not revealed when the agent makes the enrollment decision. Ability has a certain component $\widetilde{a}^c$, extracted from $N(0, \sigma^2(a))$ which is known at the time of enrollment. Based on that the student chooses the quality of the university in the differentiated system or his voting behavior in the uniform system. The second component of ability is random and given by $\epsilon_i^a \sim N(0, \sigma^2(\epsilon^a))$ for all students. The random component is revealed after enrollment. Thus, in the differentiated system all students who observe $\widetilde{a}^c$ at the time of enrollment choose the same quality. All universities that offer a curriculum with the same quality are lumped into a single university. Upon graduation, the ability of the student body at a certain university is centered on $\widetilde{a}^c$ and has variance $\sigma^2(\epsilon^a)$.

Following MacLeod and Urquiola (2012) we assume a competitive labor market that correctly anticipates the average effort exerted at the university of quality q, but does not observe the ability of the job candidate. Employers assess the skill of a worker based on two signals, a collective signal related to the average of students graduating from univiersites of given quality, and an individual signal. For the collective signal, the accuracy with which the market predicts the human capital of the candidate at graduation depends on the variance of ability of the student body within the university of quality q. In addition, the market receives an individual signal of the applicant's skill and updates the initial estimate. This additional information could be revealed by some screening mechanism, a job interview, or checking the candidate's grades.

Consider first the differentiated system. Initially, the expected human capital of a student from university q predicted by the market is $E(\widetilde{s}_i \mid q) = E(\widetilde{a}_i \mid q) + \widetilde{q} + \overline{\widetilde{e}}$, where $E(\widetilde{a}_i \mid q)$ is the expected ability conditional on the student enrolling in university q and $\overline{\widetilde{e}}$ is the average effort at university q. The precision of the estimate $E(\widetilde{s}_i \mid q)$ is the inverse of the variance of $E(\widetilde{a}_i \mid q)$. Denote it $p_{\widetilde{a}} = 1/\sigma^2(\epsilon^a)$.

Let π_i be the signal the market receives about $\widetilde{s}_i$. Thus $\pi_i = \widetilde{s}_i + \epsilon_i^s$, where $\epsilon_i^s \sim N(0, \sigma^2(\epsilon^s))$ is a measurement error. The signal has precision $p_\epsilon = 1/\sigma^2(\epsilon^s)$. Using Bayesian updating, the predicted human capital becomes a weighted average of the initial estimate and the signal received:

$$E(\widetilde{s}_i \mid \pi_i, q) = \frac{p_{\widetilde{a}}}{p_{\widetilde{a}} + p_\epsilon} E(\widetilde{s}_i \mid q) + \frac{p_\epsilon}{p_{\widetilde{a}} + p_\epsilon} \pi_i. \tag{14}$$

Students choose effort before knowing the realization of π_i. However, they know $E(\pi_i) = \widetilde{s}_i$ and use that in calculating their expected wage.

Denote by $\widetilde{y}_i$ the log wage. The wage expected by a student graduating from university q that chooses effort $\widetilde{e}_i$ is

$$\begin{aligned} E(\widetilde{y}_i \mid q) = & \log(w_s) + \frac{p_{\widetilde{a}}}{p_{\widetilde{a}} + p_\epsilon} E(\widetilde{s}_i \mid q) + \frac{p_\epsilon}{p_{\widetilde{a}} + p_\epsilon} E(\pi_i) \\ = & \log(w_s) + \frac{p_{\widetilde{a}}}{p_{\widetilde{a}} + p_\epsilon} E(\widetilde{s}_i \mid q) + \frac{p_\epsilon}{p_{\widetilde{a}} + p_\epsilon} \widetilde{s}_i \\ = & \log(w_s) + \frac{p_{\widetilde{a}}}{p_{\widetilde{a}} + p_\epsilon} \left[E(\widetilde{a}_i \mid q) + \widetilde{q} + \overline{\widetilde{e}} \right] + \frac{p_\epsilon}{p_{\widetilde{a}} + p_\epsilon} (\widetilde{a}_i + \widetilde{q} + \widetilde{e}_i), \end{aligned} \tag{15}$$

with the related expected utility of the student being $u(.) = E(\widetilde{y}_i \mid q) - \log(h(q, a_i)\psi(e_i))$.

Maximizing expected utility with respect to effort yields the first-order-condition

$$\frac{p_\epsilon}{p_{\widetilde{a}} + p_\epsilon} \frac{\chi_e(e_i)}{\chi(e_i)} - \frac{\psi_e(e_i)}{\psi(e_i)} = 0. \tag{16}$$

Uniqueness of the optimal effort follows from the fact that $\chi_e(e_i)/\chi(e_i)$ is decreasing and $\psi_e(e_i)/\psi(e_i)$ is increasing in e_i, $\lim_{e\to 0} \frac{\chi_e(e_i)}{\chi(e_i)} = \infty$, $\lim_{e\to\infty} \frac{\psi_e(e_i)}{\psi(e_i)} = 0$, $\lim_{e\to 0} \frac{\psi_e(e_i)}{\psi(e_i)} = \infty$, and $\lim_{e\to\infty} \frac{\psi_e(e_i)}{\psi(e_i)} = 0$. Due to the separability of utility function, chosen effort is independent of ability and quality. However, it differs across higher education systems.

In the uniform system, the precision of the estimate $E(\widetilde{h}_i \mid q^u)$ is smaller, because the variance in the ability of students within a university is higher than in a differentiated system. Thus the precision of the ability predicted by the market in the uniform system is $p_{\widetilde{a}}(u) = 1/\left[\sigma^2(a) + \sigma^2(\epsilon^a)\right]$, which is lower than in the differentiated system, $p_{\widetilde{a}}(d) = 1/\sigma^2(\epsilon^a)$. This makes sense, as in the differentiated system, the sorting of students in universities of different qualities solves part of the informational problem faces by employers. Knowing the type of university from which the student graduated provides additional information on her ability. In the uniform system, the estimate of ability is more imprecise. Consequently, the labor market will put a higher weight on the individual signal when estimating the skill of the candidate. This leads to a higher marginal return of effort in the uniform system and consequently to higher exerted effort.

Proposition 9 *Chosen effort is smaller under the differentiated scheme than under the uniform scheme.*

Proof. See Appendix I. □

As the collective signal is less reliable as predictor of the individual skill under the uniform system due to collecting a diverse student body, the employer attaches a higher weight to the individual signal. This in turn is associated with higher individual returns to effort, leading to higher effort both at the individual and the collective level. This outcome also removes the Pareto dominance of the differentiated system observed in the basic model. Individuals from the middle of the ability spectrum tend to fare better under the uniform system. As a consequence, countries with a more equal ability distribution may choose a uniform quality system while more unequal societies choose a university system with differentiated qualities.

Proposition 10 *Welfare is higher under the uniform scheme for some individuals that may form a majority of voters.*

Proof. See Appendix J. □

Welfare is higher when the system is uniform for ability types that obtain the same quality of the curriculum under either university system. Since the uniform quality system induces a higher weight on the individual signal of skill, chosen effort is higher. Due to asymmetric information, effort is associated with a positive externality, which turns out to be less strong with the uniform system. While chosen effort still lies below the perfect information level, it is closer to that benchmark if the university system exhibits uniform quality.

When voting between university systems, individuals have to balance the advantage of the differentiated system to offer tailored quality against the superiority of the uniform system in coping with the positive externality of effort. Proposition 10 indicates that voters from the middle of the student ability distribution will be in favor of the uniform system as their academic qualities will be similar in any case. Matters may look different for both top ability types and marginal students. It is conceivable that a majority of voters countries with a more equal distribution of abilities favor uniform systems due to having a comparatively high mass of voters in the range where the uniform system yields higher welfare for them, and vice versa.

Our analysis also sheds some new light on the Kaganovich-Su (2015) problem to explain why ability types in the middle of the student distribution perform below average over the course of the enrollment expansion. Instead of suffering from increased divergence of qualities with two suppliers, an increased number of available qualities may not improve the fit to their personal preferred levels, while relative income losses occur through the effort channel.

7 Concluding discussion

We have seen that both American-style differentiated schemes and European-style uniform schemes will respond to a higher skill premium by cutting quality in higher education: the differentiated by extending the share of comparatively low-quality colleges, and the uniform by accomodating to the needs to the incoming marginal students. One puzzling issue resulting from welfare considerations - which is unambiguously in favor of the uniform system due to Pareto dominance in the basic model - could be resolved by considering an asymmetric information environments. When employers attach a higher weight to individual performance when assesssing individual productivity relative to average skill of graduates from that university, student effort is predicted to increase. Put differently, when an acknowledged university ranking exists, competition between students attending different colleges is hampered, which may lead to smaller effort. As a caveat, such an environment can stimulate effort in secondary education as qualifying for highly ranked colleges is associated with an additional payoff, counteracting the mechanism discussed here.

It may also happen that political economy forces bring down quality in the uniform system below the Benthamite optimum, as this could benefit an important group of voters with below average talent at the expense of a smaller group of top ability types. With a typical skewed ability distribution and those remaining unskilled anyway abstaining from the vote, using a median voter framework instead of probabilistic voting would generate a lower quality. This is mainly to be traced back to voters preferring low qualities though not entering the university system in the political equilibrium. At the same time, working in the same direction, the probabilistic framework takes into account higher net gains from increasing quality for high ability students while the median voter scenario does not. The political outcome will also change if the unskilled are affected by skilled workers being trained at a higher quality.

Finally, in terms of international competition, the differentiated system is particularly attractive for highly talented individuals. Hence, one prediction of the model is that there will be net migration from countries with European-style uniform systems to the top American-style differentiated universities. While the migration incentive may also exists for other ability types, any model of imperfect mobility would suggest selectivity in migration such that migrating students exhibit disproportional high abilities.

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Appendix

A: Proof of Proposition 1

The first claim is immediate from studying the sufficient second-order condition

$$X_{qq} = \frac{g_{qq}g - (g_q)^2}{g^2(q^*)} - \frac{h_{qq}h - (h_q)^2}{h^2(q^*, a)} < 0. \tag{17}$$

The implicit function theorem then yields:

$$\frac{dq^*}{da} = -\frac{X_{qa}(q^*, a)}{X_{qq}(q^*, a)} \tag{18}$$

Since $X_{qq}(q^*, a) < 0$ holds due to second-order condition, we have $sgn\,[dq^*/da] = sgn\,[X_{qa}(q^*, a)]$. Calculating this cross-derivative yields

$$X_{qa}(q^*, a) = -\frac{h_{qa}(q^*, a)h(q^*, a) - h_q(q^*, a)h_a(q^*, a)}{[h(q^*, a)]^2} > 0. \tag{19}$$

because $0 > h_{qa}(q^*, a)/h_q(q^*, a) > h_a(q^*, a)/h(q^*, a)$.

B: Proof of Proposition 2

The market enrollment threshold is determined by $Z = 0$ with $Z = [w_s g(q)]/w_u - h(q, a^*)$. Given q, we have $\lim\limits_{a\to\infty} h(q, a) < w_s g(q)/w_u$, so $\lim\limits_{a\to\infty} Z > 0$. Also, $\lim\limits_{a\to 0} h(q, a) = \infty$, and thus $\lim\limits_{a\to 0} Z = -\infty$. Then, since Z is continuous in a, by the intermediate value theorem, there exist a unique enrollment threshold a^* which solves $Z = 0$. Uniqueness follows from the fact that $h(q, a)$ is decreasing in a.

C: Proof of Proposition 3

Differentiating $a^*(q)$ with respect to q yields

$$\frac{\partial a^*}{\partial q} = -\frac{\partial Z/\partial q}{\partial Z/\partial a^*} \tag{20}$$

Since $\partial Z/\partial a^* = -h_a(q, a^*) > 0$ holds at any interior enrollment threshold, the sign of the fraction is determined by the numerator, $sgn\,[\partial a^*/\partial q] = -sgn\,[\partial Z/\partial q]$.

Evaluating the latter gives

$$\frac{\partial Z}{\partial q} = \frac{w_s}{w_u} g_q(q) - h_q(q, a^*) = \frac{h(q, a^*)}{g(q)} g_q(q) - h_q(q, a^*) \qquad (21)$$
$$= h(q, a^*) \left[\frac{g_q(q)}{g(q)} - \frac{h_q(q, a^*)}{h(q, a^*)} \right]$$

Thus, $sgn \left[\frac{\partial a^*}{\partial q} \right] = sgn \left[\frac{h_q(q, a^*)}{h(q, a^*)} - \frac{g_q(q)}{g(q)} \right]$.

Denote by q_m the optimal quality for the individual with ability a_m. If $q > q_m$, then $\frac{g_q(q)}{g(q)} - \frac{h_q(q, a^*)}{h(q, a^*)} < 0$, so $\frac{\partial a^*}{\partial q} > 0$, i.e. increasing quality will increase a^* (decrease enrollment). The opposite holds if $q < q_m$.

D: Proof of Proposition 4

The market enrollment threshold is determined by $Z = 0$ with Z being defined as above. According to the implicit function theorem, $\frac{\partial a_m}{\partial (w_s/w_u)} = -\frac{\partial Z/\partial (w_s/w_u)}{\partial Z/\partial a^*}$. Since $\partial Z/\partial a^* > 0$ always holds, it follows that

$$sgn \left[\frac{\partial a_m}{\partial (w_s/w_u)} \right] = -sgn \left[\frac{\partial Z}{\partial (w_s/w_u)} \right] - sgn \left[g(q) \right] \Rightarrow \frac{\partial a_m}{\partial (w_s/w_u)} < 0. \qquad (22)$$

E: Proof of Corollary

Denote the market enrollment threshold in the differentiated system as $\widetilde{a}$ and $\widetilde{q}$ the quality chosen by marginal students with ability $\widetilde{a}$, defined by $\widetilde{Z} = 0$ with $\widetilde{Z} = [w_s g(\widetilde{q})] / w_u - h(\widetilde{q}, \widetilde{a})$. Since $\partial \widetilde{Z}/\partial (w_s/w_u) > 0$, we obtain $\frac{\partial \widetilde{a}}{\partial (w_s/w_u)} < 0$.

F: Proof of Proposition 6

Equation (3) shows that individualized optimal qualities are independent of wages. As enrollment increases with a higher skill premium and optimal qualities rise with ability according to Proposition 1, all additionally enrolled types have lower optimal qualities than those already enrolling at a lower skill premium. This reduces both chosen quality in the uniform system according to (6) and average quality in the differentiated scheme. For the uniform system, totally differentiating (6) yields

$$sgn\frac{\partial q}{\partial w_s/w_u} = -sgn\frac{\partial^2 W/\partial q\partial\left(w_s/w_u\right)}{\partial^2 W/\partial q^2} = sgn\frac{\partial^2 W}{\partial q\partial\left(w_s/w_u\right)} \tag{23}$$
$$= -sgn\left[\frac{\partial a^*(q)}{\partial\left(w_s/w_u\right)}\left(\frac{g_q(q)}{g(q)} - \frac{h_q(q,a^*(q))}{h(q,a^*(q))}\right)\right] < 0$$

since $\frac{\partial a^*(q)}{\partial\left(w_s/w_u\right)} < 0$ and $\frac{g_q(q)}{g(q)} - \frac{h_q(q,a^*(q))}{h(q,a^*(q))} < 0$ at the uniform optimum.

G: Proof of Proposition 7

$|\phi_a/\phi| < |h_a/h|$ implies $\partial(\phi/h)/\partial a < 0$. Thus, the function $\phi(q_1, q_2, a)/h(q_1, a)$ is decreasing in a. If $\lim_{a\to\infty}\frac{\phi(q_1,q_2,a)}{h(q_1,a)} < \frac{g(q_2)}{g(q_1)} < \lim_{a\to 0}\frac{\phi(q_1,q_2,a)}{h(q_1,a)}$ then by the intermediate value theorem equation (10) has a unique solution.

H: Proof of Proposition 8

Recall Proposition 1 stating that individualized optimal qualities increase in ability. This is also true for qualities in the second stage, noting that marginal cost terms stay unaffected by assumption. It can never be optimal to have a lower quality at the second stage, $q_2 < q_1$, because nobody is enrolling as the additional cost of obtaining the second degree is positive while the marginal return is negative. When q_1 coincides with the solution from one-stage higher education q_u, choosing some $q_2 > q_1$ for the second stage will be taken up by some top ability students, improving their utility without harming anybody. Thus, there will be two stages exhibiting $q_2 > q_1$.

Next, we demonstrate that $q_2 > q_u > q_1$. Using the fact that $\partial\phi/\partial q_2 = h_{q_2}(q_2, a)$ we rewrite (13) as

$$\frac{\partial W}{\partial q_2} = \int_{a_2^*(q_2,q_1)}^{\infty}\left[\frac{g_{q_2}(q_2)}{g(q_2)} - \frac{h_q(q_2,a)}{h(q_2,a)}\right]f(a)da \tag{24}$$
$$+ \int_{a_2^*(q_2,q_1)}^{\infty}\left[\frac{h_{q_2}(q_2,a)}{h(q_2,a)} - \frac{\phi_{q_2}(q_1,q_2,a)}{\phi(q_1,q_2,a)}\right]f(a)da$$
$$= 0.$$

Since $q_2 > q_1$, we have $\phi(q_1, q_2) > h(q_2)$. Suppose $q_2 = q_u$. Evaluating $\partial W/\partial q_2$ at

q_u yields $\frac{\partial W}{\partial q_2}(q_1, q_u) > 0$, as $a_2(q_2, q_1) > a_1(q_1)$ when $q_2 > q_1$. Consequently, when $q_2 > q_1$, $q_2 > q_u$.

Consider now (12), the first-order condition with respect to q_1 and evaluate it at $q_1 = q_u$. With $q_2 > q_1$ and $q_2 > q_u$, we obtain for the first term

$$\int_{a_1^*(q_u)}^{a_2^*(q_2,q_u)} \left[\frac{g_{q_1}(q_u)}{g(q_u)} - \frac{h_{q_1}(q_u, a)}{h(q_u, a)} \right] f(a)da < 0 \tag{25}$$

indicating that a uniform quality that would maximize welfare of agents with abilities between a_1 and a_2 is lower than q_u, which is the result of an optimization that takes into account the upper portion of the ability distribution (higher than a_2). The second term of $\frac{\partial W}{\partial q_1}(q_u, q_2)$, is positive as $\frac{\partial \phi}{\partial q_1} < 0$ for any $q_1 < q_2$. Since the assumption $\left|\frac{\partial \phi}{\partial q_1}\right| << \frac{\partial \phi}{\partial q_2}$ implies that $\int_{a_2^*(q_2,q_1)}^{\infty} \frac{\phi_{q_1}(q_1, q_2, a)}{\phi(q_1, q_2, a)} f(a)da$ remains close to zero, the first term dominates and $\frac{\partial W}{\partial q_1}(q_u, q_2) < 0$. Thus $q_1 < q_u$, and the overall enrollment is higher under the two-stage system.

I: Proof of Proposition 9

Consider the equation of optimal effort (16). Under the differentiated system the term $p_\epsilon/(p_{\widetilde{a}} + p_\epsilon)$ is higher than under the uniform system because $p_{\widetilde{a}}(d) > p_{\widetilde{a}}(u)$. Consequently, a movement towards a more differentiated system produces a decrease in the marginal return of effort at all effort levels. The RHS of the equation while the LHS is unchanged. As RHS is a decreasing function of effort while the LHS is increasing, the new intersection is associated with a lower level of effort.

J: Proof of Proposition 10

We compare the expected (ex-ante) utilities of students under the two systems at the time of enrollment, before the full realization of ability. Consider first the student for whom the ex-ante individual optimal quality is identical to the quality chosen under the uniform system q^u. The ability component known by the student when enrolling is $\widetilde{a}_u$, extracted from $N(0, \sigma^2(a))$. Under the differentiated system, this student would choose a school of quality q^u. Denote by e_u and e_d the optimal effort levels chosen under the uniform and differentiated system, respectively. Also denote by $\widetilde{y}_{u,u}$ and $\widetilde{y}_{d,u}$ the log wages for student $\widetilde{a}_u$ under the uniform and differentiated system. Using (15) we write the expected log wages under the two systems:

$$E(\widetilde{y}_{u,u} \mid q_u) = \log(w_s) + [p_{\widetilde{a}}(u)/(p_{\widetilde{a}}(u) + p_\epsilon)] \left[E_u(\widetilde{a} \mid q_u) + \widetilde{q}_u + \overline{\widetilde{e}}_u\right] \\ + [p_\epsilon/(p_{\widetilde{a}}(u) + p_\epsilon)] (\widetilde{a}_u + \widetilde{q}_u + \widetilde{e}_u) \tag{26}$$

and

$$E(\widetilde{y}_{d,u} \mid q_u) = \log(w_s) + [p_{\widetilde{a}}(d)/(p_{\widetilde{a}}(d) + p_\epsilon)] \left[E_d(\widetilde{a} \mid q_u) + \widetilde{q}_u + \overline{\widetilde{e}}_u\right] \\ + [p_\epsilon/(p_{\widetilde{a}}(d) + p_\epsilon)] (\widetilde{a}_u + \widetilde{q}_u + \widetilde{e}_d), \tag{27}$$

where $p_{\widetilde{a}}(u)$ and $p_{\widetilde{a}}(d)$ are the precisions with which the market predicts the ability of the student in the uniform and differentiated system. The term $E_u(\widetilde{a} \mid q_u)$ is the expected ability of the student body in the uniform system with quality q_u and $E_d(\widetilde{a} \mid q_u)$ is the expected ability of students at university of quality q_u under the differentiated system. Also $\overline{\widetilde{e}}_u$ and $\overline{\widetilde{e}}_d$ represent the average effort levels exerted under the two systems, where $\overline{\widetilde{e}}_u > \overline{\widetilde{e}}_d$.

Consider the expected utility differential for the student with ex-ante ability $\widetilde{a}_u : D = E(u_u(\widetilde{a}_u, \widetilde{q}_u, \widetilde{e}_u)) - E(u_d(\widetilde{a}_u, \widetilde{q}_u, \widetilde{e}_d))$. Denote $x(u) = p_{\widetilde{a}}(u)/(p_{\widetilde{a}}(u) + p_\epsilon))$ and $x(d) = p_\epsilon/(p_{\widetilde{a}}(u) + p_\epsilon)$, where $x(u) < x(d)$. Using (26) and (27) and rearranging terms, we obtain:

$$D = x(u)\left[E_u(\widetilde{a} \mid q_u) + \overline{\widetilde{e}}_u\right] - x(d)\left[E_d(\widetilde{a} \mid q_u) + \overline{\widetilde{e}}_d\right] + (x(d) - x(u))\widetilde{a}_u \\ + (1 - x(u))\widetilde{e}_u - (1 - x(d))\widetilde{e}_d + \log(\psi(e_d)) - \log(\psi(e_u)). \tag{28}$$

If the student expects that $E_d(\widetilde{a} \mid q_u) = \widetilde{a}_u$, $\overline{\widetilde{e}}_u = \widetilde{e}_u$ and $\overline{\widetilde{e}}_d = \widetilde{e}_d$, we get:

$$D = x(u)\left[E_u(\widetilde{a} \mid q_u) - \widetilde{a}_u\right] \\ + \underbrace{\log(\chi(e_u)) - \log(\psi(e_u)) - [\log(\chi(e_d)) + \log(\psi(e_d))]}_{\theta(e_u, e_d)}. \tag{29}$$

As the student receives the same quality in both systems, the utility differential boils down to 1) the difference between the average ability and own ability in the uniform system and 2) the difference in the net utility of effort of the systems. In the absence of the asymmetric information in the labor market, the effort that maximizes the student utility satisfies: $\chi_e(e)/\chi(e) = \psi_e(e)/\psi(e)$. Denote the solution of this equation e_o. Using (16) we notice that $e_d < e_u < e_o$. As utility is concave in effort, we conclude that $u(., e_d) < u(., e_u)$. Thus $\theta(e_u, e_d) > 0$ and $D > 0$ if $\widetilde{a}_u = E_u(\widetilde{a} \mid q_u)$.