Competition, Selectivity, Quality Assurance and Innovation in the Higher Educational Market

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**ABSTRACT**

Declining college matriculation rates, the unrelenting rise in net tuition costs and the questionable quality of some accredited degree programs has led to heightened public scrutiny of the higher education sector. There is current political pressure on institutions to increase access in a manner that does not require a large and growing student debt burden. Selective and top ranked schools with large endowments that charge high tuition have been cast in unfavorable light, and yet expanding access could diminish the selectivity that makes their degrees highly valued. At the same time innovations in digital learning have enabled scalability in education that has previously not been feasible, presenting a potential disruption in traditional higher education. This paper explores these issues in a vertically differentiated model with both selective and nonselective institutions. Selective institutions offer a high quality of education where value added is gained by limiting enrollment. Nonselective institutions offer lower quality, have open admissions and are tuition driven. Students differ in ability to benefit from these educational services. We describe how selective and nonselective institutions compete for students and how free non-credentialed educational services such as MOOCs affect tuition prices and quality assurance. Our model provides insight as to why selective institutions are the main proprietors of MOOCs.

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1. Introduction

Declining college matriculation rates, the unrelenting rise in net tuition costs and the questionable quality of some accredited degree programs has led to heightened public interest and scrutiny on the higher education sector. There is currently political pressure on institutions to increase access to higher education in a manner that does not require a large and growing student debt burden. Selective and top ranked schools with large endowments that charge high tuition have been cast in unfavorable light. But for these institutions expanding access and increasing the size of each year’s cohort could diminish the selectivity that makes their degrees highly valued.

At the same time recent innovations in digital learning and web-based technologies have enabled scalability in higher educational services far beyond what had previously been considered feasible. Many commentators forecast this technology to have a disruptive impact on the traditional brick and mortar higher education market, similar to what has happened in print media and the music industry. The 2012 introduction of widely accessible web-based online platforms known as Massive Open Online Courses, (MOOCs) further heightened the speculation on what could happen in higher education.

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Interestingly it is many of the nation’s most selective schools that have been pioneering the launch of costly MOOCs. EdX is a joint effort of MIT and Harvard and its charter members include Berkeley, Cal Tech, Columbia, Cornell, Dartmouth, McGill, Rice, and the University of Chicago among others. Coursera started in 2012 as a joint effort among Stanford University, Princeton, the University of Michigan, and the University of Pennsylvania. Hollands and Tirthali (2014) identify from interview data with 83 administrators and faculty from 62 selective institutions that expanding educational access is the number one goal for offering a MOOC.

While some MOOCs offer certification, the academic currency of such credentials remains an open question. Internet-based mode of delivery introduces important challenges to the accreditation process and we are in early days of understanding learning outcomes on this platform. Nevertheless offering MOOCs or free online educational resources that provide pathways to acquire valued professional skills may help resolve the challenges facing selective schools and the higher education sector.

This paper derives a simple but novel model of the higher education market that casts light on the nature of competition in higher education and as well on the MOOC phenomenon. We develop a vertically differentiated model of educational services that captures the role of selectivity and quality assurance in the higher education market. We define a selective institution as one that provides a high quality educational degree whose value is characterized by a negative externality in so far as the value of its degree declines as selectivity decreases and enrollment grows. The negative externality arises from peer effects in learning and research, which add

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3 In this paper, our analysis of MOOCs is focused on what some have called xMOOCs as distinct from cMOOCs. So-called cMOOCs are based on connectivist theories of learning and typically are organized by individuals or small communities sharing a strong interest in a common topic. xMOOCs as such are run by Coursera and EdX are classes initiated by higher education institutions and funded both by grants and private investors.

4 Microsoft has been and remains an innovator in on-line education that includes MCSE certification. Somewhat similarly, the Mozilla Foundation offers badges of skill achievement or competency. Again though, there is considerable doubt about the ability of these certificates or badges to receive academic accreditation.
value to the degree, and these effects diminish as enrollment across the student population becomes less selective. The other institution in the market for higher education is a nonselective institution. There is no negative externality or peer effects in learning at a nonselective institution, which in contrast to the selective institution offers a more standardized educational product.

This characterization of the two different kinds of higher educational institutions captures the key elements emphasized by Hoxby (2014). Hoxby (2014) points out as well that central to the mission of a selective institution is the creation of knowledge or research, whereas diffusion or transfer of knowledge is on the other hand, the primary mission of the nonselective institution. Creation of knowledge is a dimension of the value added to the degree of a selective institution.

Because selectivity leads to higher value added to its degree a selective institution is able to earn non-tuition revenue from two important sources. First there are donations from the alumni who have derived benefits from the increased value of their degree, a value greater than what they could achieve at a nonselective institution, and hence they have an incentive to give back to the selective institution. Second, the creation of knowledge is valued by society and both the public and private sectors are willing to fund the research and knowledge creation mission of selective institutions.

The selective institution’s dependence on non-tuition driven sources of revenue serves as a mechanism to assure the quality of their educational services and the value of their degree. In contrast the dependence of the nonselective institution on tuition revenue does not serve as mechanism to assure the quality of their educational services. Moreover we show that the more selective and non-tuition dependent the selective institution is the softer is the price competition in the market and the smaller is the percentage of students served at the lower end of the market.
This kind of market environment is attractive to entrants, but entry into the lower end of the market can exasperate quality assurance. By offering an educational resource that is widely accessible and that does not compete directly with its student population the high quality selective institution can discipline the lack of quality assurance in the lower end of the market. This response enables the high quality institution to practice selectivity and pursue an educational mission that differs from the nonselective institution.

The outline of the paper is as follows: we begin in the next section with a brief description of the market for higher education degrees in the U.S. In section 3 we present a vertically differentiated model of the higher education market and define and identify selective equilibria outcomes. A selective equilibrium is markedly different from the standard one in vertically differentiated markets where marginal cost does not depend on quality. In section 4 we compare a numeric example with some of the stylized facts in higher education. This sets the stage for considering in section 5 the innovation of MOOCs and their impact on competition in this market. Concluding remarks follow in section 6.

2. The US Higher Education Market

The higher education sector in the United States is characterized by a high degree of differentiation, of which there is significant “horizontal” differentiation. Institutions of higher education differ in size, location, whether they offer a liberal arts or more specialized curriculum. There is however an important “vertical” dimension to differentiation in the supply of higher education credentials in the U.S. In particular, there are some widely-recognized top quality and highly ranked institutions, typically research institutions, and these institutions tightly screen their students for admission. For example, using the Carnegie Classification, these institutions would include research universities, very high (RU/VH). On the other hand there are many other
institutions in the U.S. which are nonselective and practice open ended admissions. These nonselective institutions, such as, for example, those classified as Baccalaureate/Associate College, are viewed as lower quality higher educational institutions.

The core mission of a high quality or top ranked research institution is to create knowledge as well as to disseminate knowledge. These schools have a faculty of renowned scholars and they invest heavily to maintain a cutting-edge research infrastructure. They offer students learning experiences based on research and labor intensive mentoring. This kind of degree program is very costly and is not scalable. And while it is recognized that the tuition charge at many educational institutions is less than the full cost to educate a student, Hoxby (2014) provides evidence that this is particularly true at highly selective private institutions in the U.S.

Top ranked research institutions in the U.S. depend as well upon grant and endowment income to fund a substantial part of their research and educational mission. Private doctoral universities in the U.S. hold roughly 43 percent of total endowment assets among all universities and over three-fourths of that amount is concentrated among the top ten ranked Ph.D. research universities. The reliance upon alumni giving and charging students less than the full cost of their education and is not unlike an implicit loan program (Hansmann, 2012). Students at top ranked selective institutions are expected to give or pay back to the institution that provided them with a degree whose value is greater than the tuition cost.

In contrast the core mission of a lower ranked and less selective educational institution is to disseminate or transfer knowledge. These institutions offer or supply to their students more standardized educational services. Hoxby (2014) reports that a non-trivial share of the courses taught at non-selective institutions in the US cover the same material that appears in secondary

school curricula. Pre-set state subsidies have played an important role for these institutions, but at the margin funding at a nonselective institution is driven by tuition revenues, and in recent decades, tuition revenues have become increasingly important overall in covering their costs. Research grants and alumni giving at nonselective institutions play a minor or almost no role.

On the demand side students differ according to their preparation and talent for learning college-level material and in their ability to benefit from a higher educational experience. Some students are either better prepared and/or have a greater ability to benefit from university education. A degree program “adds value” to the student if a student gets more out, in terms of expected benefit, from the program then what they put in. The source of “value added” is “peer effects”. Hansmann (2012) observes that “the attraction of attending Harvard College, for example, derives not just-or perhaps even principally-from the quality of the teaching that Harvard offers but also in important measure from the intelligence, motivation, prior education, athletic ability, family, and social connections of Harvard's other students” (p. 160). The “value added” effect, or the externality in the degree program, decreases as selectivity decreases and when students are not screened in admissions for the “value added” effect.

A selective institution’s reliance on alumni donations to fund its mission is sustainable only if the value of the degree is in fact greater than the student’s tuition cost or what they could have achieved at a non-selective school. Degrees from a selective institution do appear to yield significant financial gains relative to those from a non-selective school. Brewer, Eide, and Ehrenberg (1999) and Hoxby (2001) use large national data sets to find a wage-premium for attending a selective college and one that appears to have grown over time. Black and Smith (2006) find a smaller but still statistically significant selectivity premium using NLYS79 data,
while Hoekstra (2009) using a regression discontinuity approach finds a significant and larger selectivity premium.

The well-known exception to the general finding of a selectivity premium is Dale and Krueger (2002, 2011) who find no financial advantage to attendance at a more selective institution. However, they are also unique in employing a data set consisting only of students at selective colleges and controlling for the schools to which an individual was accepted. Black and Smith (2004) on the other hand use a propensity score matching approach and find a wage premium of 11 percent for men and 7.5 percent for women who attend a selective school.

Further evidence of the financial advantage of attending a selective school in the U.S. is found in Rivera (2011) who documents that the most prestigious firms and the most prestigious graduate schools recruit almost exclusively from the most selective undergraduate institutions. This work builds on the earlier work of Useem & Karabel (1986) showing that a disproportionate number of Fortune 500 CEOs graduate from the most selective institutions. More recently Hershbein (2013) uses national data covering five decades to find a wage premium of seven to fourteen percent from attending a selective institution.

The foregoing evidence on the advantages of graduating from a selective institution is based on financial gains and these are typically based on wage or income data. Yet there may well be other advantages to going to a selective school that, though non-pecuniary in nature, nonetheless can be given a dollar value. These include better health, lower divorce probability, and greater job satisfaction, among others, (Oreopoulos and Salvanes, 2011).

The “value-added” to the student’s degree from a selective institution is positively enhanced by “peer effects” in learning and research. These peer effects are central to the selectivity in admissions. They may reflect the fact that having better able students permits a faculty member to
teach at a higher level and/or involve students more fully in research. Alternatively, they may reflect the fact that students learn from each other and having a higher average quality enhances the learning of each student in a cohort. Such effects could even stem from parents to students if, for example, parents of the highest-skilled students invest heavily in education aides, e.g., tutors, books, and computers, that have spillover to their students’ peers. There are, in short, many possible ways peer effects at a selective school could arise. We do not, however, model explicitly the mechanism underlying these effects.

Whatever the mechanism, the evidence of such peer effects for academic outcome seems to be strong and growing. The early study of Betts and Morel (1999), who found that high school peer group characteristics affected undergraduate grade point average (GPA), have now been augmented by much further research that is increasingly careful to address the endogeneity and selection issues that complicate the empirical separation of individual from group effects. While there is some evidence of such effects in general, e.g., Hoxby (2002), Ding and Lehrer (2007), Vigdor and Nechyba (2007) and Carrell, Fullerton and West (2008), the evidence is particularly strong if the impact of peers is differentiated by a student’s initial ability as originally argued by Hoxby and Weingarth (2006). Lavy, Paserman and Schlosser (2007), Burke and Sass (2008) and Imberman, Kugler, and Sacerdote (2009) have found compelling evidence that peer effects may be particularly strong for students at the top (or at the bottom) of the initial skill distribution.

In sum, the U.S. higher education market is characterized by both selective and non-selective institutions. These institutions compete to enroll students who differ in their ability to realize the gains from a higher education degree. Adding value to a student’s degree depends on the creation of peer effects in the degree program. Peer effects decline as admissions become less selective and the average student quality at the institution falls. Adding value is how an institution which
practices selectivity is able to generate non-tuition driven revenue streams. A nonselective institution which practices open admission depends solely on tuition revenue. We present in the next section a model that captures these key features.

3. Vertically Differentiated Model of Higher Education with Peer Effects

We consider a duopoly model with two kinds of higher educational institutions ranked as a high quality one, \( I_1 \), and a lower quality one, \( I_2 \), each offering an accredited higher education credential. There is a population of \( N \) students who are choosing whether or not to pursue a higher education credential at an accredited institution. Students differ in their academic preparation, their motivation and their ability to learn, and it is these characteristics that together determine the student’s likelihood of success or the likelihood of benefiting from a higher education degree. Denote by \( \theta_i \) the likelihood that student \( i \) is able to derive benefit \( V_1 \) from the high quality institution, or benefit \( V_2 \) from the lower quality institution.

The parameter \( \theta \) can be interpreted as the student’s likelihood of degree completion. It is assumed to be uniformly distributed over the population of \( N \) students in the interval \([0,1]\). At the high quality research-based institution \( I_1 \), a student’s ability to extract value from the degree decreases as enrollment at that institution expands. Alternatively, the value of a degree from a selective school is greater the higher the degree of selectivity, as measure in terms of \( \theta \), in the schools admissions. In contrast the value of the degree at the lower quality institution \( I_2 \) does not depend on its admissions.

The expected utility of a student \( i \) attending a high quality institution and incurring tuition cost \( t_1 \) net of any scholarship funding is:

\[
U_i = \theta_i V_1 - \alpha \hat{X}_1 - t_1
\]

Where \( \hat{X}_1 \) is the expected number of credentials or degrees conferred at the high quality institution. The greater is the number of degrees conferred at the high quality institution, the less
selective it is, and the lower is the average student quality, which in turn, weakens the “peer effects” and value added at the selective institution. The parameter $\alpha$ is a measure of the importance of the externality associated with selectivity, or the importance of the “peer effect” on academic quality. Strong peer effects correspond to higher values of $\alpha$. The term $\alpha x_1$ measures how a decrease in selectivity adversely affects the student’s expected gain from attending a high quality institution. The higher is the parameter $\alpha$, the more weight is given to selectivity of the high quality institution. This in turn makes the expected value of attending a high quality institution less attractive for students with lower values of $\theta$.

The student’s expected utility of attending a lower quality or nonselective institution at tuition cost $t_2$ is:

$$U_i = \theta_i V_2 - t_2$$  \hspace{1cm} (2)

We assume without loss of generality that $V_1 = 1$ and $V_2 = v$, where $v < 1$. This normalization assumption implies that the parameter $\alpha$, which measures the externality associated with selectivity, is such that $\alpha < 1$. In addition we set the population of potential students $N = 1$.

Denote by $\hat{\theta}_1$ the student who is just indifferent between attending the high quality and the lower quality institution, and by $\hat{\theta}_2$ the student who is just indifferent between enrolling in a low quality institution and not pursuing a higher education credential. The following conditions define these marginal consumers of higher education accredited degrees:

$$\hat{\theta}_1 - \alpha x_1 - t_1 = \hat{\theta}_1 v - t_2$$  \hspace{1cm} (3)

$$\hat{\theta}_1 - \alpha x_1 - t_1 \geq 0$$

$$\hat{\theta}_2 v - t_2 = 0$$

Given the assumptions of a uniform distribution of $\theta$ and $N = 1$ the demand functions facing the high quality and low quality institutions are given by:
\[ X_1(t_1, t_2) = [1 - \hat{\theta}_1(t_1, t_2)] \]
\[ X_2(t_1, t_2) = [\hat{\theta}_1(t_1, t_2) - \hat{\theta}_2(t_2)] \]

(4)

We assume that students have rational expectations about the enrollment of institutions, which as in Grilo, Shy and Thisse (2001), is equivalent to assuming that the institutions announce and commit to their net tuition charges, \( t_1 \) and \( t_2 \) before students enroll.

Application and admission are equivalent in our model but, of course, in reality selective institutions do not admit all students that apply. However, in the U.S. it is the case that students who apply to a selective college or university typically apply to a number of such institutions, often more than ten or fifteen selective or top ranked institutions, and most likely each student will be accepted by at least one of these institutions. In this regard the market clears and so our selective institution can be interpreted as representative of this category of selective schools. At a non selective school on the other hand application and admission are in fact likely to be equivalent.

Let the marginal cost \( c \) of supplying a student credential be constant and the same at both types of institutions. For simplicity, we set \( c = 0 \). However, both schools incur fixed costs in supplying educational services. At the lower quality school, these costs \( F_2 \) reflect long term contracts for faculty and classroom facilities. At the high quality institution, fixed costs \( F_1 \) are much higher, \( F_1 > F_2 \), reflecting the higher percentage of tenured or long contracts for faculty and the substantial and high fixed costs associated with maintaining a modern research infrastructure.

Both schools need to generate revenue to cover their costs. Yet while the lower quality school relies totally on tuition revenue, the high quality school also has access to donation and grant
income. This external funding stream at a selective institution, whether alumni donations or grant funding, depends on the quality of its student body. The higher is the quality of student body at the selective institution the higher the social return from investing in the institution’s research activities. Similarly, alumni are willing to give more back to a school the higher is the education value they received, or alternatively, greater is the “value added” by the institution to the educational credential.

We denote by $D(\hat{\theta}_1)$ the present value of the external funding stream at the high quality institution and assume that $D(\hat{\theta}_1) = \hat{\theta}_1 D$, where $0 < D < 1$. This assumption captures the critical feature that grants and alumni donations at a selective institution depend upon the average quality of the student body, as measured by $\hat{\theta}_1$. Higher values of the parameter $D$ correspond to higher returns to the education at the selective institution which lead to higher alumni donations and grant funding. Because $(1 - \hat{\theta}_1)$ is the enrollment at a selective institution the assumption that $D(\hat{\theta}_1) = \hat{\theta}_1 D$ implies that lower enrollment and higher student quality increases alumni donation.

To understand how selectivity, as measured both by the parameters $\alpha$ and $D$, affect the institution’s revenue maximizing behavior it is instructive to begin with the simple monopoly case in which only the selective institution offers a credential. In this case the marginal student admitted satisfies the condition $\hat{\theta}_1 - \alpha \hat{\lambda}_1 - t_1 = 0$ or $\hat{\theta}_1(t_1) = \frac{t_1 + \alpha}{1 + \alpha}$, and the institution sets $t_1$ to maximize $t_1[1 - \hat{\theta}_1(t_1)] + \hat{\theta}_1(t_1)D - F_1$. The revenue maximizing tuition is $t_1^* = \frac{1 + D}{2}$ and $\hat{\theta}_1^* = \frac{1 + D + 2\alpha}{2(1 + \alpha)}$. The selective monopoly outcome compared to the simple monopoly outcome is described in the figure below.

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6 To the extent that $D(\hat{\theta}_1)$ reflects government or research grant funding or charitable giving by foundations, students can do not consider it a fee when deciding to enroll in an elite institution.
The monopolist revenue, equal to \( \frac{(1+D)^2 + 4\alpha D}{4(1+\alpha)} \), includes tuition as well as the present value of future donations, and is greater than the simple monopoly revenue of \( \frac{1}{4} \) for values of future donation \( D > (1 + 8\alpha + 4\alpha^2)^{1/2} - 1 - 2\alpha \). As the externality in creating peer effects, as measured by \( \alpha \), increases so does the value \( D \) of the future donation required increase in order for selectivity to yield revenue greater than the simple monopoly case.

Now suppose the selective institution competes in the market with a nonselective institution. In this case the marginal student attending the selective institution satisfies \( \hat{\theta}_1(t_1, t_2) = \frac{t_1 - t_2 + \alpha}{1 + \alpha} \) and the marginal student attending the nonselective school satisfies \( \hat{\theta}_2(t_2) = \frac{t_2}{v} \). The high quality institution chooses its net tuition charge \( t_1 \) to maximize tuition revenue plus the present value of donation and grant revenue:

\[
\max_{t_1} \ t_1 \left[ 1 - \hat{\theta}_1(t_1, t_2) \right] + \hat{\theta}_1(t_1, t_2)D - F_i \tag{5}
\]
By assumption, the lower quality institution does not receive donations or grant income. Instead its goal is to maximize tuition revenue. That is the lower quality institution chooses \( t_2 \) to:

\[
\max_{t_2} t_2 \left[ \hat{\theta}_1(t_1, t_2) - \hat{\theta}_2(t_2) \right] - F_2
\]  

(6)

This leads to the following set of best response functions:

\[
t_1^* = \frac{(1 + D - v + t_2)}{2}
\]

(7)

\[
t_2^* = \frac{(\alpha + t_1)v}{2(1 + \alpha)}
\]

Figure 2 provides an illustration of the best response function and the tuition price equilibrium. A rise in the value of the grants and donations revenue stream, or an increase in \( D \), shifts the best response function of the high quality institution outward, and raises the equilibrium net tuition for both schools. Increasing importance of peer effects as measured by the parameter \( \alpha \) shifts the best response function of the low quality institution up and also makes it flatter. This again raises the equilibrium net tuition of both schools. The underlying intuition is that both higher \( D \) and higher \( \alpha \) increase the value of selectivity or the value of lower enrollment at the top quality school, and hence make the lower quality institution less price aggressive. This softens tuition competition between the two institutions. An increase in the value of the education provided by the lower quality school, or the parameter \( v \), causes \( t_1^* \) to fall but has an ambiguous effect on \( t_2^* \).
In equilibrium the institutions set net tuition:

\[
\begin{align*}
t_1^* &= \frac{2[(D+1)(1+\alpha)-v]-\alpha v}{4(1+\alpha)-v} \quad (8) \\
t_2^* &= \frac{v[(2\alpha+1+D)-v]}{4(1+\alpha)-v} \quad (9)
\end{align*}
\]

Inspection of equations (8) and (9) confirms that increases in the value of selectivity as measured by the parameters, \( D \) and \( \alpha \) lead to higher tuition prices: \( \frac{\partial t_1^*}{\partial \alpha} > 0; \frac{\partial t_2^*}{\partial \alpha} > 0; \frac{\partial t_1^*}{\partial D} > 0; \frac{\partial t_2^*}{\partial D} > 0 \).

### 3.1 Identifying Selective Equilibria:

The standard vertically differentiated model pioneered by Mussa and Rosen (1978), Gabszewicz and Thisse (1980), and Shaked and Sutton (1982) is one in which marginal costs do not depend on quality and the outcome in that model is that the high quality firm has a significantly larger market share than the low quality firm. However, in the high education
market, because of the value added effect of raising student quality and the alternative revenue stream it generates, the high quality institution has an incentive to limit its market share relative to the low quality institution. We define a selective equilibrium in this market to one in which the high quality institution maximizes revenue by selectivity and adding value to the degree. This leads in equilibrium the selective institution to enroll a smaller share of the student population than the nonselective institution.

For any equilibrium outcome we can identify the marginal student at the high quality institution and the marginal student at the lower quality institution. These are defined in equilibrium by the following:

\[
\hat{\theta}_1^* = \frac{2(1+\alpha)(2\alpha+1+D)-v(3+4\alpha+D-v)}{[(4(1+\alpha)-v)(1+\alpha-v)]} \\
\hat{\theta}_2^* = \frac{2\alpha+1+D-v}{[4(1+\alpha)-v]}
\]  

Increases in the value of endowment and grant funding, or the parameter \(D\), soften tuition competition between the two types of institutions. Hence, the marginal student at the top institution \(\hat{\theta}_1^*\) and the marginal student at the lower ranked institution \(\hat{\theta}_2^*\) both increase when \(D\) increases and less of the total student population is served in equilibrium. Similarly increases in the selectivity parameter \(\alpha\) have the same effect on increasing the marginal student at each institution, again leading to a lower share of the total student population earning a credential.

That is: for all \(0 < v < 1\), \(\frac{\partial \hat{\theta}_i^*}{\partial \alpha} > 0, \frac{\partial \hat{\theta}_i^*}{\partial D} > 0, i = 1,2\).  

\[ (12) \]

For all parameter values \(0 < \alpha < 1\) and \(0 < D < 1\), and for all values of the quality of the nonselective institution \(0 < v < 1\), it is straightforward to show that \(\min[\hat{\theta}_1^*, 1] > \hat{\theta}_2^* > 0\). The nonselective institution always has a positive market share. However, if the value of the non-tuition revenue parameter \(D\) is sufficiently high relative to the externality parameter \(\alpha\) such that
Then in order for the top ranked institution to serve students the value of the credential of the lower ranked must be bound above by 
\[ \hat{\theta}_1(\alpha, D) = \frac{2(1+\alpha)(1-D)}{2-D+\alpha} < 1. \]

In order for there to be “value added” to the degree program at the high quality institution the benefit to a student of attending the high quality institution must be greater than the benefit the student could achieve at the low quality institution. This implies that for the marginal student \( \hat{\theta}_1 \) we have that \( \hat{\theta}_1 - \alpha(1 - \hat{\theta}_1) > \hat{\theta}_1 v \) holds in equilibrium. A necessary condition for “value added” to hold in equilibrium is that the quality, or the value of the credential offered by the nonselective institution, \( v \), is such that \( 0 < v < \hat{v}_2(\alpha, D) = \frac{3(1+\alpha)+D}{2} - \frac{[8+16\alpha+9\alpha^2-8D(1+\alpha)]^{1/2}}{2}. \)

When the value of the non-tuition revenue parameter \( D \) is sufficiently high relative to the externality parameter \( \alpha \) such that \( D > \frac{\alpha}{1+2\alpha} \) it is straightforward to show that \( \hat{v}_2(\alpha, D) > 1 > \hat{\theta}_1(\alpha, D) \), and the necessary condition for “value added” holds for all \( v \) when \( D > \frac{\alpha}{1+2\alpha} \).

However, as noted above, the quality of the nonselective institution \( v \) is bound in this case by \( \hat{\theta}_1(\alpha, D) \) to ensure that the high quality institution has a positive market share.

By contrast when the value of the non-tuition revenue parameter \( D \) is sufficiently low relative to the externality parameter \( \alpha \) such that \( D < \frac{\alpha}{1+2\alpha} \) then we have that \( \hat{\theta}_1(\alpha, D) > 1 > \hat{v}_2(\alpha, D) \). In this case the high quality institution always has a positive market share, or will for all \( 0 < v < 1 \) enroll students, but in order for there to be “value added” to its degree the quality of the nonselective institution is bounded above by \( \hat{v}_2(\alpha, D) < 1 \).

Finally, observe that the share of the potential student population served by the higher quality selective institution \( I_1 \) will be less than the share served by the nonselective institution \( I_2 \), or \( 0 < 1 - \hat{\theta}_1 < \hat{\theta}_1 - \hat{\theta}_2 \), when the value of the credential offered by the non-selective
institution is sufficiently high such that \( v > \hat{v}_3 (\alpha, D) = \frac{1 - 3(1 + \alpha)D - \alpha(1 + 2 \alpha)}{1 - D} \). This is a necessary condition for the higher quality institution to be more selective in terms of number of students enrolled. Note that when \( \alpha = D = 0 \), as in the standard vertically differentiated model, it is not possible for the market share of the top ranked institution to be less than the lower ranked institution.

We define a selective equilibrium outcome in the market for higher education as follows:

\textbf{Definition:} A selective market outcome in higher education is defined as one in which the high quality institution adds value to the degree, \( \hat{\theta}_1^* - \alpha (1 - \hat{\theta}_1^*) > \hat{\theta}_1^* v \), and enrolls a smaller but positive share of the student population, \( 0 < 1 - \hat{\theta}_1^* < \hat{\theta}_1^* - \hat{\theta}_2^* \).

The regions of the parameter space \( \alpha, D \) in Figure 3 help identify the conditions for an equilibrium outcome to be selective. Region A, bounded by the downward-sloping curve, is the area for which the parameter values are such that \( \hat{v}_3 (\alpha, D) > 0 \). This means that for all feasible combinations of the selectivity parameters, \( \alpha, D \), outside of the region A, we have that \( v > 0 \geq \hat{v}_3 (\alpha, D) \), and the higher quality institution is more selective, in terms of number of students enrolled, than the lower ranked institution.

It is worth noting that selectivity parameters \( \alpha, D \) can result to in a smaller market share of the top quality school relative to that of the less-selective one, despite the fact that we have assume a zero marginal cost at each. This is markedly different from the usual outcome in the standard vertically differentiated product market.

For the high quality institution to have a positive market share the value of the lower quality institution \( v \) must also be such that \( 0 < v < \hat{v}_1 (\alpha, D) \). This condition always holds in the region of the parameter space below the line identified by \( \beta \). This line describes the values of \( \alpha, D \) for which
\( \hat{v}_1(\alpha, D) = 1. \) Thus, the region B identifies values of the parameters \( \alpha, D \) such that \( \hat{v}_1(\alpha, D) > 1. \) In this region the value of the lower ranked institution \( v \) must be less than \( \hat{v}_2(\alpha, D) \) to ensure that there is value added to the degree of the top ranked institution.

For parameter values \( \alpha, D \) above the \( \beta \) line, identified by region C, the condition \( 0 < v < \hat{v}_2(\alpha, D) \) is always satisfied. However, in the region C we must ensure that the quality of the lower ranked institution is such that \( v < \hat{v}_1(\alpha, D) < 1 \) in order for the top ranked institution to have a positive market share.

When the conditions for a selective equilibrium are satisfied it is easy to show that the tuition set by the institutions are such that the top ranked institution always sets the higher fee, \( t_1^* > t_2^* \).

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7 The boundary curve for Region B extends south-westward to the origin. We have suppressed the portion of the curve that lies in Region A.
Observe that sufficient conditions for \( v > \hat{v}_3(\alpha, D) = 0 \) are either \( D > \frac{1}{3} \) or \( \alpha > \frac{1}{2} \).

Alternatively, for parameter values \( D < \frac{1}{3} \) and \( \alpha < \frac{1}{2} \) the equation \( \hat{v}_3(\alpha, D) = 0 \) shows how decreases in \( D \) must be offset by increases in \( \alpha \) if the selective institution is to be more selective than its rival in equilibrium.

**Result 1:** For \( 0 < \alpha < 1 \) and \( 1 > D > \frac{1}{3} \) if the quality of the lower ranked institution \( v \) is such that \( v < \frac{2(1-D)}{(2-D)} \) then the necessary conditions for the equilibrium to be selective are satisfied.

Region \( C \) in Figure 3 includes the feasible parameter space \((\alpha, D)\) in Result 1. The constraint on the quality of the lower ranked institution \( \hat{v}(D) = \frac{2(1-D)}{(2-D)} \) is decreasing in \( D \), \( \hat{v}'(D) < 0, \hat{v}''(D) < 0 \). As the parameter \( D \) increases, the incentive to be selective increases and the tuition set by the high quality institution increases. It attracts students only if the quality of the lower ranked institution falls.

**Result 2:** For \( 1 > \alpha > \frac{1}{2} \) and \( 0 < D \leq \frac{1}{4} \) if the quality of the lower ranked institution \( v \) is such that \( 0 < v < \frac{3}{2}\left[1 + \alpha - \left(\frac{8}{9} + \frac{16}{9} \alpha + \alpha^2\right)^{1/2}\right] \) then the necessary conditions for the equilibrium to be selective are satisfied.

Region \( B \) in Figure 3 includes the feasible parameter space \((\alpha, D)\) in Result 2. The constraint on the quality of the lower ranked institution \( \hat{v}(\alpha) = \frac{3}{2}\left[1 + \alpha - \left(\frac{8}{9} + \frac{16}{9} \alpha + \alpha^2\right)^{1/2}\right] \) is increasing in \( \alpha \). Specifically, \( \hat{v}'(\alpha) > 0, \hat{v}''(\alpha) > 0 \). When \( \alpha = \frac{1}{2} \) and \( D = 0 \) the quality of the lower ranked institution must be less \( \hat{v} = 0.42 \). This is the minimum lower bound for this case.

For parts of the feasible space not covered by Result 1 or 2, or more generally the following necessary conditions for an equilibrium to be selective do apply.
**Result 3:**

(i) For $0 < \alpha < 1$, $0 < D < 1$ the necessary condition for $\hat{\theta}_1^* - \alpha (1 - \hat{\theta}_1^*) > \hat{\theta}_1^* v$ to hold in equilibrium is that $0 < v < \hat{v}_2(\alpha, D) = \frac{3(1+\alpha)+D}{2} - \frac{[8+16\alpha+9\alpha^2-8D(1+\alpha)]^{1/2}}{2} < 1$.

(ii) For $0 < \alpha < 1$, $0 < D < 1$ the necessary conditions for $0 < (1 - \hat{\theta}_1^*) < (\hat{\theta}_1^* - \hat{\theta}_2^*)$ to hold in equilibrium are $D > \frac{1-\alpha(1+2\alpha)}{3(1+\alpha)}$ and $0 < v < \hat{v}_1(\alpha, D) = \frac{2(1+\alpha)(1-D)}{2-D+\alpha} < 1$.

If a selective institution is a non-profit institution then in a selective equilibrium outcome the revenue earned by institution $I_i$ is such that: $t_1^*(D, \alpha, v)[1 - \hat{\theta}_1(D, \alpha, v)] + \hat{\theta}_1(D, \alpha, v)D = F_1$. The value of $D$ may therefore constrain the institution’s investment in research infrastructure, $F_1$. Alternatively, if $F_1$ is the research infrastructure necessary for a high quality institution to be selective and create value added then the institution must ensure outside funding sources consistent with that value of $D$ that covers costs.

**4. An Example and Some Stylized Facts:**

The impact of selectivity, as captured by the parameters $D$ and $\alpha$, on the market for higher education may be best illustrated by an example: Suppose that the quality of the credential from the non-selective institution is relatively high or $v = .7$ and that the high quality institution is characterized by the parameters $D = .35$ and $\alpha = .25$. In this case the outcome is in Region C and has the high quality institution enrolling 12.5% of the student population at a net tuition price of $t_1^* = .42$ and the lower ranked institution enrolling 60.8% of potential enrollees at a fee of $t_2^* = .19$. The high quality institution earns only about half the tuition revenue of its non-selective rival. However, given its donations and grant funding, its total revenue is nearly three times higher, which enables the institution to cover its much more costly research-intensive infrastructure.
This simple example makes clear how important it is that the high quality institution be selective. Although limiting its enrollment means serving a smaller share of the potential student market, two forces work to offset the tuition loss that this would otherwise imply. First, that increased selectivity results in greater value added and willingness to pay on the part of those students who do attend a selective institution. Second, the ability to earn grant income and charitable and/or alumni donations increase with a more selective and higher-quality student body.

The relative magnitudes in the example are not inconsistent with stylized facts in the U.S. Among private research universities, the four institutions with the highest endowment assets per student received an average of $72,000 of annual endowment income per student, which is significantly higher than the average tuition revenue per student. When grant income is added to endowment receipts, the total non-tuition income at such schools is that much larger relative to tuition income.8

In addition, if we take graduation rates as a rough measure of student success, then the marginal values $\hat{\theta}_1^*, \hat{\theta}_2^*$ are roughly consistent with real world data. In 2004, for instance, only 31 percent of full-time US students who began at an open-admission institution and 45 percent at institutions accepting at least 90 percent of applicants earned their degrees within six years. At the most selective four-year institutions, however, 88 percent of full-time students completed their degrees in six years.9 In our example, the average graduation or success rate is 91 percent at a high quality institution, but only 52 percent at the lower quality school.

Our simple model establishes a relationship between an institution’s completion rate, as measured by $\hat{\theta}_1^*$, $\hat{\theta}_2^*$ and its tuition charges. Such a relationship has been empirically validated and reported in Zemsky, Sharman and Perna (2014) who have shown that the five-year graduation rate is the single best predictor of tuition prices charged at both public and private institutions.

Continuing with the example suppose that the value of the donation and/or grant income parameter increases to $D = .4$, while the quality of a credential from the lower ranked institution and the selectivity parameter remain the same at $\nu = .7$ and $\alpha = .25$. The high quality school raises its net tuition fee to $t_1^* = .45$, leading it to now enroll only nine percent of the total potential student population. A number of those who would have enrolled at the selective school now switch to the lower ranked institution with the result that it now serves 63% of the student population even though it raises its tuition charge to $t_2^* = .195$.

Not surprisingly, this increase in $D$ has positive revenue effects for both schools. At the selective institution, total revenue rises by nearly 13 percent. Income at the lower ranked school also rises by a more modest but still significant six percent. However, the fraction of all potential student population enrolled in higher education falls from 73 to 72 percent and the weighted average net tuition fee paid rises by 24% (from $\bar{t} = .203$ to $\bar{t} = .252$).

This example suggests that a general rise in asset prices, or other positive endowment shock or, alternatively, an increase in grant-earning assets permits the high quality school to become more selective, thereby softening price competition and permitting both institutions to raise tuition prices. Again, these implications are not inconsistent with some of the broad empirical facts of the last 30 years. This period is characterized by an unsteady but overall positive increase in asset
prices and real endowment values as Peña (2010) has emphasized.\textsuperscript{10} It has also been accompanied by a substantial rise in tuition rates at both highly ranked and lower ranked institutions, averaging by some measures as much as three percent per year above the inflation rate on average.

Somewhat paradoxically, even though rising endowments and research grants at elite schools support the costly research infrastructure essential to a knowledge-based economy, they also generate a climate for rising tuition prices, which in turn leads to more limited access to higher education across the board. Ehrenberg (2013) documents that the steady rise in tuition has been accompanied by an increase in selectivity at top schools, and declining rates of college participation among the college-age population.

The environment of soft price competition coupled with a growing underserved segment of the market creates conditions for entry. And so not surprisingly there has been in the U.S. a marked increase in the number of for-profit higher education institutions entering the lower end of the market. As the number of undergraduate students enrolling in degree programs increased from 2000 to 2010, the share of degrees awarded by for-profit institutions increased from 4% to 10%, and the percentage of degrees awarded by public and private nonprofit institutions during this 10-year period declined from 66% to 62% and from 30% to 28%, respectively.\textsuperscript{11} Moreover, in recent years, the absolute number of students attending four-year public and non-profit universities has declined.\textsuperscript{12}

\textsuperscript{10} Peña (2010) also argues that the rise in the real value of selective college endowments is a prime source of the rise in tuition rates but his model behind this result is somewhat different. In his model, the rise in $D$ and endowment income implies more and better university facilities that raises students’ willingness to pay.

Deming, Goldin, Katz and Yuchtman (2015) have recently shown, using data from the Integrated Postsecondary Education Data System, that the recent innovation of online education is for the most part concentrated in large for-profit chains and less-selective public institutions. In addition they find that colleges with a higher share of online students charge lower tuition prices, and that real and relative prices for full-time undergraduate online education have in recent years (2006-2013) declined.

Although the results in Deming et al. (2015) suggest that online technology could “bend the cost curve” in higher education, they observe that much less is known about the impact of online technology on the quality of education. Although the quality of American higher education is generally viewed by world standards as very high, the recent and rapid rise of for-profit institutions has caused public concern about the quality of higher education. Scandals over student indebtedness coupled with evidence of poor educational training has led to calls for increased regulation and oversight in the higher education sector.

The revenue model of a selective institution acts as an important mechanism for quality assurance. The implicit loan or promise of future alumni donations work only if students do obtain added value from their education. But what assures quality of the nonselective institution? The failure to assure quality in the lower segment of the market is what is triggering a call for tighter regulation of the market. The debate on higher education has also drawn into question the tax free status of selective schools’ endowments. The next section considers how free online resources, which offer an alternative, but non-accredited credential affects competition in this market and the incentive of selective schools to provide these resources. Specifically, offering MOOCs may be a way for selective schools to increase access without reducing selectivity and at the same time provide quality assurance in the lower segment of the market.
5. Online Educational Resources: Alternatives to Accredited Degrees

To understand the impact of the selective school offering a free educational resource, such as a MOOC, we denote by $R$ the maximum value to the student of completing the educational resource. This resource is available for student enrollment at no charge. Because this resource does not lead to an accredited certificate or degree we assume that the maximum value $R$ realized by any student is less than the maximum value $v$ provided by the lower ranked but accredited school, or $1 > v > R$.

The availability of a valuable and free educational service creates competitive pressure in the market. For the lower ranked nonselective institution to have a positive market share it must be the case that the marginal student $\hat{\theta}_1$ at the high quality institution prefers a degree from an accredited institution than a free online non-accredited alternative; that is, given net tuition prices $t_1$, $t_2$, we must have: $\hat{\theta}_1 - \alpha \hat{\theta}_1 - t_1 = \hat{\theta}_1 v - t_2 > \hat{\theta}_1 R$. The marginal student $\hat{\theta}_2$ at the lower ranked institution is however indifferent between the value of the alternative and the value of the lower ranked degree as defined by the condition: $\hat{\theta}_2 v - t_2 = \hat{\theta}_2 R$.

Tuition competition for students at the accredited institutions leads to the following best response functions:

$$t_1^* = \frac{(1 + D - v + t_2)}{2}$$

$$t_2^* = \frac{(\alpha + t_1)(v - R)}{2(1 - R + \alpha)}$$

(13)

It is easy to see that the availability of acquiring educational services that yield a maximum value $R$ at no charge shifts down and flattens the best response function of the lower ranked institution. This
of course spills over to tougher price competition overall leading to lower equilibrium tuition prices at both accredited institutions:

\[ t_1^* = \frac{2[(D+1-v)(1+\alpha-R)+\alpha(v-R)]}{4(1+\alpha)-3R-v} \quad t_2^* = (v - R) \frac{[1+2\alpha+D-v]}{4(1+\alpha)-3R-v} \] (14)

Tuition prices at both institutions are, as expected, decreasing in the value of the free educational resources as measured by \( R \), or \( \frac{\partial t_1^*}{\partial R} < 0, \frac{\partial t_2^*}{\partial R} < 0 \). The lower is \( v \) relative to \( R \) the less likely it is that the nonselective institution will survive the competitive pressure from the alternative credential.

The availability of the alternative \( R \) implies a change in the marginal students \( \hat{\theta}_1, \hat{\theta}_2 \) as follows:

\[ \hat{\theta}_1^* = \frac{[2(\alpha+1+D-v)(2(1+\alpha)-R-v)]}{[(4(1+\alpha)-3R-v)(1+\alpha-v)]} \quad \hat{\theta}_2^* = \frac{[2\alpha+1+D-v]}{[4(1+\alpha)-3R-v]} \] (15)

The value of the marginal student enrolling at each institution increases, implying that the market shares of both types of institution decline, as \( \frac{\partial \hat{\theta}_1}{\partial R} > 0 \) and \( \frac{\partial \hat{\theta}_2}{\partial R} > 0 \). However, because of the availability of a free alternative educational resource it is now the case that the entire population of students seeking some form of higher educational services is served.

The vertical nature of differentiation in higher education implies that the impact of the free educational resource is markedly different for the two accredited institutions. To see this, consider the example discussed above in which the higher education market is characterized by the following parameter values: \( v = .7, D = .35 \) and \( \alpha = .25 \). The equilibrium in the absence of any free alternative is characterized by tuition charges: \( t_1^* = .42 \) and \( t_2^* = .19 \), and with the high quality institution enrolling 12.5\% of the student population and the low quality institution enrolling 60.8\% of all potential students. What happens if we now introduce an online alternative offering educational services with a maximum value of \( R = 0.2 \) and offering them for a zero price?
The entry of the free educational resource alters the equilibrium outcome in a number of key respects. To begin with, the zero-price alternative introduces some tougher price competition. As a result, the equilibrium tuition prices fall to \( t_1^* = .40 \) and \( t_2^* = .15 \), implying declines of 3.8 percent and 17.1 percent for the two schools, respectively. The vertical or ranked hierarchy of the three educational services means that the pricing pressure introduced by the free alternative bears much more intensely on its nearest rival, the lower ranked school.

However, the greater proportionate fall in the non-selective school’s tuition price means that it now becomes attractive to formerly marginal students at the selective school. As a result, the selective institution sees its share of the potential student market fall from 12.5 percent to just under 10 percent. Yet its non-selective rival does not gain students overall because the share of students it gains from the selective school is more than offset by the larger number of students that it loses to the free alternative. The non-selective school now serves 59 percent of the eligible student population. Observe that while the selective school loses some market share, these losses are concentrated among its lowest \( \theta \) students. Consequently, the average quality of its students rises with the result that its grant and endowment income also rises thereby softening the competitive pressure introduced by the free alternative.

The overall impact of the free alternative educational resource is very different for the two accredited institutions. Whereas the non-selective school sees an overall revenue decline of 19 percent, the selective school’s revenue falls by under one percent. Moreover, the impact on the selective institution would be even smaller if it were less tuition dependent. For example, if in the foregoing example we had instead assumed a value of \( D = .4 \), a MOOC innovation would reduce its total revenue by only half of one percent.
Offering MOOCs as an alternative free educational resource addresses some of the challenges that the selective institution faces in expanding educational access. It permits the selective school to leverage its brand without diluting it. That is, it permits the selective school to offer expanded access to educational services without reducing the selectivity of the school itself. Yet because the negative revenue impact of the competition that the MOOC introduces falls so heavily on the non-selective school, the reduction in the selective school’s revenue is relatively small. In addition and perhaps most importantly it provides a degree of quality assurance in the lower end of the market. The $R$ offered by the MOOC program acts as a lower bound to the quality being offered at the nonselective school.

Weissman (2012) and Belleflamme and Jacqmin (2014) have queried the business model that could make a MOOCs sustainable. They note that there are potential revenue streams from certification, or in screening for employee or graduate school. However, these kind of activities typically require partnership with a firm, e.g., Pearson VUE, to administer the MOOC and authenticate student performances, and such intermediaries take a share of revenue so that the net revenue to the school can be modest. Yet as we have shown above, the net revenue may not need to be very large in order for the selective school to find it worthwhile to enter this segment of the market.

If the selective school offers a MOOC and charges an administrative fee, so it is no longer “free” there is both a direct and an indirect effect. The fee directly raises revenue from those students who enroll in the MOOC. Indirectly, however, it works to soften the price competition between the MOOC and the non-selective school, and this again spills over to softening price competition at the selective institution. There is as well another indirect effect. As the selective

\[13\text{ Because the MOOC does not lead to an accredited credential the fee is different from a tuition charge.}\]
school raises its tuition, it again loses its least well-prepared marginal students so that its average student quality rises, which leads to an increase in grant and donation income.

For example, a fee of $t_3 = 0.016$ for the MOOC resource leads to tuition fees at accredited institutions of $t_1 = 0.402$ and $t_2 = 0.16$, respectively, and this is sufficient to restore the selective school’s pre-MOOC revenue stream. In other words, a MOOC fee of about one tenth the non-selective school’s fee and less than one twenty-fifth of the elite tuition price is enough for the selective school to break even by offering a MOOC.\(^\text{14}\) If the per course fee at the high quality institution were $4,000 the break-even MOOC fee would be under $160—surprisingly close to the $100 that Coursera charges for identity-verified completed courses.

The selective school’s effort to expand educational access may also attract donations and grants. For example, the Gates Foundation donated $1 million to MIT in support of its effort (joint with Harvard) to launch the EdX online learning program. Relatedly, the data generated by the EdX courses are likely to be the basis of subsequent grant-funded research. Within our model, it takes only a relatively small rise in $D$ to offset the selective school’s revenue loss that a MOOC introduces. This is only partly due to the fact that an increase in $D$ directly raises endowment and grant income. It is also due to the fact that as donations and grants become more important, tuition price competition is again softened.

6. Summary and Conclusion

American higher education includes selective institutions which through research create as well as disseminate knowledge whereas less selective institutions primarily focus on the latter. The

\(^{14}\) Again we consider parameter values satisfying conditions where both institutions have positive market share.
knowledge or value creating schools are selective in their student enrollment, limiting access to those students who will benefit and add value to their mission. To cover the cost of creating knowledge and educating their students selective schools depends upon donations and/or grant income. This external funding depends upon the realization of the value-added in their educational services and acts to assure quality. Nonselective institutions on the other hand are tuition driven and offer standardized curricular without these value added effects and quality assurance.

We have developed a simple vertically differentiated model of higher education that captures these features in order to shed light on some of the competitive dynamics in the current higher education market. In particular, it makes clear the softening effect of grant and endowment revenue streams on tuition-price competition. The model shows how increasing weight on selectivity at high quality schools similarly reduces the intensity of competition for students in the higher educational market.

The model also allows us to understand the impact of recent innovations in online educational resources that have introduced large scale economies into the production of higher educational services. It is clear that the disruptive effects of new digital learning environments are likely to be most severe for their nearest neighbor in the vertical education chain, namely, the non-selective schools. In this same connection, the model also provides insight as to why it has been predominantly the selective institutions that have fostered the development of MOOCs. By offering an educational resource that is widely accessible and that does not compete directly with its student population the high quality institution can discipline the lack of quality assurance in the lower end of the market. This response to the challenges facing higher education enables the high quality institution to practice selectivity and pursue its mission. To our knowledge, this paper is the first to explore innovations in education production in a model of competition in higher education.
7. References


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