Higher education reforms and signaling equilibria

Giuseppe Rose*

Birkbeck College, University of London, UK; Department of Economics and Statistics, University of Calabria, Rende, Italy

The paper examines job market signaling equilibria in the presence of perturbations coming from policy reforms and unobserved individuals’ cost functions. We show that when the single-crossing property is preserved, in the one-shot version of the game the basic Spence result of separation always holds. Then we show that in the repeated version of the game both separating and pooling equilibria may arise conditional on the intensity of educational policy reforms. In this case, a frequent implementation of higher education reforms may be crucial in generating pooling equilibria.

Keywords: single-crossing property; perfect Bayesian equilibrium; forward induction; higher education reforms

JEL classification: C73, D82, H77, I28

1. Introduction

This paper analyzes the job market signaling game in the presence of policy reforms affecting the higher education sector. The aim of the work is to understand if the large number of reforms that are involving many countries in the European Union can have an unconsidered side effect, by influencing the signaling role of education. The issue is relevant since many European governments are undertaking major reforms of the university system in order to develop an integrated and coherent European Higher Education Area. The move to a common structure of the university sector has different implications for the countries: for some of them it simply represents a minor rescheduling of the existing higher education programs, while for others it represents a restructuring of the whole university sector and the need to change the system, duration and intensity of the study programs. For instance, the Italian higher education sector has been modified, in the light of the so-called Bologna Agreement, by introducing short cycle (three years) and Bachelor (two years) instead of the unique five-year degree.1 Indeed, the controversy on the implementation of these reforms is still in progress between those who consider the short cycle–Bachelor reform necessary to improve access to university and those who feel that behind this reform there has only been a dramatic reduction of the academic contents of university courses, generating larger enrolment of low-ability individuals (see Cappellari and Lucifora 2008). However, it is reasonable to expect new changes within the European Union since there is still “a call” for further reforms by the European Commission (2005) and by the Council of European Union (2005) targeted to a sort of “Anglo-Saxonization” of the European higher educational system. Indeed, in continental Europe universities are characterized by a combination of excessive public control and bad governance coupled with insufficient funding (Jacobs and van der Ploeg

*Email: g.rose@ems.bbk.ac.uk

ISSN 1748-7870 print/ISSN 1748-7889 online
© 2009 Taylor & Francis
DOI: 10.1080/17487870902872847
http://www.informaworld.com
The modernization of European universities, involving their interlinked roles of research, education and innovation has been acknowledged as a core condition for the success of the broader Lisbon Strategy.

In this paper we show that, while there can be many theoretical and empirical reasons to raise enrolment rates and access, improve governance and reduce underperformances on research and teaching, lack of internationalism, and lack of funding, politicians cannot ignore that educational reforms should be made carefully. In particular, policies should be mainly characterized by a long-run perspective in order to preserve the signaling role of education. We focus on higher education reforms by studying how the use of policy may affect the signaling role of education in the presence of asymmetric information on individuals’ working ability. In particular, using a job market signaling game set-up, we evaluate how the use of policy reforms may affect agents’ beliefs in the Bayesian equilibrium path. The issue can be described in technical terms by considering that in dynamic games with incomplete information, it is possible to reduce the number of equilibria that come from the application of the perfect Bayesian equilibrium concept, by using the refinement called intuitive criterion (Cho and Kreps 1987) or, more generally, by using a forward reasoning (Kohlberg and Mertens 1986). Typically in these games, there is asymmetric information concerning a given agent’s characteristic and, at the same time, there are some other elements, on which there is common knowledge, which can be used as a signal to deduce the agent’s private information. In the job market signaling game (Spence 1973, 1974, 2002), where individuals’ innate ability is unobserved by firms, the application of these refinements leads to the conclusion that, when acquiring education is more costly for low-ability than for high-ability individuals, only the efficient separating equilibrium may arise. This conclusion is based on the assumption that there is no uncertainty with respect to the elements that allow us to obtain the signal. In particular, it is assumed that firms can always perfectly observe how the cost of acquiring education changes across high- and low-ability individuals. However, in a context where institutions are involved in the signal generating process, this assumption could prove to be too unrealistic. In particular, when considering the economics of higher education, the presence of reforms affecting the amount of tuition fees, university funding, or the degree of centralization in fixing academic standards, determines how the costs of education may change across individuals with different abilities. In this work we argue that, when the single-crossing property is preserved, in the one-shot version of the game the basic Spence result of separation always holds. Then, we show that in the repeated version of the game both separating and pooling equilibria may arise conditional on the intensity of educational policy reforms. In this case, a frequent implementation of higher education reforms may be crucial in generating pooling equilibria, even if the single-crossing property is satisfied. The paper is divided as follows. Section 2 describes the model set-up. Section 3 discusses the possible equilibria for both the one-shot and the repeated interaction process. Section 4 presents a graphical intuition of the analytical results. Section 5 concludes and some proofs are given in the Appendix. Subscripts are omitted when this does not generate confusion.

2. The model

In order to study the equilibria that may arise in the job market in the presence of unobserved individuals’ cost functions and higher education reforms, we use a strategic interaction framework à la Spence, where individuals are heterogeneous with respect to their education costs because they have different innate abilities. We assume productive human capital i.e., we consider the case where education raises individuals’ productivity. On top
of that, education works as a device that makes firms able to formulate beliefs on individuals’ ability conditional on their schooling level. Using this framework, we can analyze how firms’ beliefs and expectations change in the presence of policy reforms that affect the schooling sector. We consider a simple model where there are a large number of individuals and universities. We refer to the case in which universities operate within a centralized funding system, as in continental Europe. In this system, students’ tuition fees have only a marginal impact on universities’ resources that are mainly represented by governmental subsidies. Universities are assumed to be heterogeneous with respect to the effort they require from the individuals in order to achieve a given qualification. Moreover, the larger the effort that universities require, the larger will be the individuals’ productivity, once they are in the labor market. We summarize this heterogeneity by considering universities that supply different levels of education quality. We do not model how universities act in order to determine their supply of education quality. Many works in the literature focus on competition among universities, showing that in equilibrium they may decide to supply different levels of quality. A crucial ingredient of our model is that the quality of education magnifies the complementarity between education and individuals’ ability by determining the “distance” between the costs of acquiring education for high- and low-ability types. We assume that the quality of education is observed only by the individuals, since only these agents are directly involved in the learning process. At the same time, we assume that firms formulate rational expectations to evaluate the quality of education using the history of the quality of each institution and all other information they have in each period.

2.1. Individuals, universities and firms

Consider the following set-up where \( \theta \) indicates the individual’s innate ability (with \( a = h, l \) and \( \theta_h = 1 \) and \( \theta_l = 0 \)), \( e \geq 0 \) indicates the education level and \( w \) represents wage. The individual’s innate ability is unobserved by firms. The share of high-ability individuals, indicated by \( \gamma \) (with \( 0 < \gamma < 1 \)) is common knowledge. Each individual matches randomly with a university and conditional on his ability and on the observed quality of education, he chooses the level of schooling \( e \) he wants to acquire. The assumed individual–university random match is an extreme case to model the presence of market imperfections and frictions that limit the possibility that individuals sort universities and vice versa. In this respect, some issues are worth noting. First, in our setting universities cannot select students on the basis of their ability, since ability is not perfectly observed. However, as we point out in the following sections, the quality of education is, in itself, an instrument that allows selection of students. Hence, \( \text{ex-post} \) in our model we have a positive correlation between university’s quality and the average ability of the student body. Second, with respect to the individuals’ choices, typically frictions such as mobility costs, liquidity constraints, or family ties at least partially limit individuals’ optimal behavior. For instance, Ordine and Rose (2008) consider a model where individuals choose among universities that differ in quality, but they have to sustain mobility costs. The authors show that in equilibrium a share of high-ability individuals may decide to study in low-quality universities. Finally, it is important to keep in mind that we are referring to a context in which universities are mainly public financed institutions that do not implement strong selectivity criteria. After the schooling process has been completed, a large number of identical firms observe the educational level acquired by the individual and the university he comes from. These firms simultaneously make a wage offer \( w \) to the individual who accepts the highest wage. The output of an individual in a firm is a function \( y(e, \theta, q_{is}) \) of his education, his ability and of the
quality of education $q_{is}$ received in university $i$ (with $i = 1, 2, \ldots$) in period $s$ (with $s = 1, 2, \ldots$). The individual’s productivity $y()$ is assumed to be linearly increasing in $e$ with:

$$y_{is}(\cdot) = q_{is} \quad \forall \theta$$

and

$$y(e, 1, q_{is}) > y(e, 0, q_{is}) \quad \forall e, q.$$  

We can write the individual’s productivity differential due to ability as:

$$\Delta = y(e, 1, q_{is}) - y(e, 0, q_{is}) \quad \forall e, q.$$  

Individuals maximize the following utility function:

$$U(w, e, q_{is}) = w(e, \theta, q_{is}) - c(e, \theta, q_{is})$$

where $c(e, \theta, q_{is})$ represents the cost of education. This cost is a function of the education level $e$, of the individual’s ability $\theta$ and of the quality of education $q_{is}$ supplied by university $i$ in period $s$. Assume that the cost function satisfies the following properties:

$$c_{e}(\cdot) > 0$$  

and

$$c_{q}(\cdot) > 0.$$  

Equation (6) assumes that the higher the quality of education, the higher the cost that an individual needs to sustain in terms of effort to achieve a given qualification. In other words, high-quality universities supply a larger set of skills than low-quality institutions and, as a consequence, individuals studying in high-quality universities must exert more effort than their colleagues in order to acquire a degree qualification.

We assume that the quality of education, and hence the cost of acquiring it, is observed only by individuals since only individuals are directly involved in the learning process. As a consequence, we consider the cost’s function as one of the individual’s private information.

In each period $s$ the quality of education is distributed across universities following a normal distribution $N$, that is common knowledge, on a given support with mean $\bar{q}$. We assume that the single-crossing property holds only if $q_{is} \geq \bar{q}$:

$$c_{e}(e, 0, q_{is}) > c_{e}(e, 1, q_{is}) \quad \text{if} \quad q_{is} \geq \bar{q}.$$  

In other words, if $q_{is} < \bar{q}$ the single-crossing property disappears and the marginal cost of education is identical for individuals with different abilities. The idea, that has also been recently addressed by Ordine and Rose (2009) is that the quality of education can be crucial in generating the single-crossing property since it might magnify the complementarity between education and an individual’s innate ability by lowering the impact that other elements, such as family background or opportunity costs, may have in determining the marginal cost of education. Considering the utility function (4), when the single-crossing property (7) holds it is possible to draw the indifference curves for both the high- and the low-ability individuals ($\theta_h$ and $\theta_l$ respectively) as illustrated in Figure 1.
A corollary of Equation (7) is that:

\[ c_{eq}(e,0,q_{is}) > c_{eq}(e,1,q_{is}) \quad \text{if} \quad q_{is} \geq \bar{q} \]  

where \( c_{eq}(\cdot) \) is the cross-partial derivative of the cost function with respect to the level and the quality of education. The implication of Equation (8) is that a reduction in the quality of education lowers the indifference curves of low-ability more than those of high-ability individuals. The net effect of a decrease in \( q_{is} \), illustrated in Figure 2, results in the fact that the indifference curves of low- and high-ability individuals become less distant from each other and, when \( q_{is} < \bar{q} \), the two maps become as one.  

Finally, we assume that the following holds:

\[ \Delta > y(e,0,q_{is}) + c(e^{sep}(q_{is}),1,q_{is}) \quad \forall q_{is} > \bar{q} \]  

where \( e^{sep}(q_{is}) \) indicates the educational level that generates separation given \( q_{is} \). Equation (9) is a technical assumption ensuring that a high-ability individual strictly prefers to signal his ability instead of being considered as a low-ability type.

### 2.2. The timing of the model

The interaction process that takes place in each period \( s \) is described in Figure 3. In particular, each period \( s \) consists of \( t = 0,1,2,3 \) instants of time. Using the Harsanyi (1967/68) approach, at time \( t = 0 \) Nature chooses all the elements that are not common knowledge. In
our case Nature chooses randomly the vector $\omega = [\theta, q]$. At time $t = 1$ the individual chooses the education level he wants to acquire contingent on his type and conditional on the observed quality of education. At time $t = 2$, all firms (in the Figure, $f$ and $-f$) observe a level of education $e$, and the university where the individual comes from, and make a wage offer simultaneously. At time $t = 3$ the individual decides which offer to accept, if any.

The equilibrium concept used to solve the model is perfect Bayesian equilibrium (PBE) consistent with forward induction (Kohlberg and Mertens 1986). In the PBE concept, the elements that are not common knowledge are (Bayesian) updated by players. In our case, since the element that should allow us to obtain the signal on individuals’ ability (the cost of acquiring education) is not common knowledge, firms need to formulate expectation on it. As a consequence, firms’ beliefs on $e$ are conditional to firms’ expectations on $q$. In particular the beliefs function is:

$$b(e_s) = b(e | E[q_{is} | s - 1, N]).$$  \hfill (10)

where $E[q_{is} | s - 1, N]$ indicates that firms formulate rational expectations on $q_{is}$ using all the information they have in period $s$. This information set is given by $(s - 1)$ which represents all the realizations of $q_{is}$ till $s - 1$ (for all $i$) and it is also given by $N$, which represents the prior knowledge concerning the cross-sectional distribution of $q_{is}$ (for all $s$).
2.3. Higher education reforms

We assume that policy reforms on higher education affect the supply of education quality of each university. Recently, many works (among others see Kemnitz 2007, Ordine and Rose 2008) studied how reforms involving the level of tuition fees, university funding, or the degree of centralization in fixing schooling standards may strongly affect the supply of education quality. For instance, Ordine and Rose (2008) show that the decentralization process concerning academic standards in the presence of a centralized funding system may lead to large quality differentials across universities because of heterogeneous monopoly power of each institution on local demand. Moreover, these authors show that a change in the level of the governmental subsidy per student induces the universities to re-set the optimal level of quality maximizing their objective functions. Here, in order to discuss the effects of policies that affect the supply of education quality, consider firms’ rational expectation on \( q_{i1} \) at \( s = 1 \). Since no past observations are available, the expected value of \( q_{i1} \) conditional to the prior \( N \) might differ from the actual realization \( q_{i1} \) only for a random error \( u_{i1} \):

\[
q_{i1} = E[q_{i1}|N] + u_{i1}
\]

(11)

with

\[
u_{i1} \sim N(0, \sigma^2_{u_{i1}})
\]

(12)

because of our assumption concerning the distribution of \( q_i \). More generally, we can write that:
We model the occurrence of a reform that affects the educational sector in period $s$, as a white noise $\varepsilon_s \sim N(0,\sigma^2_s)$. We assume that a policy on education that occurs in period $s$ affects the supply of education quality for all the cross-sectional units; hence we have that:

$$\text{cov}(\varepsilon_s,u_{is}) = \sigma_{eu} \geq 0.$$  

Equation (15) simply states that when a policy is implemented it affects the cross-sectional distribution of $q$. We consider $\sigma^2_e$ as a function of the intensity in the use of policies. Notice that if reforms are never implemented, we have that:

$$\sigma^2_e \to 0; \sigma_{eu} \to 0; \text{ and } \sigma^2_{as} = \sigma^2_u.$$  

3. The equilibria

In what follows we discuss the equilibria that may arise in both the one-shot ($s = 1$) and the infinitely repeated version ($s \to \infty$) of the game. We show that, in the one-shot version of the game when the single-crossing property is preserved, the basic Spence result of separation always holds. Then we show that in the repeated version of the game both separating and pooling equilibria may arise, conditional on the intensity of educational policy. In this case, a frequent implementation of higher education reforms may be crucial in generating pooling equilibria.

3.1 The equilibria in the one-shot game

**Proposition 1** If $q_is < \bar{q}$ the only PBE of the game described in Figure 3 is a (degenerated) pooling equilibrium.

**Proposition 2** If $q_is \geq \bar{q}$ any PBE of the game described in Figure 3 consistent with forward induction must be a separating equilibrium.

The proof of Proposition 1 and Proposition 2 is given in the Appendix. The intuitions behind these are straightforward. Since $s = 1$,

$$E[q_{is}|s-1,N] = \bar{q}$$  

and this makes firms consider education as a credible signal of individuals’ ability by assumption. Because of Bertrand’s competition, each firm offers a wage according to the wage schedule depicted in Figure 4 where $e^{\sigma_e(\bar{q})}$ indicates the level of education that generates separation given $\bar{q}$. If the actual realization of $q$ is $q_{is} < \bar{q}$ then all individuals from university $i$ have the same indifference curves and, as a consequence, the outcome of the interaction process is trivial since no signal can be sent and individuals acquire the same
level of education independently of their ability. In this case, individuals maximize their utility in point A or in point B in Figure 4, conditional on the slope of their indifference curves (Proposition 1). If $q_{is} \geq \bar{q}$ the indifference curves are actually different for the two types of individuals. In this case, the single-crossing property is satisfied and, as shown in the Appendix, we can only have separating equilibria consistent with forward induction (Proposition 2).

3.2 The equilibria in the infinitely repeated version of the game

**Proposition 3** Given the information on past quality available at $s - 1$, if firms expect $E\left[q_{is}\mid s - 1\right] \geq \bar{q}$ and policies on education have been used seldom in the history of the game ($\sigma_e \rightarrow 0$), when $q_{is} \geq E[q_{is}\mid s - 1]$ any equilibria of the game consistent with forward induction must be a separating equilibrium.

**Proposition 4** Given the information on past quality available at $s - 1$, if firms expect $E\left[q_{is}\mid s - 1\right] \geq \bar{q}$ and policies on education have been used frequently during the history of the game ($\sigma_e, \sigma_u > 0$), pooling equilibria consistent with forward induction may arise even if $q_{is} \geq E[q_{is}\mid s - 1]$. 

Figure 4. Two pooling equilibria.
The proof of Proposition 3 and Proposition 4 is given in the Appendix. Here we present the main intuitions of the results. Taking expectation on both sides of Equation (13) conditional on \((s - 1)\), we have that:

\[
E[q_{is} | s - 1, N] = E[q_{is} | s - 1] - E[u_{is} | s - 1]
\]  
(18)

\[
= E[q_{is} | s - 1] - \frac{\sigma_{mu}}{\sigma_{x}^{2}} E[q_{is} | s - 1]
\]  
(19)

or, equivalently:

\[
E[q_{is} | s - 1, N] = E[q_{is} | s - 1] \frac{\sigma_{x}^{2} - \sigma_{u}^{2}}{\sigma_{x}^{2}} \begin{cases} > 1 & \text{if } \sigma_{x}^{2} > \sigma_{u}^{2} \\ < 1 & \text{if } \sigma_{x}^{2} < \sigma_{u}^{2} \end{cases}
\]  
(20)

Equation (20) indicates how firms weight the information they have, given the assumed data-generating process, in order to estimate the quality of education \(q_{is}\) to generate their beliefs function. It is important to note that:

- If reforms are implemented very seldom, both \(\sigma_{x}^{2}\) and \(\sigma_{u}\) converge to zero. As shown in the Appendix, this leads to \(E[q_{is} | s - 1, N] = E[q_{is} | s - 1]\). Hence, as for Proposition 2, if \(E[q_{is} | s - 1] \geq \bar{q}\) and \(q_{is} \geq E[q_{is} | s - 1]\) a separating equilibrium always arises. In other words, if institution \(i\) satisfied on average the single-crossing property during its history and policy reforms did not induce any perturbation on firms’ expectation, firms consider education acquired in this institution as a signal of individuals’ ability. If institution \(i\) satisfies the single-crossing property in period \(s\) as it did in the past \((q_{is} \geq E[q_{is} | s - 1])\), we can only have separating equilibria (Proposition 3).

- If policies on higher education have been used over time \((\sigma_{x}^{2} > 0\) and \(\sigma_{u} > 0)\) even if on average the cost of acquiring education in university \(i\) has always been higher for low-ability than for high-ability individuals, i.e. \(E[q_{is} | s - 1] \geq \bar{q}\), because of the perturbation generated by the use of policy, the rational expectation on \(q_{is}\) may be set at a level that does not necessarily induce firms to consider education as a signal of individuals’ ability. From Equation (20) we can see that ceteris paribus, the higher the effect of policy on cross-sectional quality heterogeneity \((\sigma_{u})\), the lower the quality expected by the firms. Hence, conditional to the distance between \(\bar{q}\) and \(E[q_{is} | s - 1]\), firms might not consider education from university \(i\) as a signal of individuals’ ability. In this case, as shown in the Appendix, even if \(q_{is} \geq E[q_{is} | s - 1] \geq \bar{q}\) only pooling equilibria may arise (Proposition 4).

4. A graphical intuition of the results

In this section we present a graphical intuition of the results discussed above. Indicate with \(\gamma\), the expected productivity of individuals coming from university \(i\) in period \(s\):

\[
\gamma_{is} = \gamma \gamma(e, 1, E[q_{is}]) + (1 - \gamma) \gamma(e, 0, E[q_{is}]).
\]  
(21)

Assume that university \(i\) satisfies the single-crossing property in period \(s\) as well as it did on average during its history \((q_{is} = E[q_{is} | s - 1] \geq \bar{q})\). In Figure 5, consider the following
assessment: $\alpha^* = [\alpha^*_f, \alpha^*_\theta, b(e_i)]$ which represents a pooling PBE of the game illustrated in Figure 3, where $\alpha^*_f$ and $\alpha^*_\theta$ are firms’ and individuals’ strategies respectively:

$$\alpha^*_\theta \Rightarrow \{\text{Choose } e = e_p \quad \forall \theta \} \quad (22)$$

$$\alpha^*_f \Rightarrow \text{set } w = \begin{cases} y_{i\theta} & \text{if } e \geq e_p \\ y(e, 0, E[q_{i\theta}]) & \text{if } e < e_p \end{cases} \quad \forall f \quad (23)$$

$$b(e_{i\theta}) = \begin{cases} \gamma & \text{if } e \geq e_p \\ 0 & \text{if } e < e_p \end{cases} \quad \forall f. \quad (24)$$

If we were in the presence of a perfectly observable quality of education (the Spence model), we would have that firms observe the position of the individuals’ indifference curves in Figure 5. In this case, the pooling equilibrium described above would not be consistent with forward induction simply because when an educational level $e \in (e'', e')$ is observed, a firm must set beliefs such that:

$$b(e_{i\theta}) = 1 \forall e \in (e'', e'). \quad (25)$$
In fact, only the high-ability type can be better off by choosing \( e \in (e'', e') \) with respect to point A. Now, consider our case in which firms cannot perfectly detect the distance between the two individuals’ indifference curves \( \theta_l \) and \( \theta_h \) because of the asymmetric information on the education quality \( q_{is} \). In this case, differently from what we argued above, in the presence of a policy reducing the marginal cost of education, the above pooling equilibrium can be consistent with forward induction. In fact, a level of schooling \( e \in (e'', e') \) does not necessarily imply that individuals with such education must be high-ability types. To set \( b(e_{is}) = \gamma \) when \( e \in (e'', e') \) could be reasonable in the presence of a policy lowering the indifference curve from \( \theta_l \) to \( \theta'_l \). More precisely, using Equation (20) we have that:

\[
 b(e_{is}) = b \left( e | E[q_{is} | s - 1] \frac{\sigma^2 - \sigma_{en}}{\sigma^2_e} \right) 
\]

(26)

Hence, to set \( b(e_{is}) = \gamma \) for all \( e \in (e'', e') \) is reasonable conditional to:

i) the probability that a policy modifying the slope of the indifference curves actually occurs \( (\sigma^2_e > 0) \);
ii) the extent of policy’s impact on the university’s behavior \( (\sigma_{en}) \);
iii) the distance between \( e'' \) and \( e' \) (determined by the difference between \( E[q_{is} | s - 1] \) and \( \bar{q} \)) which represents the university’s reputation in terms of quality.

If reforms have been used seldom in the history of the game (both \( \sigma^2_e \) and \( \sigma_{en} \) converge to zero), the beliefs \( b(e_{is}) = \gamma \) for all \( e \in (e'', e') \) would not be consistent with a forward reasoning and, as a consequence, only separating equilibria may arise (Proposition 3). On the other side, when \( \sigma^2_e > 0 \) and \( \sigma_{en} > 0 \), we have that even if \( E[q_{is} | s - 1] \geq \bar{q} \) and \( q_{is} \geq E[q_{is} | s - 1] \), in the case in which:

\[
 E[q_{is} | s - 1] \left( \frac{\sigma^2 - \sigma_{en}}{\sigma^2_e} \right) < \bar{q} 
\]

(27)

setting \( b(e_{is}) = \gamma \) for all \( e \in (e'', e') \) is reasonable for all \( e \in (e'', e') \). The intensity in the effective use of policy reforms on education \( (\sigma^2_e) \), the impact of such reforms on universities’ behavior \( (\sigma_{en}) \), and the “reputation” in terms of quality of each university \( (E[q_{is} | s - 1]) \) determine the reasonability of firms’ beliefs.

5. Conclusions

In this paper we study the job market signaling game in the presence of asymmetric information on individuals’ cost functions and higher education reforms. We show that the frequent use of policy reforms affecting the quality of higher education can be crucial in determining pooling equilibria even when the single-crossing property is satisfied. In our model, firms rationally ground their beliefs on both the reputation that universities have in generating the signal and the probability that educational reforms occur inducing modifications of the universities’ behavior. We show that, when universities generated on average during their history the single-crossing property, only separating equilibria may arise. At the same time, we show that when educational reforms characterize the history of the game, firms rationally correct their expectations. This correction may lead to pooling
equilibria even for individuals coming from universities that in their history satisfied the *single-crossing property*. The model has important implications since in the recent past a number of reforms have been implemented to modernize the higher educational sector in continental Europe. We suggest that while there exist many theoretical and empirical justifications to implement such reforms, governments should avoid endeavors of modernization and should implement reforms targeted to modify the educational sector only with a long-run perspective.

**Acknowledgements**

I would like to thank Patrizia Ordine and Sandeep Kapur for their useful comments. All errors are mine.

**Notes**

1. At the same time, many universities in Italy, in the light of their increased autonomy, are re-introducing for some subjects a unique five-year degree, very similar to that used in the past, eliminating the distinction between short-cycle and Bachelor degrees. Moreover, in Italy, there has also been introduced an original system of exchange between work experience and academic exams. A few months later, the new Italian Ministry of Higher Education pointed out the importance of re-reforming the higher educational sector by eliminating this exchange system. In France, higher education reforms that occurred in the 1990s have been based on the so-called *Attali Report* (see Rodriguez 2000). See also Cardoso *et al.* (2006) for additional evidence of the *Bologna Process* in Portugal.

2. In the job market signaling game with productive human capital, a *pooling* equilibrium is less efficient than a *separating* equilibrium simply because in the former, two inputs with different marginal productivity are paid the same wage, while in the latter wages reflect workers’ productivity, generating a Pareto efficient allocation of resources (see Mas-Colell *et al.* 1995).

3. Among others, De Fraja and Lossa (2002) focus on universities that maximize their prestige, showing that under some reasonable assumptions, in equilibrium two universities set different levels of education quality. Epple *et al.* (2006) refer to universities that maximize the quality they supply by attracting smart students using scholarships financed with heterogeneous resources and high tuition fees charged to rich students. Ordine and Rose (2008) consider a model where universities supply different levels of quality since they have monopoly power on local demand. There exists also some empirical evidence on the quality of education in centralized funding systems that appear to depend on the specific institution attended and on the location of the universities. See Brunello and Cappellari (2005), Makovec (2006) and Ordine and Rose (2007).

4. The basic results of the paper would hold even if we were to consider a generic value $q^* \leq \bar{q}$ as the “critic value” for the *single-crossing property*. Here we want to point out that in each period the average value of $q_i$ allows for signaling.

5. See Ordine and Rose (2008) for another application of changes in the quality of education on individuals’ indifference curves.

**References**


Council of the European Union, 2005. Resolution of the Council and of the Representatives of the Governments of the Member State, meeting within the Council, on mobilising the brainpower of


Appendix

Proof of Propositions 1 and 2 Since \( s = 1 \), we have that \( E[q_i | s - 1, N] = \bar{q} \), hence firms consider education as a credible signal of individuals’ ability by assumption. Given the level of education that generates separation at \( \bar{q} \) \((\epsilon^{sep}(\bar{q})) \) in Figure 4) we can have three scenarios conditional on the actual realization of \( q_i \):

1) \( q_i < \bar{q} \Rightarrow \) Individuals from university \( i \) have the same indifference curves, hence any equilibrium of the game must be a (degenerated) pooling equilibrium. As shown in Figure 4, all individuals end up in point A or in point B conditional on the actual realization of \( q_i \) which determines the slope of the indifference curves.

(Proposition 1 Q.E.D.)

2) \( q_i = \bar{q} \Rightarrow \) Individuals have different cost functions conditional on their ability. We are in the case of the simple Spence model (Cho and Kreps 1987) in which only a separating equilibrium can be consistent with forward induction.

3) \( q_i > \bar{q} \Rightarrow \) Because of assumptions (6) and (8) we have that the actual level of education that generates separation at \( q_{is} (\epsilon^{sep}(q_{is})) \) is always lower than the level of education that generates given firms’ expectation \( \bar{q} \) \((\epsilon^{sep}(\bar{q})) \). High-ability individuals know firms’ expectation \( \bar{q} \), hence they know they have to acquire \( \epsilon^{sep}(\bar{q}) > \epsilon^{sep}(q_{is}) \) in order to signal their ability, otherwise they will be considered as low-ability types earning a wage equal to \( y(e, 0, \bar{q}) \). Because of assumption (9) we have that high-ability individuals are better off by acquiring education \( \epsilon^{sep}(\bar{q}) \), hence only a separating equilibrium can characterize this game.

(Proposition 2 Q.E.D.)

Proof of Propositions 3 and 4 Taking expectations of both sides of Equation (13) conditional on \((s - 1)\) we have that:

\[
E[q_{is} | s - 1, N] = E[q_{is} | s - 1] - E[u_{is} | s - 1].
\]

Considering that, given two random variables \( y \) and \( x \) we have that:

\[
E[y | x] = \frac{cov(y, x)}{var(x)} E[x];
\]

we can write Equation (28) as follows:

\[
E[q_{is} | s - 1, N] = E[q_{is} | s - 1] (\frac{\sigma_x^2 - \sigma_{uy}}{\sigma_u^2}).
\]

Since \( \epsilon_i \) and \( u_i \) are distributed following a bivariate normal density function we have that:

\[
\sigma_{ui} = \rho \sigma_u \sigma_{\epsilon_u}
\]

where \( \rho > 0 \) is the correlation index between \( \epsilon_i \) and \( u_i \). Since:

\[
\lim_{\sigma_{\epsilon_u} \to 0} \left( \frac{\sigma_x^2 - \rho \sigma_u \sigma_{\epsilon_u}}{\sigma_u^2} \right) \to 1
\]

because of the infinitesimals’ order, we have that if \( \sigma_{\epsilon_u} \to 0 \):

\[
E[q_{is} | s - 1, N] = E[q_{is} | s - 1].
\]
In this case, if $E[q_{is}|s-1] \geq \overline{q}$ and $q_{u} \geq E[q_{is}|s-1]$ as in points 2 and 3 in the previous proof, we can have only a separating equilibrium.

(Proposition 3 Q.E.D.)

Now, consider Equation (30). Because of Equation (15) when $\sigma_{e}^2 > 0$ we have that $\frac{\sigma_{\varepsilon}^2 - \sigma_{\varepsilon\varepsilon}}{\sigma_{\varepsilon}^2} < 1$. This implies that, conditional on $\rho$, $\sigma_{\varepsilon}$ and $\sigma_{u}$ firms make a downward correction of the time average $E[q_{is}|s-1]$. If this correction leads to $E[q_{is}|s-1, N] < \overline{q}$ firms do not consider education acquired in university $i$ as a signal of individuals’ ability and set $b(e_{is}) = \gamma$ and wage equal to $\overline{y}_{u} \forall e$, where:

$$\overline{y}_{u} = \gamma \gamma(e,1,E[q_{is}]) + (1-\gamma)\gamma(e,0,E[q_{is}]).$$

(34)

Even when the actual realization of $q_{is}$ generates the single-crossing property and $E[q_{is}|s-1] \geq \overline{q}$ we cannot have any separating equilibrium since $\mathbb{A} e s t. b(e_{is}) = 1$.

(Proposition 4 Q.E.D.)