Overeducation and Instructional Quality. A Theoretical Model and Some Facts

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Abstract

This paper studies educational choices in a signalling setting in the presence of heterogeneous opportunity costs. We show that even if individuals can use education to signal their ability, when opportunity costs are heterogeneous, pooling equilibria may arise. These equilibria may be characterized by overeducation depending on firms' technologies. The role of instructional quality may be crucial in determining the emergence of this phenomenon. To find evidence of the main implications of the model we use data on Italian graduates merged with two data sets from the Italian Ministry of Education and CIVR. We find that overeducation is strongly determined by university quality and by other variables that characterize the individual's socioeconomic background.

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1 Introduction

The paper proposes a possible explanation of the phenomenon known as overeducation that characterizes most of the economies among the OECD countries. Overeducation arises when there are workers in occupations that require less schooling than they actually have.[1] The dimensions of this phenomenon are surprising large in developed countries. For instance, in the UK and in the United States overeducation is estimated to involve a number of workers that ranges between the 17% and the 42% of the whole employed graduate labour force.[2] At the same time, in Germany and in the Netherlands this percentage ranges between 17% and 28%.[3] In Italy, the share of overeducated workers is around 39% but it changes dramatically across degree subjects.

Overeducation is potentially costly to the economy, to the firms and to the individuals since resources are wasted on non-productive investments. The main ideas on which the theoretical motivations on overeducation have been grounded so far can be collected within three main classes of models: Human Capital Theory (HCT), Job Competition and Assignment.[4] Models based on the Becker's HCT consider overeducation as a phenomenon associated to a temporary workers under-utilization. This is due to the assumption that education rises productivity in the same measure for all the individuals and, as a consequence, this under-utilization should characterize only short run (dis)equilibria. HCT models have been considered not consistent with the observed facts since overeducation seems not to be a temporary phenomenon in the individual's life (Dolton and Vignoles, 2000). The Job Competition models are based on the Thurow's idea (Thurow, 1975) that workers' productivity rises only within firms on the job place. As a consequence, individuals compete to obtain the jobs that generate the highest productivity levels and they use education as an instrument to obtain a better job position. While these models can entirely explain overeducation, it is not clear how to determine the extent of this phenomenon (McGuinness, 2006). The Assignment models represent a middle ground between the two previous extremes. In particular, both individual and job characteristics are taken into account and overeducation may easily be explained using search-frictional environments.[5]

In this paper we show that HCT can be consistent with overeducation in a long run equilibrium assuming imperfect labour market, incomplete information and heterogeneous firms and individuals. We model a strategic interaction

[1] This definition usually matches with the following stylized facts: *i*) overeducated workers earn lower wages than workers with similar level of schooling who work in jobs that require the level of schooling they have obtained; *ii*) overeducated individuals earn more than their co-workers who are not overeducated (Sicherman, 1991).

[2] For the US see Daly *et al.* (2000) and McGoldrick and Robst (1996); for the UK see Chevalier (2003) and Sloane *et al.* (1999).

[3] See Daly *et al.* (2000) and Allen and van der Velden (2001).

[4] See McGuinness (2006) for a survey of these models.

[5] Among others, see Andolfatto and Smith (2001), Charlot *et al.* (2005), Moen (1999), Charlot and Decreuse (2005) and Saint-Paul (1996) for overeducation in frictional environments.

framework where education rises individuals' productivity depending on individuals' ability, education quality and firms' technology. We show that overeducation may arise in a signalling setting because of the presence of elements that lower the individual's marginal cost of schooling but are uncorrelated with his productivity. The issue represents an extension of the signalling theory as indicated by Spence (2002), who explicitly advocated the need of considering variables that determine the cost of acquiring education but do not influence productivity. In this setting, education may not be a credible signal of individuals ability affecting the firms' technological decisions. Consequently, when individuals have heterogeneous opportunity costs, self-selection in education can be inefficient.

The idea that inefficient educational choices can generate overeducation has been recently modelled in a matching environment by Charlot and Decreuse (2005). These authors show that, since job opportunities increase by schooling and low ability individuals do not internalize the impact of their choices on firms' behaviour in job creation, overeducation may arise. It is important to note that, although the presence of individuals with different ability levels is crucial for their results, the authors assume that ability is perfectly observed by firms and education generates the same cost upon all the individuals. In their setup, the authors conclude that "the optimal education policy is thus to set a tax on education to deter low ability individuals from participating to high productivity sector".[6] In our paper, we model inefficient self-selection in education by considering a job market signalling setting with productive human capital. We assume that individuals' ability is not observed by firms and that the cost of schooling is inversely related to it. As it is well known, in the job market signalling game there cannot be any equilibrium characterized by high and low ability individuals that decide to acquire the same educational level, unless we assume that agents may formulate unreasonable beliefs (Cho and Kreps, 1987). Here, we show that, by expanding signalling model to keep into account heterogeneous opportunity costs, equilibria where individuals with different abilities acquire the same level of education may arise consistently with reasonable beliefs. The idea is that low opportunity costs, by lowering the marginal cost of acquiring education may destroy a signalling equilibrium if the signalling device (the cost of the effort that an individual must exert in order to acquire the academic skills) is not strong enough. In this sense, the educational quality, by determining the role that ability has in acquiring education, is crucial for individuals' choices. Differently from Charlot and Decreuse (2005), increasing the monetary costs of education would not prevent an inefficient self-selection in education. Only policies targeted to improve the education quality may prevent low ability individuals to pool themselves with high ability individuals in terms of educational choices. Hence, our policy indications point out the importance that education quality may have in reducing overeducation.

In order to test the main implications of the theoretical model, we estimate a *Probit* regression, corrected for sample selection bias, where the probability

[6] See Charlot and Decreuse (2005) p. 235.

of not being overeducated is related to a set of covariates including individual and household attributes, job characteristics, socioeconomic environments and university features. We use data of a large sample of Italian graduates merged with data sets containing information on university characteristics from the Ministry of Higher Education and CIVR.[7] We find that education quality strongly determines the probability of working in a job position where the degree is actually needed. Individuals characteristics and job features also shape the likelihood of being overeducated. The socioeconomic context, as a determinant of opportunity costs, is also crucial for a correct job match.

The paper is organized as follows. Section 2 contains the theoretical setup. Section 3 describes the equilibria of the model. In Section 4 we discuss the empirical model and in Section 5 we illustrate the explanatory variables. In Section 6 we comment the empirical results and we conclude in Section 7.

2 The Model

Consider the following setup where individuals and firms act strategically. We assume that there are two types of individuals with ability θ_α (with $\alpha = h, l$ and $\theta_h > \theta_l$) that, before entering the job market decide to acquire a level of education e (with $e \in [0, \infty)$) involving monetary and non-monetary costs. Once in the job market, individuals can obtain a wage w working in a firm. Firms set the production on the basis of technology T and employ individuals. Individuals' ability is unobserved by firms. The share of high ability individuals, indicated by γ (with $0 < \gamma < 1$) is common knowledge. We assume that individuals incur in opportunity costs if they decide to acquire education and we explicitly consider opportunity costs heterogeneously distributed. Individuals may have different opportunity costs since typically these costs are related to many personal, households and macroeconomic features. In particular, we assume that the performance of the local economy and of the local labour market, strongly influence these costs. To keep things simple, we indicate with λ_β the individuals' opportunity cost with $\beta = h, l$ and $\lambda_h > \lambda_l$. Opportunity costs are not observed by firms. Firms observe only the share of individuals with low opportunity costs indicated by p (with $0 < p < 1$). We consider an interaction process where there are only firms and individuals and the quality of education is exogenous. Using this setting, we demonstrate how opportunity costs as well as education quality are crucial in deriving pooling equilibria. Moreover, we show that if individuals do not observe the cost that a firm has to sustain to invest in technology, overeducation takes place.

2.1 The individuals

Consider a continuum of individuals that maximize an utility function, $u(\cdot)$, expressed in terms of wage $w(\cdot)$ and in terms of the cost of education $c(\cdot)$. Both

[7] CIVR is the Italian commission for the academic research evaluation.

functions $w(\cdot)$ and $c(\cdot)$ are determined by workers ability:

$$u\,(w, e, q, \lambda|\theta, T) = w\,(e, q, \theta_\alpha, T) - c(e, q, \theta_\alpha, \lambda_\beta). \tag{1}$$

Before entering the job market the individual can obtain a level of education e, involving monetary and non-monetary costs. The cost of acquiring education is a function $c(e, q, \theta_\alpha, \lambda_\beta)$ of the education level e, of the quality of education q, of the individual's ability θ and of the individual's opportunity costs λ. The wage depends on both the quality and the amount of education received by the individual and it also depends on individual's ability and on the firm's technology T. Assume that the cost function satisfies the following properties:

$$c_e(\cdot) > 0 \tag{2}$$

$$c_q(\cdot) > 0 \tag{3}$$

$$c_e(\cdot, \theta_l) > c_e(\cdot, \theta_h) \quad \forall \quad q \tag{4}$$

$$c_e(\cdot, \lambda_h) > c_e(\cdot, \lambda_l) \quad \forall \quad q \tag{5}$$

First, notice that we define the quality of education as the set of scientific and technical skills provided by universities that rise the individuals' productivity. Consistently with our definition of education quality, we assume that the higher is the quality supplied by an institution, the higher is the cost (in terms of effort) that an individual has to sustain to obtain a given qualification (3). Equation (4) represents the so called single cross property, which implies that the cost of an additional year of education is higher for low ability individuals than for those with high ability. Equation (5) indicates that the cost of an additional year of education is higher for individuals with high opportunity costs than for those with low opportunity costs. For instance, individuals located in areas with high employment rates, would find more costly to acquire an additional year of education than individuals located in areas where the employment rates are low, since the latter have a lower probability of being employed.

Considering the utility function (1), the slope of the indifference curves is given by:

$$mrs_{e,w} = c_e(e, q, \theta_\alpha, \lambda_\beta) - w_e(e, , q, \theta_\alpha, T). \tag{6}$$

Given assumption (4) and (5) we know that high ability individuals with low opportunity costs have the lowest marginal cost of education. As a consequence, in Figure 1 the graphical statement is that these individuals have the less steep indifference curve (θ_h, λ_l). On the contrary, low ability individuals with high opportunity costs have steeper indifference curves (θ_l, λ_h) than other individuals. Within these boundaries, we can draw the indifference curves for high ability individuals with high opportunity costs (θ_h, λ_h) and those for low ability individuals with low opportunity costs (θ_l, λ_l). The position of the curve (θ_h, λ_h) with respect to the curve (θ_l, λ_l) depends on which of the following relations holds:

$$|c_e(\cdot, \theta_h) - c_e(\cdot, \theta_l)| > |c_e(\cdot, \lambda_l) - c_e(\cdot, \lambda_h)| \tag{7}$$

or

$$|c_e(\cdot,\theta_h) - c_e(\cdot,\theta_l)| < |c_e(\cdot,\lambda_l) - c_e(\cdot,\lambda_h)| \tag{8}$$

or

$$|c_e(\cdot,\theta_h) - c_e(\cdot,\theta_l)| = |c_e(\cdot,\lambda_l) - c_e(\cdot,\lambda_h)|. \tag{9}$$

In Figure 1 we represent the case where (θ_l,λ_l) is steeper than (θ_h,λ_h). This implies that relation (7) holds. In words, if this is the case, the impact of being a high ability individual in reducing the marginal cost of education is larger than the impact of having low opportunity costs. Of course, we could draw these curves the other way around (8) or we could draw only one curve, indicating that being a low opportunity costs type or being a high ability type has the same impact in determining the marginal cost of education (9). We assume also that:

$$c_{eq}(\cdot,\theta_l) > c_{eq}(\cdot,\theta_h) > 0 \tag{10}$$

where c_{qe} is the cross partial derivative of the cost function with respect to the level and the quality of education. The implication of (10) is that an increase in the quality of education rises the indifference curves of low ability individuals more than those of high ability individuals. The net effect of an increase in q, results in the fact that *ceteris paribus* ability becomes more important than opportunity costs for the relative position of the curves. An increase in education quality may change the scenarios depicted in relations (8) or (9) into the scenario implied by equation (7) since when q increases, the LHS of all these relations always increases in absolute value. Hence, *ceteris paribus* the higher is the education quality the more is plausible that we are in the case depicted in Figure 1.[8]

2.2 The firms

Consider a continuum of firms. Each firm f employs only one worker to produce the final output. Before hiring a worker each firm has to decide the technology to adopt. In particular, the firm can choose between high or low technology. We indicate $T = \{HT, LT\}$ the firm's investment in high or low technology respectively. The cost of technology HT is given by $\delta_f > 0$ for all f. The cost of technology LT is normalized to zero.

Following Acemoglu (1997), the average productivity per worker is given by:

$$y = y(e,q,\theta_\alpha,T) = e_0 + e(q + \varepsilon \times 1_{\{\theta=\theta_h, T=HT\}}) \tag{11}$$

where e_o is a constant and $\varepsilon > 0$. From (11) it appears that high technology is complementary only to high ability workers. As a consequence, firms need a credible signal on individuals' ability in order to invest in high technology. Equation (11) assumes a scenario where the effect of education on worker's productivity depends on the quality of education and on the match between high ability individuals and high technology firms. We assume that the wage

[8] Ordine and Rose (2007) consider a setup where education quality affects individuals' indifference curves in a way that is similar to the one presented here.

schedule is given by the workers productivity minus a rent $\Delta > 0$ that remains within the firm.[9] We assume that the wage structure is compressed which implies that:

$$\Delta = \Delta(e), \quad with \quad \Delta_e > 0. \tag{12}$$

The relation between productivity and wage in the presence of a compressed wage structure is graphically illustrated in Figure 2 where, the higher is the human capital of an individual the higher is the rent that a firm can obtain from him. A compressed wage structure may be generated by many causes. Minimum wages, efficiency wages, bargaining problems and transaction costs represent only some possible sources of wage compression.[10] Moreover we assume that:

$$\Delta(e, HT) > \Delta(e, LT) \qquad for\ all\ e \quad iff \quad \theta_\alpha = \theta_h \tag{13}$$

which implies that in the case of a match with a high ability individual, firms are able to capture from him higher rents by investing in high technology than by investing in low technology.

2.3 The interaction process

The interaction process consists in the following stages. First, individuals conditional on their ability and on their opportunity costs, choose the level of education e they want to acquire. Secondly, each firm randomly matches with an individual. Firms observe the education acquired by the individual and decide the technology T to adopt. Then, production takes places and payoffs realize.[11] The strategic interaction of this model considers explicitly the externalities generated by low ability individuals that want to signal an ability that they do not have in order to achieve a higher utility. There is a strategic complementarity between firms' investment decisions and the education acquired by individuals in order to signal their ability since we explicitly consider that education increases both firm's rent and wage. In a Spence setting (corrected for human capital theory i.e., with education that increases productivity) the only equilibrium of a similar interaction process would be an efficient separating equilibrium where the signal is credible and no pooling equilibria may arise.[12] In our setting, we are considering the presence of an element (opportunity costs) that represents another individuals' unobserved attribute that influences the cost of acquiring human capital but that is completely uncorrelated to the individual's productivity. Quoting Spence "..it is possible that attributes that lower the cost of

[9] This result in terms of wage structure can be achieved by assuming a discrete number of firms that compete *à la Bertrand* to employ individuals and considering the presence of frictions (as mobility costs) so that, *ceteris paribus*, some individuals strictly prefer to work for one firm. It is also possible to consider this rent as the result of firms collusion in a repeated wage offers game.

[10] See Acemoglu (1997) and Acemoglu and Pischke (1998) for a complete and detailed discussion on all the elements that can compress the wage structure.

[11] See Acemoglu (1997) for another application of random matching between firms and workers in a strategic environment.

[12] See Gibbons (1992) pp. 239-244 for a recall of this result.

acquiring education might not be those that enhance productivity....".[13] Here, we model this issue explicitly. As we discuss in the next Section, the dimension of the "ability effect" with respect to the "opportunity costs effect" is crucial in (partially) re-establishing pooling equilibria.

3 The Equilibria

We start by considering the simplest case where all firms have the same cost of investing in high technology i.e., $\delta_f = \delta$. We show that while pooling perfect Bayesian equilibria may arise, overeducation may not characterize any equilibrium of this game. Later we consider the strategic interaction process assuming, more realistically, that δ changes across firms. In this last case, pooling perfect Bayesian equilibria characterized by overeducation may take place.

3.1 The equilibria when $\delta_f = \delta$

Using the Harsanyi (1967/68) approach, the strategic interaction process can be represented as a game in extensive form as shown in Figure 3. At time $t = 0$ *Nature* chooses the vector $\omega = [\theta_\alpha, \lambda_\beta]$ that contains all the elements that are not common knowledge i.e., *Nature* chooses the type of ability and the type of opportunity costs of the individual faced by firms. At time $t = 1$ each individual decides his educational level. At $t = 2$, each firm observes the level of education acquired by the individual and makes the technological choice. At the end, production takes places and payoffs realize. To solve the model we use perfect Bayesian equilibrium (*PBE*) consistent with forward induction (Kohlberg and Mertens, 1986).

Proposition 1 *If relation (7) holds, the only PBE consistent with forward induction of the game illustrated in Figure 3 is a separating equilibrium.*

The intuition behind proposition 1 is straightforward. Since we are assuming that ability is more important than opportunity costs in determining the cost of education (7), given the wage schedule, only separating equilibria may be consistent with forward induction as in the simple job market signalling framework. In this case, firms invest in HT only if they observe an education level that generates separation.

Proposition 2 *If either relation (8) or relation (9) holds, the only PBE consistent with forward induction of the game illustrated in Figure 3 is a "partial" pooling equilibrium where high ability individuals with high opportunity costs and low ability individuals with low opportunity costs are pooled together.*

First notice that we refer to "partial" pooling as an equilibrium where only a share of individuals with different ability are pooled together. The proof of proposition 2 is given in the Appendix. Intuitively, consider Figure 4 where,

[13] See Spence (2002) p. 449.

in order to simplify the illustration, we consider the case where relation (9) is satisfied i.e., we consider the case where high ability individuals with high opportunity costs (θ_h, λ_h) and low ability individuals with low opportunity costs (θ_l, λ_l) have exactly the same map of indifference curves.[14] Here, we refer to these individuals as pooled individuals. In the figure, first notice that individuals (θ_h, λ_l) always separate themselves from others by acquiring education e_s. When e_s is observed, firms always invest in HT. Now, consider pooled individuals (θ_h, λ_h)=(θ_l, λ_l). These individuals in order to separate from types (θ_l, λ_h), must acquire an education $e \geq e_p$. Here, for simplicity, assume that if they do not separate, firms always invest in LT. Indeed, pooled individuals acquire education $e \geq e_p$ only if firms invest in HT when such e is observed. In fact, when $T = HT$, by acquiring e_p pooled individuals reach a higher indifference curve (point A) than the one they would reach if they acquired education $e_m < e_p$ (point B). On the contrary, if $T = LT$, when $e = e_p$ they would reach a lower curve (point C). More precisely, pooled individuals prefer to acquire an educational level $e \in [e_p, e_k]$ with respect to e_m only if firms invest in HT. As proved in the Appendix, firms invest in HT when $e \in [e_p, e_k]$ is observed only if:

$$E[\Delta(e, HT)] - \delta > \Delta(e_m, LT) \tag{14}$$

where the LHS of (14) represents the expected profits of firms investing in HT when $e \in [e_p, e_k]$ is observed. Since all the elements in equation (14) are common knowledge, all pooled individuals choose the same level of education conditional on inequality (14). Whatever is the choice of pooled individuals in terms of education, in this equilibrium individuals with the same educational level work within the same type of firm (HT or LT, conditional on inequality (14)) and they earn the same wage. No overeducation arises in this setup.

3.2 Equilibria with heterogeneous δ

Consider now the case where the cost of technology HT changes across firms. In fact, there is no reason why firms should have the same cost to obtain the same technology since, for instance these costs may be related to the actual technological endowment of each firm, to the structural characteristic of the specific environment, to spillover effect, etc.[15] Assume that there are two types of firms δ_f with $f = h, l$ and $\delta_h > \delta_l$. Indicate with ξ $(0 < \xi < 1)$ the probability that a firm is a low cost type, i.e. $\xi = prob(\delta_f = \delta_l)$. Individuals know the value of ξ. In Figure 5, we illustrate the interaction process using a game in extensive

[14] In the Appendix we show that the same results are valid when relation (8) holds.

[15] In the growth theory literature, the cost of advanced technology has been considered typically related to the actual firm's technological endowment. The closer is a firm to the technological frontier the lower is the cost that it needs to sustain in order to update its technology. The concept of technological frontier has been introduced by Nelson and Phelps (1966). Acemoglu *et al.* (2006) study empirically the relation between R&D expenditure and the distance from the technological frontier and build up a model where firms differ in terms of costs to adopt new technologies.

form where *Nature* chooses the vector $\chi = [\theta_\alpha, \lambda_\beta, \delta_f]$.[16] Consider Figure 4 and assume that when $e \in [e_p, e_k]$ a firm invests in HT only if $\delta_f = \delta_l$ i.e., relation (14) holds only if $\delta = \delta_l$.

Proposition 3 *If either relation (8) or relation (9) holds and q is lower than a given value $\bar{q} = \bar{q}(\xi)$ the only PBE of the game illustrated in Figure 5 is a "partial" pooling equilibrium where pooled individuals acquire the same level of education and they are employed in HT or LT firms, following a stochastic process.*

The proof of proposition 3 is given in the Appendix. To have an intuition of the result, consider Figure 4 and assume that relation (14) holds in $e = e_p$ if $\delta = \delta_l$ but it does not hold for any $e \in [e_p, e_k]$ when $\delta = \delta_h$. In this case, we know that pooled individuals have to choose between education e_m and education $e = e_p$. Individuals choose the educational level e_p only if:

$$E[w(\cdot)|e_p] - w_m \geq c(\cdot, e_p) - c(\cdot, e_m) \tag{15}$$

where

$$E[w(\cdot)|e_p] = \xi w_p + (1 - \xi)w' \tag{16}$$

with w_m representing the wage paid to pooled individuals with education e_m and w_p and w' representing respectively the wage paid by HT and LT firms to pooled individuals with education e_p. Notice that if condition (15) is satisfied, all pooled individuals decide to acquire an educational level e_p, but once in the labour market, they have only a probability ξ of being employed in a HT firm. In this setup, individuals with the same educational level can be employed in firms that differ in terms of technology and pay different wages to individuals having the same educational level. The result is completely consistent with the main implications of overeducation.

The role of education quality is crucial in determining the overeducation phenomenon. As shown in the Appendix, the LHS of relation (15) is constant with respect to q while the RHS is an increasing function of education quality because of assumption (10). In words, when q increases the marginal cost of education increases as well. *Ceteris paribus* a higher education quality reduces the probability that overeducation takes place since the RHS of (15) becomes larger.

It is important to note that, while in this analysis we are considering only one exogenous level of education quality, the main result would hold in the presence of a finite number of institutions fixing different quality levels to maximize their objective functions.[17] Here, we want to focus on the main mechanisms that may link the quality of education to the overeducation phenomenon. As McGuinness

[16] In this game, the types of individuals that may arise from the combination of θ_α and λ_β are indicated with i_{hl}, i_{hh}, i_{lh}, and i_{ll} while the two types of firms that can be matched by the individuals are indicated with f_h and f_l.

[17] For instance, Ordine and Rose (2007) consider a model where universities supply a different quality of education since they have monopoly power on local demand. These authors show that each institution lowers the quality of education according to its monopoly power

(2003) points out, there is empirical evidence that university quality is correlated with overeducation but, at the same time, it is not clear what is the transmission mechanism whereby institutional quality affects the labour market outcomes. In this work, we show how education quality can be crucial in giving a prominent role to ability with respect to other variables influencing the costs of obtaining a degree qualification. In this sense, *ceteris paribus* the higher is the instructional quality supplied by an institution, the lower is the probability that a student from this institution would be overeducated. Moreover, since $\frac{\partial \bar{q}}{\partial \xi} > 0$, when the share of firms that can invest in technology at a low cost (δ_l) increases, it is necessary to rise the quality of education in order to avoid overeducation. This is a relevant conclusion since, in different industrial environments, education policies may have different impacts in terms of utilization of competencies.

4 Some Empirical Issues

The debate on overeducation is based on evidence supplied by recent studies highlighting the incidence of the phenomenon and investigating trends and determinants of its occurrence.[18] There exists a moderate consensus on the hypothesis that the problem derives from the excess supply of educated workers with respect to demand in the presence of an inflexible labour market where firms do not have any incentive to modify their production processes to fully utilize the available skills. Overeducation has been recently studied in order to detect its impact on wages. Very seldom overeducation has been related to the quality of education. Robst (1995) and McGuinness (2003) represent important exceptions. Cainarca and Sgobbi (2007) find that in Italy overeducation is a pervasive phenomenon that involves mature workers who also appear as penalized in terms of wages. In line with the existing literature, they argue that the reasons of the diffusion of overeducation may reside in the specific structure of the Italian industrial sector where firms are not innovative and do not require high qualified workers. We intend to add to this empirical evidence by exploiting the role of some other relevant variables associated to the interactions between firm behaviour and individual choices in a way illustrated in our theoretical model. In particular, we believe that the outcome in terms of overeducation is not independent on the educational quality supplied by universities since it shapes the individual indifference curves and the final decision on human capital investment. In this respect, we intend to relate the phenomenon of overeducation to some specific measures of university quality, to the characteristics of the local labour markets and to individual attributes and features. According to the theoretical model illustrated in the previous sections, we should expect that the probability of finding a job in a position where the university degree is actually

and low quality institutions do not loose all the demand due to the presence of mobility costs. The study considers the particular case of higher education funding systems in which students' tuition fees are determined by a central authority (as in Continental Europe) and universities can only use the quality of education to attract students. See De Fraja and Iossa (2002) for a case where institutions compete to attract students by setting both quality and tuition fees.

[18] For a survey see McGuinness (2006).

required depends on both school quality and firms' requirements conditional on individuals attributes and opportunities.

In order to test the relevance of these variables in the process of the individual allocation into a job we apply a *Probit* model with selection on individual data from a survey carried out by the National Statistical Institute on the labour market outcomes of a representative sample of students who completed university in 1998 and were interviewed in 2001. We merge this data set with data from the Italian Ministry of Education which report statistics on enrolments and degrees for 69 universities in Italy, and with the CIVR data set that ranks the universities in terms of research and provides data on structural features of the universities such as the number of researchers, administrative staff and account information.

Figure 6 shows the extent of overeducation in Italy considering degree subjects in three geographical macroareas. It is interesting to note that overeducation is diffused homogeneously in the macroareas where, on the other hand, the industrial structure is very different. As it is well known, the South of Italy is less developed and less industrialized than the North, with a large share of public employment and high rates of unemployment.

Since overeducation is observed only for employed workers we need to employ a selection model in order to evaluate its determinants. In fact, we have data containing information on college graduates coming from and operating in very different socioeconomic contexts and selection bias may be a serious obstacle for our inference. It is well understood that individuals are systematically sorted across jobs and operate their choices of accepting a specific occupation on the basis of individual characteristics, attributes and opportunities so that in order to evaluate the probability of finding a "good" job, where the degree is actually needed, we need to employ a selection model where in the first stage we consider the general probability of being employed and in the second stage we estimate the probability of accepting a job where a degree is actually needed. We estimate a *Probit* model with sample selection which assumes that there exists a theoretical relationship for the set of variables y and x referred to individuals j $(j = 1, 2, ...)$:

$$y_j^* = x_j\beta + u_{1j} \textit{ latent equation} \tag{17}$$

where $y_j^* \equiv [y_{jn}^*; n = 1, ., N]$ is a vector of N latent dependent variables, such that we observe only:

$$y_{jn}^p = 1_{\left\{y_{jn}^* = \max\limits_{n=(1,..,N)} y_{jn}^*\right\}}. \tag{18}$$

However, the dependent variable y_{jn}^p is observed only if:

$$y_j^s = (z_j\gamma + u_{2j}) > 0 \textit{ selection equation} \tag{19}$$

with z representing a set of explanatory variables for the selection equation and the error terms $u_1$and u_2 are distributed as follows:

$$\begin{aligned} u_1 &\sim \mathcal{N}(0,1) \\ u_2 &\sim \mathcal{N}(0,1) \\ corr(u_1,u_2) &= \rho. \end{aligned}$$

In our specific case of interest, we estimate a selection *Probit* model where we associate the occurrence of overeducation to a binary 0-1 dependent variable, Y_j, and we relate it to a set of explanatory variables:

$$Y_j = \alpha P_j + \phi Q_j + \delta J_j + \nu E_j + u_{1j} \tag{20}$$

where P_j indicates a vector of variables related to the individual and household attributes and characteristics, Q_j represents a vector of variables measuring the quality of education, J_j indicates the characteristics of the job while E_j is a set of variables controlling for the different geographical socioeconomic contexts. However, since we observe the dependent variable Y_j only if the individual actually works, we define a selection equation where the dependent variable L_j is associated to a binary outcome which takes the value 1 if the individual is working at the time of the interview:

$$L_j = \sigma M_j + u_{2j} \tag{21}$$

where M_j are variables which determine the probability of working. We estimate the parameters' vectors $\alpha, \phi, \delta, \nu, \sigma$ in (20) and (21) simultaneously using the so called averaged log-likelihood function and using the *Newton-Raphson* algorithm as search direction for the maximum.

5 Description of explanatory variables

We estimate the selection model illustrated in the previous Section assuming that the individual's probability of not being overeducated is determined by a set of variables which summarize personal characteristics as well as job features, the type and quality of education received, and the individual opportunity costs.

Before turning to the discussion of explanatory variables included in our model we should clarify that our measure of overeducation is a subjective one since we consider overeducated graduates who affirm that their degree is not a necessary requirement for their job. There exists a substantive literature comparing the outcomes deriving from subjective and objective measure of overeducation (obtained by technical evaluation by professional job analysts of job positions). However, there is no consistent evidence that these different approaches give rise to systematic and significant bias of the incidence or wage effects of overeducation (McGuinness, 2006). The variables used in the empirical analysis, illustrated in detail in Table 1, may be grouped as follows.

- Basic individual characteristics. We assume that personal attributes may influence the educational choice and the individual's opportunity costs. Among these variables we include a dummy controlling for the macroarea of residence. We know that in Italy there exist huge regional disparities influencing the probability of getting a degree and the probability of finding a job. We also include in our set of explanatory variables the expected wage since it is reasonable to assume that individuals having higher expectations will end in a good match. Additionally, we use the usual control variables such as age and gender.

- Home characteristics. The individual socioeconomic background strongly influences its choices in terms of education and occupation. It is well understood in the economic literature that the cultural and intellectual resources of parents are even more relevant than income and financial constraints in shaping the students' behaviour.

- Education and ability. In any study of return to education and job match it is essential to control for fields of education. For example, there exists evidence that individuals with a degree in humanities have a higher probability of being overeducated. In Figure 6 it is evident that the share of overeducated is very high among people with a degree in humanities, linguistic, teaching or psychology. We also include variables that should help in controlling for individual ability such as high school or university leaving grade and a dummy variable related to the completion of the degree on time. The use of high school leaving grade in order to control for ability has been suggested in the literature in order to alleviate selection bias. In fact, pre-college variables provide an effective control for the possible existence of a positive relationship between innate ability and university quality.

- Job characteristics. The probability of the occurrence of overeducation is obviously determined by the firms characteristics in terms of industry, dimension and location. These variables influence the job productivity and its contents in terms of skills. We also include in our empirical model the characteristics of the occupation such as duration and the type of contract.

- A key ingredient of our theoretical model is the university quality. We argue that it influences the chances of a good match by determining the typology of signalling equilibria arising in the job market. We have different measures of educational quality that attempt to capture the set of scientific and technical skills provided by the university. Usually, the education quality is measured by some outcome or structure indicators such as the student-teachers ratio, the class size, the students' marks or the proportion of students who graduate on time. We support these measures with different indicators derived from the universities' accounts including the ratio of investments on the value of total assets, per-student expenditures and the ratio of the total number of researchers on administrative staff. However, these indicators are not strongly correlated each other as Figure 7 may suggest, since they probably express a different measure of university quality.

6 Empirical Results

In Table 2 and Table 3 we report the results of our empirical model as described in the previous Sections. First of all, in Table 3, we notice that our model is well specified since we can reject the null hypothesis that $\rho = 0$. We assume that the likelihood of being employed (on which depends the likelihood of the phenomenon of overeducation being observed) depends on a set of personal characteristics and on the education received. We see that both sets of variables influence the probability of working. As expected, geographical dummy variables also influence the probability of working highlighting a penalization for people in the Southern labour market. We find that the probability of working increases with the mark obtained at university. However, the concavity of this relationship may be due to the fact that the best students may choose to follow post-graduate courses delaying their entrance in the job market. In Table 2 the *Probit* for overeducation shows a series of interesting results. Overeducation increases with age. There is a negative coefficient that links the probability of having a good match and the individual's age and this could indicate that students that spent too much time to terminate their degree course usually are employed in occupations that underutilize their skills. Notice that an ability' signalling mechanism is completely consistent with this finding.[19] At the same time, the expected wage influences positively the probability of not being overeducated, showing that overeducation may originate from a sort of dejection or discouragement in finding a good job. Individual's ability, controlled by university or high school marks, is an important determinant of job matches. Considering that in Italy education strongly changes across the specific high schools i.e., lyceum, technical or magistralis, we build three interaction dummies in order to control for the high school final mark depending on the specific school followed. Interestingly, we find that only the marks received at the most engaging lyceum works as a valid signal of individuals' ability. The individual's socioeconomic background strongly influences both the probability of working and the probability of working in a firm where the degree obtained is a necessary qualification. The parameters' estimates significantly show that people coming from more educated families reduce their chances of ending overeducated. Controlling for fields of education is compulsory for studying the phenomenon of overeducation. Indeed, as expected in the majority of cases the dummies for fields of education are significant, showing that only a degree in medicine does not give an advantage in terms of job match with respect to the excluded motorial science field. In this respect, it is important to note the negative and significant parameter associated to the medicine degree in the selection equation. This is due to the fact that usually students with a degree in medicine are involved in three years of specialization courses, hence most of them were not in the job market at the time of the interview. Firm characteristics also influence the likelihood of overeducation. The occurrence of it is more likely if

[19] Notice that in Italian universities students may reset exams without any limit and the marks obtained when the exams fail are not registered. The final mark is not affected by exams' failures.

the firm is small and belongs to the service sector. Moreover, we notice that once we control for the probability of being employed and for a set of covariates, overeducation characterizes Southern more than Northern workers. Turning to our parameter of high interest, we may see that university quality, as measured by the ratio of researchers on administrative staff, strongly influences the probability of being overeducated. Other measures of the university quality have been introduced among the explanatory variables but they do not appear to be significant. This may be due to the fact that in Italy about 80% of students do not graduate on time so, measures that contain this variable may not be indicative of university quality. On top of that "grade inflation" phenomena may generate an inverse correlation between university quality and the number of students who graduate on time. At the same time, balance sheets figures may not be indicative of quality considering the method of funds' allocation for Italian universities (see Johnstone, 2003). The ratio of researchers to administrative staff may capture how much the university is research-oriented and, in this sense this measure may be a good indicator of university quality. There exists some evidence that there are consistent positive links between research work in the university and students performance in the labour market (Black and Smith, 2004). However, there exists scarcity of evidence on the relationship between university quality and job matches. McGuinness (2003) uses a proxy for university quality derived from the 2001 Guardian research score and shows that in the UK there exists a high correlation between university research score and the percentage of overeducated. At the same time his results, derived by estimating a *Probit* model without addressing the selection bias issue, indicate that there is little benefit, in terms of job match, from being educated at a superior institution. Here, for the Italian labour market we see that controlling for selection problems gives rise to an estimate of a positive and strong effect of university quality on the probability of finding a job that require the acquired competencies and skills.

7 Conclusions

Overeducation is a widespread phenomenon that characterizes developed countries. The issue is at the centre of political debates since it may be essential to understand the sources and the costs of the existing mismatch. In this paper we show that if we expand the Spence signalling model to consider heterogeneous opportunity costs, equilibria where individuals with different ability acquire the same educational level may arise consistently with a forward induction reasoning. We show that in the presence of heterogeneous firms in terms of technological endowment, these equilibria may be characterized by overeducation. The occurrence of this phenomenon is strongly related to the education quality since it determines the role that ability has in the individuals' schooling choice. We find that the larger is the share of innovative firms the higher must be the quality of education in order to avoid overeducation. This is due to the fact that low ability individuals may see better job opportunities by acquiring high education and they do not internalize the impact of their choice on firms' behaviour.

The empirical estimates show that indeed the extent of overeducation depends on education quality. Using a sample of Italian graduates we find that having a degree from research-oriented universities significantly reduces the probability of being overeducated. We also highlight that overeducation may be the natural end of a long time period spent to obtain a degree. This may reflect both low ability and low opportunity costs. At the same time, geographical environment strongly influences the overeducation phenomenon. All that given, our empirical findings support our theoretical model and put forward important determinants of inefficient self-selection in education that resolves in overeducation in the job market.

Our policy indications point out the importance that education quality may have in reducing overeducation and the need to consider interactions with the socioeconomic context in refining policy measures for higher education. Only by giving a prominent role to ability in the schooling process it would be possible to discourage low ability individuals and to prevent overeducation. Increasing tuition fees or other monetary costs could be completely ineffective in reducing this phenomenon.

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8 Appendix

Proof of Proposition 2 when relation (9) holds[20] We define a PBE as the assessment $\mu^* = (\mu_f^*, \mu_i^*, b(e))$ where μ_f^* and μ_i^* represent firms and individual strategies respectively and $b(e)$ is the firms' beliefs function. First, it is useful to define the rent that a firm can obtain when it is not able to discriminate between (θ_l, λ_l) and (θ_h, λ_h) individuals. If a firm chooses $T = LT$, whatever is the ability of the matched individual, it obtains a rent equal to $\Delta(e, LT)$ for all θ because of assumption (13). If a firm chooses to invest in $T = HT$ (that, as a reminder, costs δ) then the expected rent is given by:

$$E[\Delta(e, TH)] = \gamma(1-p)\Delta(e, HT) + (1-\gamma)p\Delta(e, LT). \tag{22}$$

Hence, a firm that is not able to discriminate between (θ_l, λ_l) and (θ_h, λ_h) individuals invests in HT only if:

$$E[\Delta(e, HT)] - \delta \geq \Delta(e, LT). \tag{23}$$

Here we start to analyze the equilibria assuming that relation (23) holds. In particular, in order to simplify the exposition, we assume that in Figure 4, condition (23) holds for $e = e_p$ (we could consider another value of $e \in [e_p, e_k]$ but this would only complicate the graphical intuitions). We construct the proof in two parts. In Part 1 we show that a "partial" pooling PBE is consistent with forward induction. In Part 2, we show that a "partial" pooling PBE can be the only PBE of the game.

Part 1. In Figure 4, consider the following assessment μ^*:

$$\mu_i^* = \begin{cases} e = e_s & if \quad (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_l) \\ e = e_l & if \quad (\theta_\alpha, \lambda_\beta) = (\theta_l, \lambda_h) \\ e = e_p & if \quad (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_h) = (\theta_l, \lambda_l) \end{cases} \tag{24}$$

$$\mu_f^* = \begin{cases} T = HT & if \quad e \geq e_p \\ T = LT & if \quad e < e_p \end{cases} \tag{25}$$

$$b(e) = \begin{cases} 1 & if \quad e \geq e_s \\ 0 & if \quad e < e_p \\ \frac{\gamma(1-p)}{\gamma(1-p)+(1-\gamma)p} & if \quad e_p \leq e < e_s. \end{cases} \tag{26}$$

Given the wage schedule, the indifference curves and the values of e_p, e_s and e_l indicated in Figure 4, the above assessment represent a "partial" pooling PBE. First (θ_l, λ_h) individuals do not imitate the choice of individuals $(\theta_h, \lambda_h) = (\theta_l, \lambda_l)$ since the former reach a higher indifferent curve by locating in point L (in order to simplify the illustration, we are assuming that the indifference between L and A is resolved in favour of L; alternatively we could increase e_p by an arbitrarily small amount so that the (θ_l, λ_h) individuals would strictly prefer e_l). By choosing education e_s, the (θ_h, λ_l) individuals can give a credible

[20] We are in the case depicted in Figure 4 where $(\theta_l, \lambda_l) = (\theta_h, \lambda_h)$.

signal of their ability since individuals $[(\theta_h, \lambda_h) = (\theta_l, \lambda_l)]$ prefer to locate in point B instead of acquiring education e_s, even if they were paid a wage equal to $w(HT, \theta_h)$. The beliefs function $b(e)$ expresses only reasonable beliefs since there is no action off the equilibrium path that can be taken by any type of player to improve his situation.

(Part 1 *Q.E.D.*)

Part 2. In order to prove that assessment μ^* describes the only typology of *PBE* consistent with forward induction that may arise in the game in Figure 3, we need to show that all the other typologies of *PBE* different from μ^* are not consistent with forward induction.

First, consider Figure 8 (graphic a) and consider the following profile of strategies and beliefs representing a *PBE* in which all individuals are pooled together and firms invest in *LT*:

$$\mu_i^* = \{e = e_m \quad \forall \ \lambda, \theta \tag{27}$$

$$\mu_f^* = \{T = LT \quad iff \ \ e = e_m \tag{28}$$

$$b(e) = \begin{cases} \gamma & if \ \ e = e_m \\ 0 & if \ \ e \neq e_m. \end{cases} \tag{29}$$

By contradiction, assume that $b(e) = 0$ if $e \neq e_m$ is consistent with forward induction. As shown in the figure, if educational level e_s is observed, firms must set their beliefs such that $b(e_s) = 1$, since only high ability individuals with low opportunity costs can choose e_s instead of e_m. In fact, only this type of player can be better off by choosing e_s instead of e_m. As a consequence, setting $b(e_s) = 0$ is not reasonable and we have a contradiction.[21]

Second, consider Figure 8 (graphic b) and consider the following profile of strategies and beliefs representing a *PBE* in which only (θ_l, λ_h) individuals separate from the others that are all pooled together:

$$\mu_i^* = \begin{cases} e = e_p & if \ \ (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_l) \\ e = e_p & if \ \ (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_h) = (\theta_l, \lambda_l) \\ e = e_l & if \ \ (\theta_\alpha, \lambda_\beta) = (\theta_l, \lambda_h) \end{cases} \tag{30}$$

$$\mu_f^* = \begin{cases} T = HT & if \ \ e \geq e_p \\ T = LT & if \ \ e < e_p \end{cases} \tag{31}$$

$$b(e) = \begin{cases} \frac{\gamma}{p+(1-p)\gamma} & if \ \ e \geq e_p \\ 0 \quad if \ \ e < e_p. \end{cases} \tag{32}$$

[21] The same arguments can be replicate for the following *PBE* of the game in Figure 3 where all individuals are pooled together and firms invest in *HT*:

$\mu_i^* = \{e = e_m \quad \forall \ \lambda, \theta$

$\mu_f^* = \{T = HT \quad iff \ \ e = e_m$

$b(e) = \begin{cases} \gamma & if \ \ e = e_m \\ 0 & if \ \ e \neq e_m. \end{cases}$

By contradiction, assume that $b(e) = \frac{\gamma}{p+(1-p)\gamma}$ if $e \geq e_p$ is consistent with forward induction. As shown in the figure, if the educational level e_s is observed, firms must set their beliefs such that $b(e_s) = 1$, since only high ability individuals with low opportunity costs can choose e_s instead of e_p. Hence, setting beliefs $b(e_s) = \frac{\gamma}{p+(1-p)\gamma} < 1$ is not reasonable and we have a contradiction.

Third, consider Figure 8 (graphic c) and consider the following profile of strategies and beliefs representing a *PBE* of the game in Figure 3 where only (θ_h, λ_l) individuals are separated from the others that are pooled together and firms invest in *HT*:

$$\mu_i^* = \begin{cases} e = e_s & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_l) \\ e = e_m & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_h) = (\theta_l, \lambda_l) \\ e = e_m & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_l, \lambda_h) \end{cases} \tag{33}$$

$$\mu_f^* = \{T = HT \;\; iff \;\; e \geq e_m \tag{34}$$

$$b(e) = \begin{cases} 1 & if \;\; e \geq e_s \\ \frac{\gamma(1-p)}{1-p\gamma} & if \;\; e < e_s. \end{cases} \tag{35}$$

By contradiction, assume that $b(e) = \frac{\gamma(1-p)}{1-p\gamma}$ if $e < e_s$ is consistent with forward induction. As shown in the figure, if the educational level $e_p < e_s$ is observed, firms must set their beliefs such that $b(e_p) = \frac{\gamma(1-p)}{\gamma(1-p)+(1-\gamma)p}$, since only high ability individuals with low opportunity costs can choose e_p instead of e_m. Hence, setting beliefs $b(e_p) = \frac{\gamma(1-p)}{1-p\gamma} < \frac{\gamma(1-p)}{\gamma(1-p)+(1-\gamma)p}$ is not reasonable and we have a contradiction.[22]

(Part 2 *Q.E.D.*)

Proof of Proposition 2 when (8) holds Consider Figure 8 (graphic d) and consider the following "partial" pooling *PBE* expressed by the following assessment:

$$\mu_i^* = \begin{cases} e = e_s & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_l) \\ e = e_l & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_l, \lambda_h) \\ e = e_p & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_h) \\ e = e_p & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_l, \lambda_l) \end{cases} \tag{36}$$

$$\mu_f^* = \begin{cases} T = HT & if \;\; e = e_p \;\; or \;\; e \geq e_s \\ T = LT & if \;\; e < e_p \;\; or \;\; e_p < e < e_s \end{cases} \tag{37}$$

[22] The same arguments can be replicate for the following *PBE* of the game in Figure 3 where only (θ_h, λ_l) individuals are separated from the others that are pooled together and firms investing in *HT* only when an educational level that generates separation is observed:

$$\mu_i^* = \begin{cases} e = e_s & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_l) \\ e = e_m & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_h, \lambda_h) = (\theta_l, \lambda_l) \\ e = e_m & if \;\; (\theta_\alpha, \lambda_\beta) = (\theta_l, \lambda_h) \end{cases}$$

$$\mu_f^* = \{T = HT \;\; iff \;\; e \geq e_s$$

$$b(e) = \begin{cases} 1 & if \;\; e \geq e_s \\ \frac{\gamma(1-p)}{1-p\gamma} & if \;\; e < e_s. \end{cases}$$

$$b(e) = \begin{cases} 1 \quad if \quad e \geq e_s \\ 0 \quad if \quad e < e_p \quad or \quad e_p < e < e_s \\ \frac{\gamma(1-p)}{\gamma(1-p)+(1-\gamma)p} \quad if \quad e = e_p. \end{cases} \tag{38}$$

The profile of strategies and beliefs expressed above contains an equilibrium consistent with forward induction since setting $b(e) = 0$ when $e_p < e < e_s$ is reasonable. In fact, as shown in the figure, only (θ_l, λ_l) individuals may improve their utility by acquiring such e even if the wage were $w(HT, \theta_h)$ for all individuals. Firms know that and the beliefs function $b(e) = 0$ if $e_p < e < e_s$ is consistent with forward induction. Since individuals (θ_l, λ_l) can always imitate the behaviour of (θ_h, λ_h), but they cannot imitate the behaviour of (θ_h, λ_l) (assumptions (4) and (5)), the best action that (θ_l, λ_l) individuals can take is to pool with the (θ_h, λ_h) types. All arguments made in the case where $(\theta_h, \lambda_h) = (\theta_l, \lambda_l)$ can then be easily replicated (only by adjusting appropriately the beliefs function when $e_p < e < e_s$) to show that only a "partial" pooling PBE can be consistent with forward induction.

Q.E.D.

Proof of Proposition 3 Pooled individuals would be indifferent between choosing e_p and e_m only if

$$\xi u(e_p, w_p) + (1 - \xi) u(e_p, w') = u(e_m, w_m). \tag{39}$$

The education quality level for which relation (39) is satisfied is given by $\bar{q} = \bar{q}(\xi) > 0$ such that:

$$\xi w_p(q, \cdot) + (1 - \xi) w'(q, \cdot) - w_m(q, \cdot) = c(e_p, q, \cdot) - c(e_m, q, \cdot). \tag{40}$$

We show that if $q < \bar{q}(\xi)$, individuals strictly prefer to acquire education e_p and overeducation arises.

First, we can write relation (40) as follows:

$$\xi \left\{ e_0 + e_p[q + \varepsilon - \Delta(HT, \theta_h)]\gamma(1-p) + e_p[q - \Delta(HT, \theta_l)](1-\gamma)p \right\} +$$

$$(1 - \xi) \left\{ e_0 + e_p[q - \Delta(LT, \cdot)] \right\} - e_0 - e_m(q - \Delta(LT, \cdot) = c(e_p, q, \cdot) - c(e_m, q, \cdot). \tag{41}$$

Differentiating with respect to q we have that:

$$e_p \left[\xi(\gamma - 2\gamma p + p) + (1 - \xi) \right] - e_m = \frac{\partial c(e_p)}{\partial q} - \frac{\partial c(e_m)}{\partial q}. \tag{42}$$

Relation (42) indicates that:

- The LHS of (40) is linearly increasing in q;
- The RHS of (40) is always increasing and convex in q, since $\frac{\partial c}{\partial q \partial e} > 0$.

If in $\bar{q} > 0$ the RHS and LHS of relation (40) are equal, if $q < \bar{q}$ we must have that the LHS is larger than the RHS. As a consequence, if $q < \bar{q}$ pooled individuals are not indifferent between e_p and e_m but they strictly prefer to acquire education e_p and overeducation takes place.

Q.E.D.

Table 1: Description of variables in probit and selection equations

Degree needed for the job	Answer to the question: "Is your degree a required qualification for your job?".
Individual characteristics	
Sex	Dummy variable indicating the respondent's sex, male=0.
Age	Respondent's age at the interview.
Marital status	Dummy variable indicating if the respondent is married, married=1.
North	Dummy variable indicating if the respondent is resident in the North of Italy.
Centre	Dummy variable indicating if the respondent is resident in the Centre of Italy.
South	Dummy variable indicating if the respondent is resident in the South of Italy.
Employed	Dummy variable indicating if the respondent is working at the interview.
Expected wage	Minimum monthly wage desired.
Home characteristics	
Father education	Highest grade of years of school completed by respondent's father.
Mother education	Highest grade of years of school completed by respondent's mother.
Education achieved	
Degree subject	A vector of 6 dummy variables indicating degree subjects: 1) math-scientific, chemistry-pharmacy, geo-biology, agrarian; 2) medical, 3) engineering and architecture, 4) political science, economics and statistics, law; 5) humanities, linguistic, teaching and psychology; 6) motorial science.
University location	A vector of 6 dummy variables indicating if the university is located in the North, in the Centre or in the South of the country.
High School	A vector of three dummy variables for the type of High School followed: Lyceum, Technical, Magistralis.
High school leaving grade	Final score.
University leaving grade	Final score.
Degree on time	Dummy variable indicating if the degree is completed on time, on time=1.
Job Characteristics	
Employed temporary	Dummy variable indicating if the respondent has a temporary or a permanent contract at the interview.
Firm Size	A three level dummy variable for firm size, <50 employees, >50 and <100 employees, >100 employees.
Industrial Sector	Dummy variables indicating the industrial sector of firm.
Firm ownership	Dummy variable indicating if the firm ownership is public or private, public=1.
University characteristics	
Total enrolment	Number of students enrolled in the years 2001-2003.
Graduates	Number of graduated, total and in course, for the years 2001-2003.
Accounting information	Total entries and investments, number of researchers and administrative staff for the years 2001-2003.

Table 2: Overeducation Probit

Indep.Vars			
Constant	−4.072 (0.000) [0.610]	Public sector	0.216 (0.000) [0.051]
Age	−0.052 (0.088) [0.031]	University quality	0.258 (0.000) [0.058]
Sex	−0.036 (0.435) [0.047]	Firm size	0.056 (0.001) [0.017]
High school leaving grade-Lyceum	0.053 (0.054) [0.027]	Employed temporary	−0.194 (0.000) [0.043]
High school leaving grade-Technical	0.042 (0.122) [0.027]	North	0.297 (0.000) [0.047]
High school leaving grade-Magistralis	−0.027 (0.421) [0.033]	South	−0.223 (0.001) [0.065]
University leaving grade	0.025 (0.069) [0.014]	Degree subject medicine	0.217 (0.673) [0.514]
Father education	0.061 (0.031) [0.028]	Degree subject engineering	2.140 (0.000) [0.419]
Mother education	0.063 (0.049) [0.032]	Degree subject economics & law	1.353 (0.001) [0.417]
Expected wage	0.191 (0.001) [0.059]	Degree subject humanities	1.383 (0.001) [0.419]
Service sector	−0.216 (0.000) [0.051]	Degree subject mathematics	1.685 (0.000) [0.422]

Notes: i) The dependent variable is a latent variable equal to 1 in case of affirmative answer to the question: "Is your degree a required qualification for your job?". ii) University quality is measured as Researcher to Administrative staff ratio; iii) Probability value under the null in parenthesis. Standard errors in square brackets.

Table 3: Selection model for overeducation Probit

Indep.Vars			
Constant	-0.645 (0.001) [0.193]	Degree subject economics & law	0.093 (0.549 [0.155]
Age	0.043 (0.028) [0.197]	Degree subject humanities	0.381 (0.015) [0.156]
Sex	-0.127 (0.000) [0.034]	Degree subject mathematics	0.065 (0.681) [0.157]
University leaving grade	0.029 (0.000) [0.005]	North	0.245 (0.000) [0.040]
University leaving grade^2	-0.001 (0.000) [0.000]	South	-0.453 (0.000) [0.041]
University quality	0.158 (0.001) [0.046]	*Main Statistics*:	
North	0.245 (0.000) [0.040]	ρ	0.940
South	-0.453 (0.000) [0.041]	L.R. test ($\rho = 0$)	$9.96(\chi^2_1)$ (0.002)
Degree subject medicine	-1.81 (0.000) [0.169]	Wald Test	$577(\chi^2_{19})$ (0.000)
Degree subject engineering	0.683 (0.000) [0.157]	Observations	8488
		Censored	5875

Notes: i) The dependent variable is a dummy variable equal to 1 if the respondent is working at the interview; ii) University quality is defined as in the overeducation probit; iii) Probability value under the null in parenthesis. Standard errors in square brackets; iv) University leaving grade^2 is the variable squared.

Figure

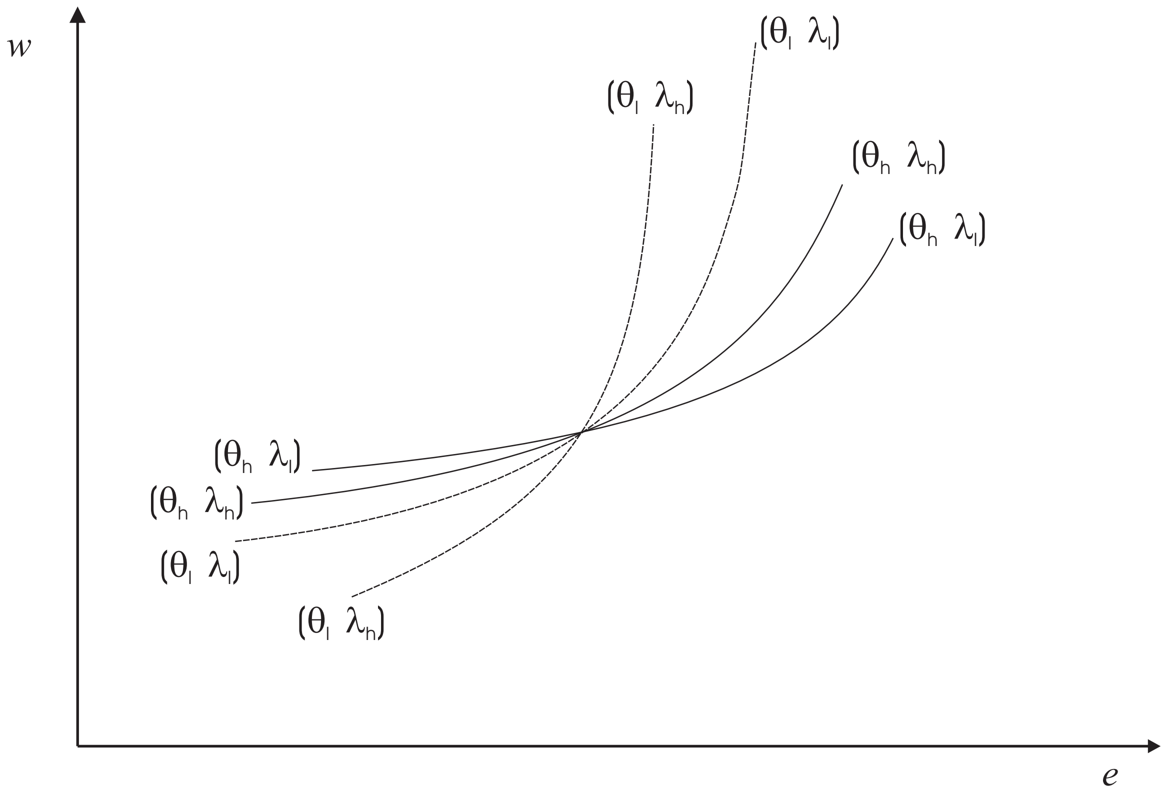


Figure 1: High and low ability individuals indifference curves with high and low opportunity costs

Figure

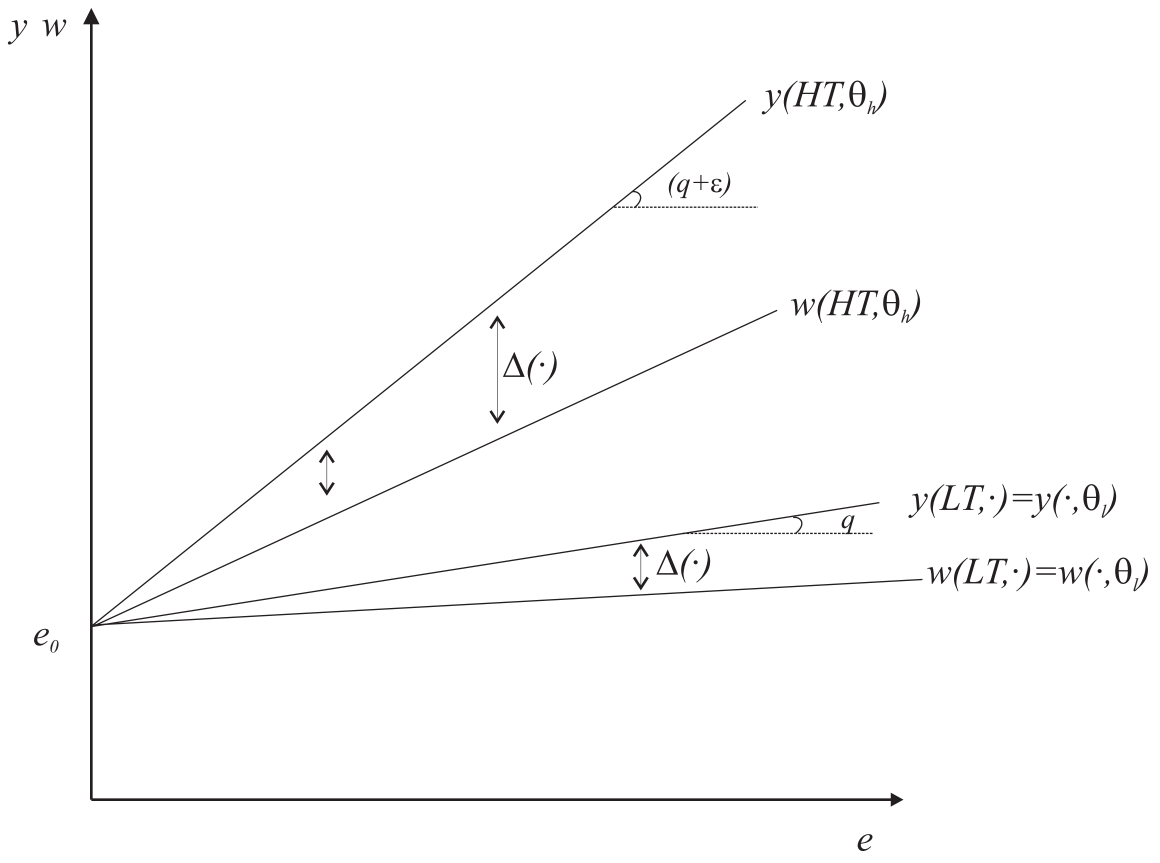


Figure 2: Productivity, wages and rents conditional to firm-individual match

Figure

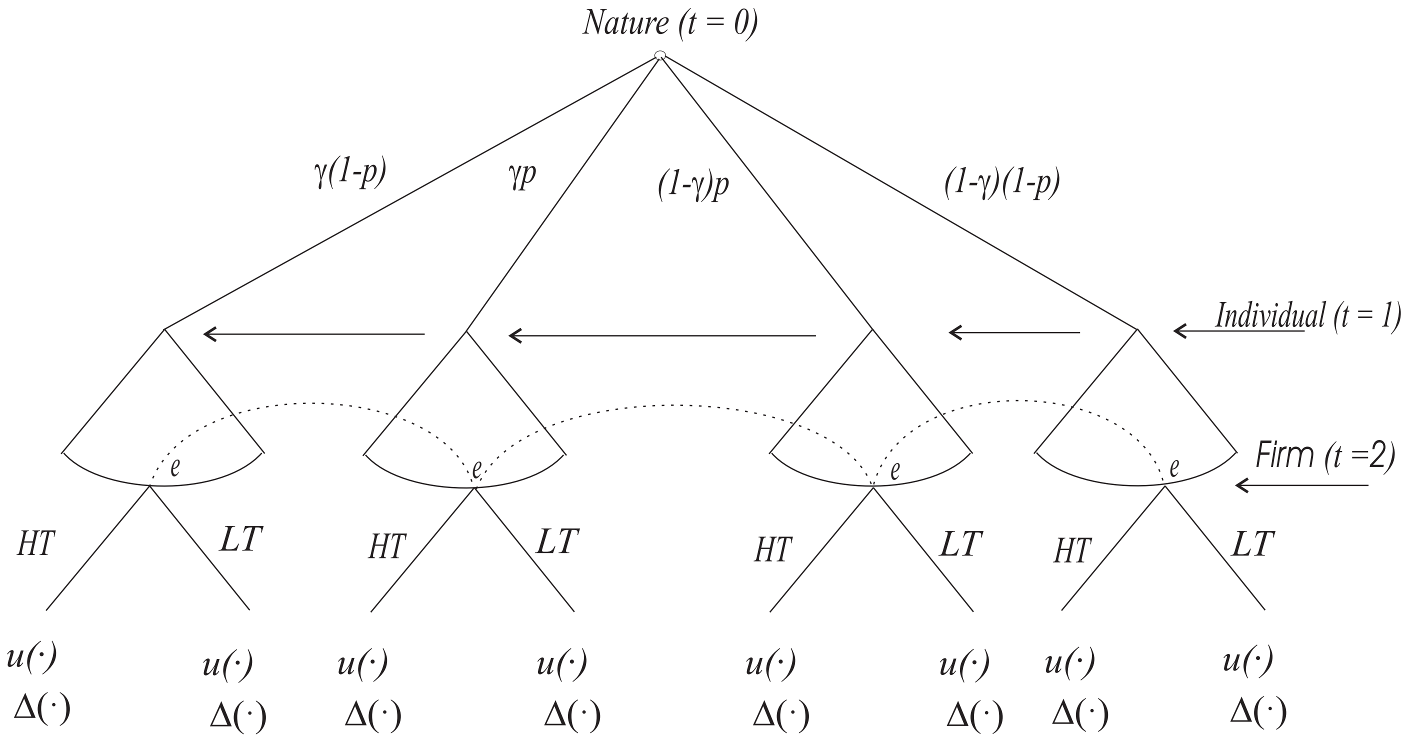


Figure 3: The job market signalling game with unobserved opportunity costs

Figure

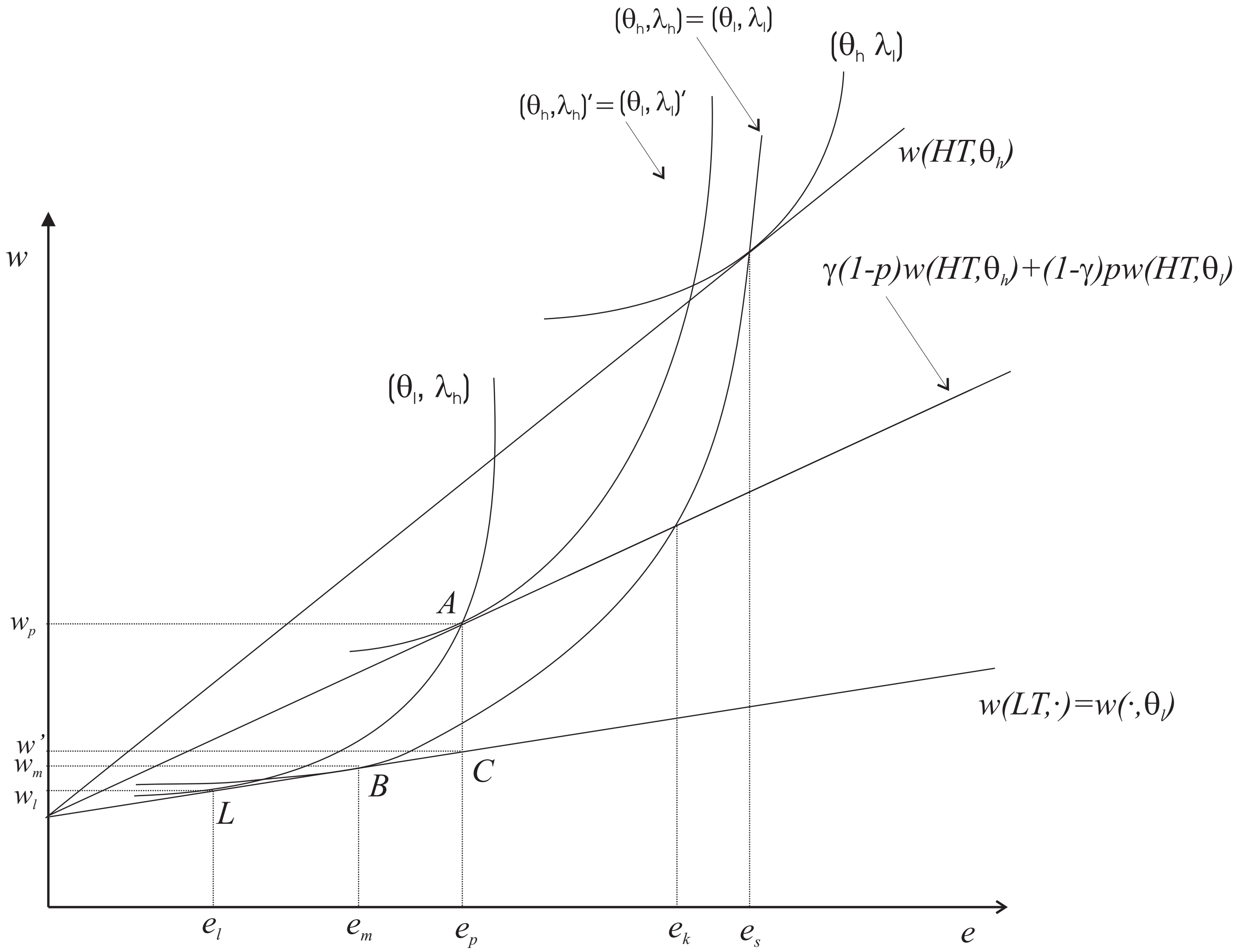


Figure 4: A partial separating equilibrium

Figure

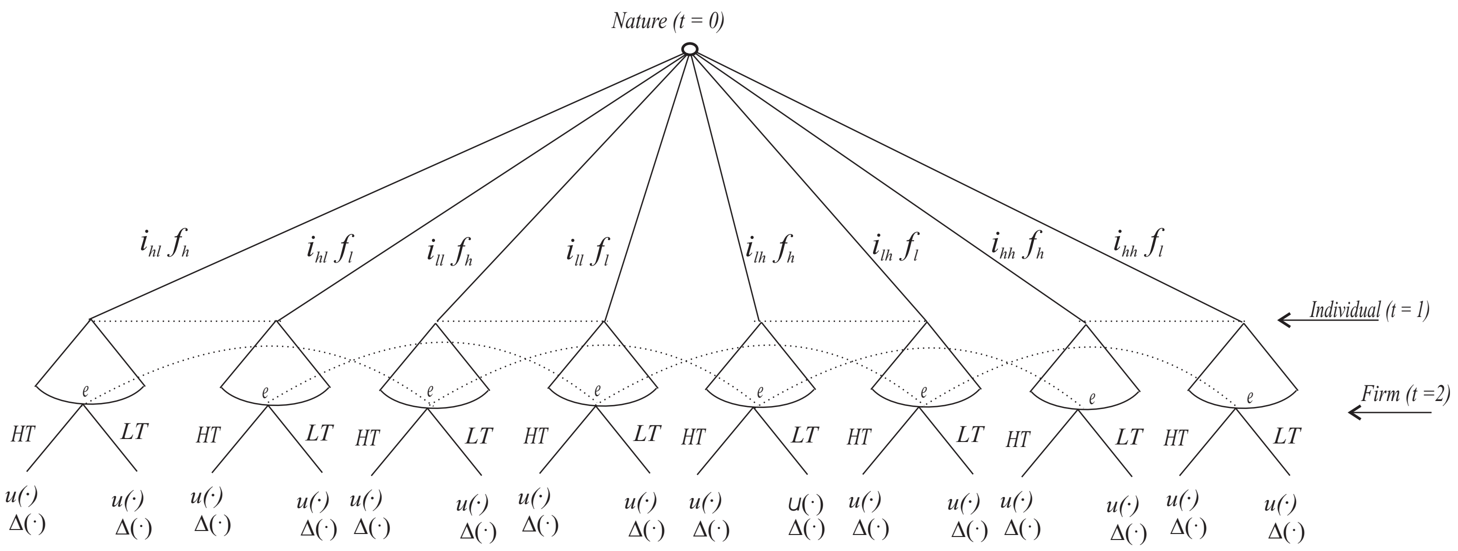


Figure 5: The signalling game with heterogeneous firms

Figure

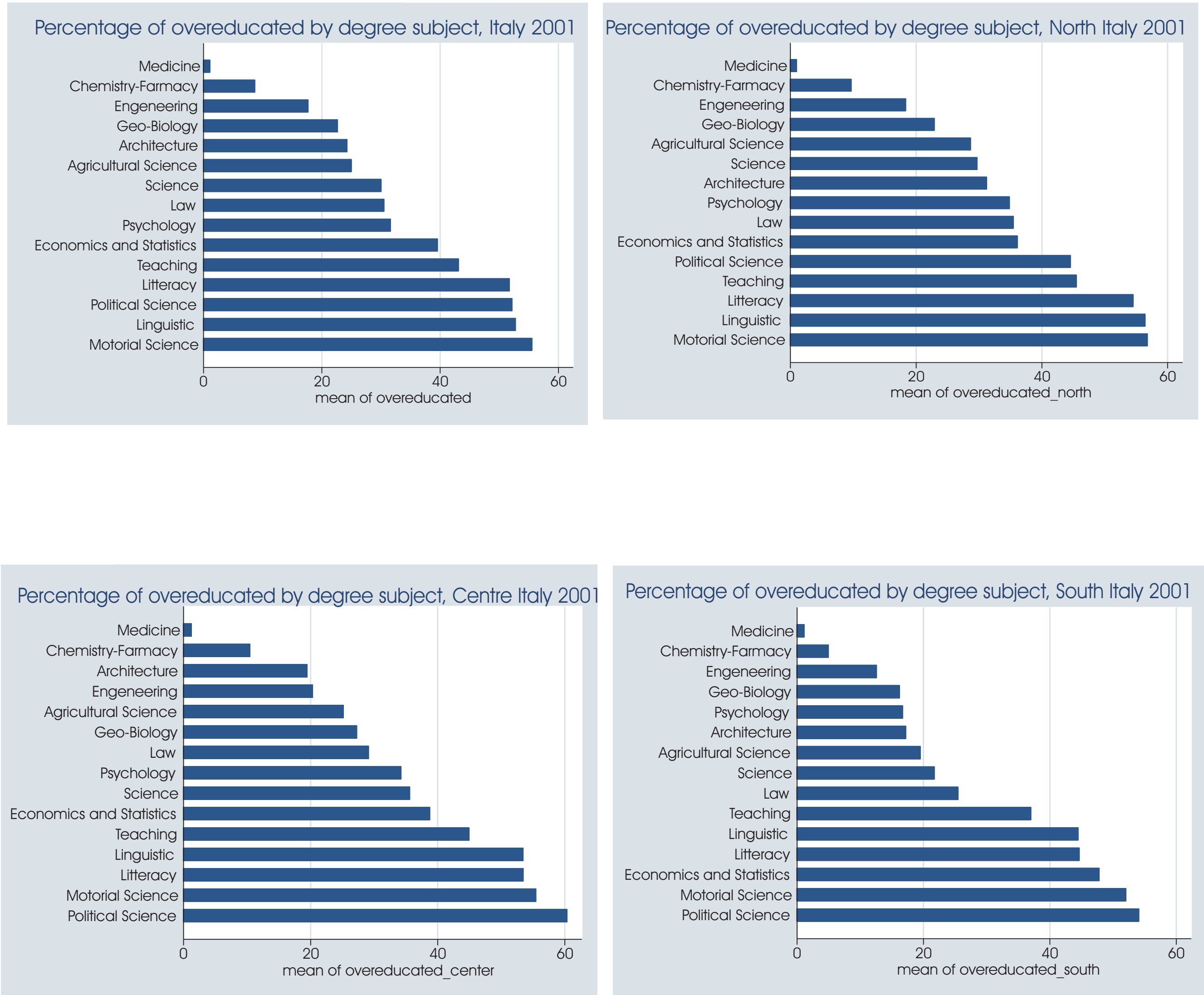
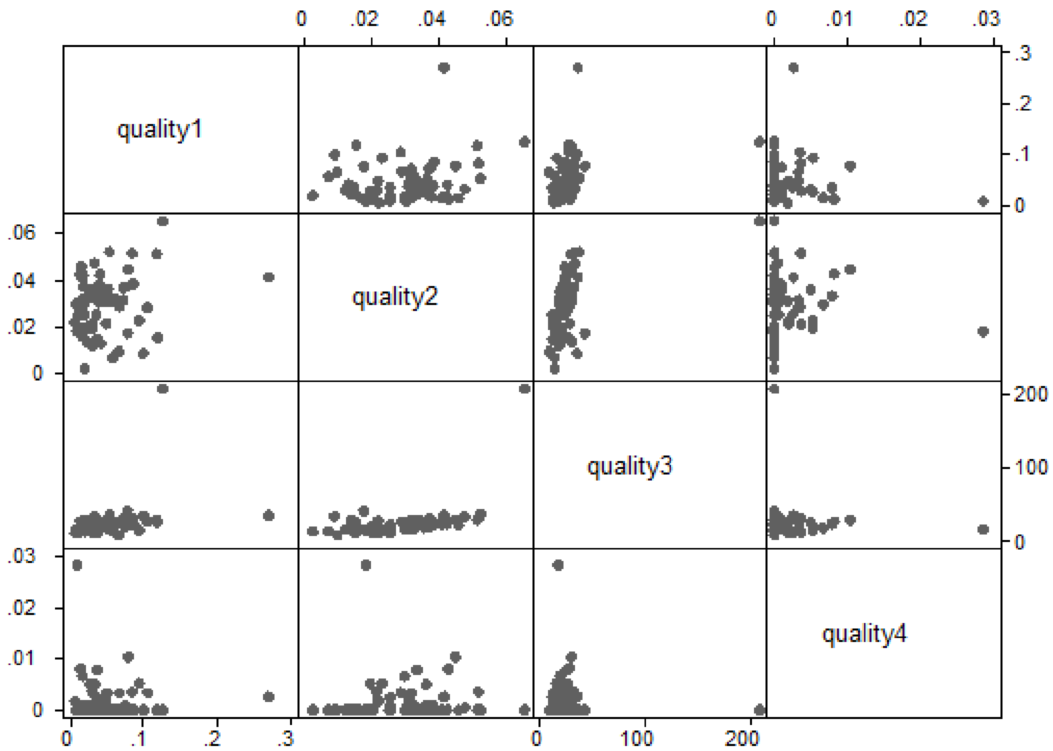


Figure 6: Overeducation in Italy by subject degree and macroarea. Percentages on total employed graduates

Figure



Note: quality1= *graduates on time/total enrolment;*
quality2= *researchers/total enrolment;*
quality3=*university funds/total enrolment;*
quality4= *researchers/administrative staff.*

Figure 7: Correlations between different measures of education quality

Figure

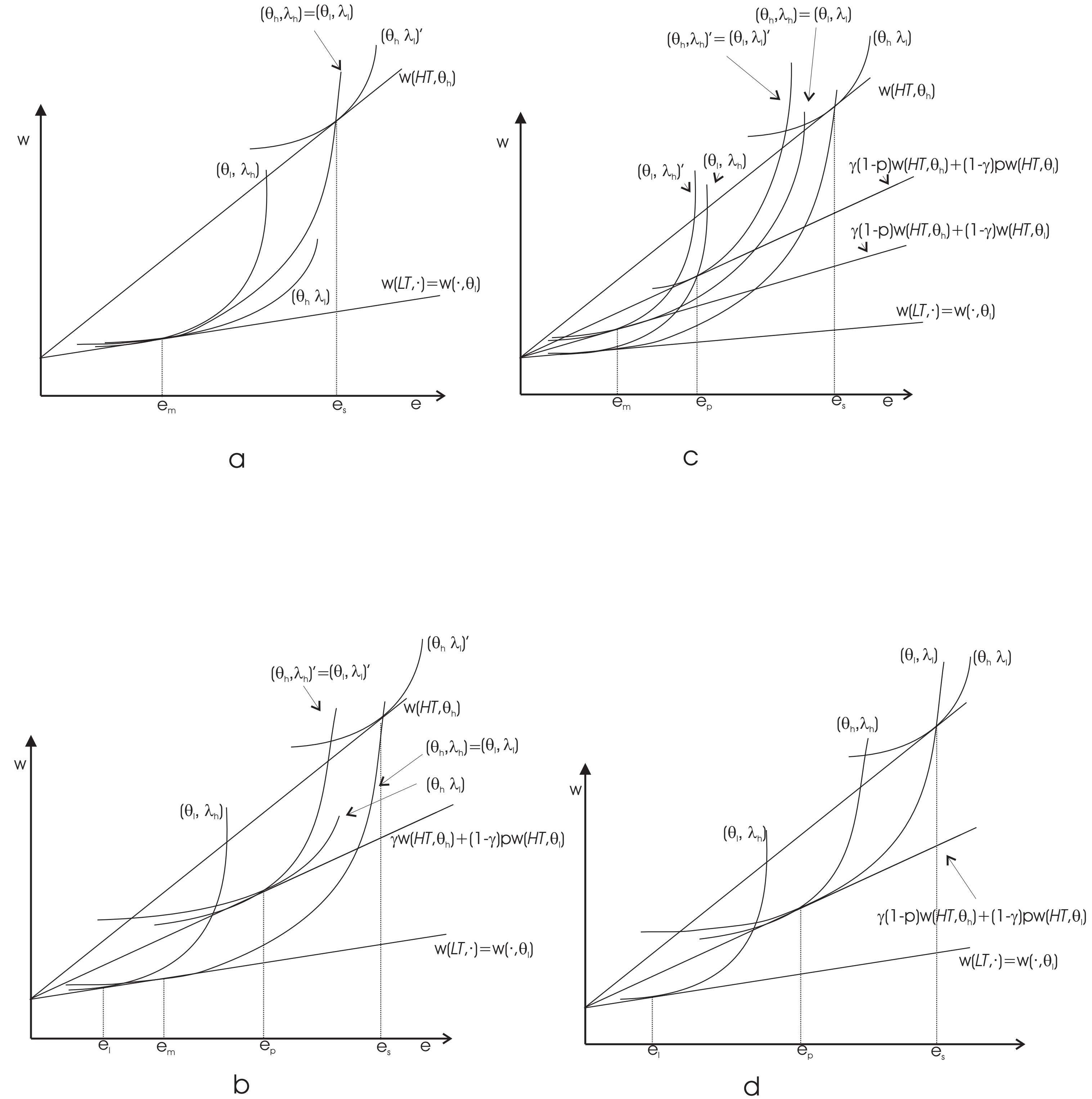


Figure 8: Other perfect Bayesian equilibria