The paper analyzes the characteristics of the supply of higher education in different geographical macroareas using a strategic interaction framework. We investigate the issue of educational quality differentials in a centralized funding system. In the presence of moving costs and asymmetric information on individuals’ ability, we show that only high-ability students acquire education and the quality of education is lower in macroareas where the moving costs are higher in the only perfect Bayesian equilibrium consistent with forward induction. Our model predicts that direct subsidies to universities may be ineffective in improving the quality of education in the less developed areas. When regional disparities are not too large, efficiency can be increased by subsidizing student mobility.

**JEL Classification:** I21, I28, D82, J24.  
**Keywords:** perfect bayesian equilibrium, forward induction, spatial models, propensity score matching.

1. Introduction

The paper aims at characterizing the determinants of quality differentials among Italian universities. To this end, it models supply of education focusing on how the intensity of competition among universities depends on students moving costs across areas.

The debate on education quality in Italy is based on evidence supplied by recent studies ranking the universities in terms of research (CIVR, 2006) or teaching effectiveness (MIUR, 2001 and 2006). There is also some evidence that the returns to education depend on the specific institution attended and on the location of the universities. Moreover, the Italian higher education sys-
tem is widely perceived to feature little effective competition, and hence little incentive for improvement in either instruction or research. In this paper we report some empirical evidence on the impact of graduating in northern and central regions on wages of southern employees and we show that the average treatment effect of studying in northern colleges is about +19%. We relate the advantage of attending universities located outside the less developed areas of the country to differences in instructional quality.

We set up a theoretical model suitable for analyzing supply of higher education in different geographical macroareas, using a strategic interaction framework. In particular, we focus on the quality of education showing that in equilibrium it is inversely related to students’ moving costs across areas. We show that, in the presence of asymmetric information on individuals’ ability and asymmetric costs of moving, the only perfect Bayesian equilibrium (PBE) consistent with forward induction implies that only high ability individuals acquire education, and that quality of education is lower in macroareas where mobility costs are higher. We believe that this framework may represent well the case of Italy, where quality differs substantially across universities and geographical mobility is low.

The model setup considers an economy that can be described as a circular city (Salop, 1979) where a finite number of universities compete to attract students. The universities are located at the same distance from each other and give rise to regional markets where there is a continuum of individuals. The individuals choose to invest in human capital. In this economy firms set production on the basis of technology and compete to employ individuals. We model a strategic interaction process where there are strategic complementarities between the educational choice of individuals and the technological choices of firms. At the same time, we assume that the universities choices in terms of quality spill over on productivity and wages.

In terms of policy, the theoretical model has many interesting implications. First of all, if moving costs are a crucial determinant of the education quality, since they contribute to generate monopoly power of local institutions, the supply of education may be improved by modifying structural characteristics and institutions operating in the regional economies or by introducing an appropriate vouchers scheme. Inefficiencies in the credit market for example and liquidity constraints may imply high mobility costs, and consequently influence the supply of education quality. The labour market performance and the local rate of unemployment also might strongly influence the individuals’ choice of moving and consequently the incentive of local universities to improve quality.

A crucial issue is to evaluate if the government may affect the quality of higher education by changing the level of spending. In particular, it is rele-
vant to evaluate the right instruments to implement this policy: tax exemptions, educational vouchers or direct subsidies to universities. In general, our model predicts that direct subsidies to universities may be ineffective in improving the quality of education in the less developed areas. This conclusion is consistent with the results of Aghion et al. (2005) who highlight that regions investing more in higher education do not necessarily grow faster. We also give some hints to evaluate the effects of increasing the autonomy of universities. Although there may exist theoretical justifications for decentralizing education systems, in our model a side effect of increased autonomy may arise through an increase in the monopoly power of local institutions.

The paper is organized as follows. Section 2 describes the existing empirical evidence for Italy and presents the results of our econometric exercise. Section 3 contains a discussion of the theory that relates moving costs to the supply of quality. Section 4 considers explicitly some policy implications and Section 5 concludes.

2. SOME EMPIRICAL ISSUES

Recent empirical evidence in Italy focuses on the impact of educational quality on individuals’ wage prospects. Some studies point out that the returns to education depend on the specific institution attended and on the location of the universities. Makovec (2006), shows that students that leave from southern regions to study in universities in the North have a higher probability of finding a job in the North and receive higher earnings than stayers. Brunello - Cappellari (2005) find a significant impact of college specific quality on employment probabilities and wages of Italian college graduates and report a low students’ mobility. Hence, geographic mobility is low even though employment probabilities and expected wages could be higher for students attending northern universities, and tuition fees are similar in the North and in the South of the country. According to the Lupi - Ordine (2006) analysis of students’ choice to attend universities located in a region different from the region of residence, low mobility appears to be related to the effect of family income and other financial and background characteristics. In particular, by estimating a multi-level model which allows for variable parameter estimates in different macroareas, they report that the mobility of southern students is significantly constrained by family income. In general, the fall in labour mobility from the South to the Northern areas is considered as a possible explanation for the increase in regional disparities in Italy.¹ Dis-

¹ See, among others, Baici - Samek Lodovici (2001), Brunello et al. (2001), Sestito (2002).
parities in the regional economic performances have also been related to the functioning of the credit market.\textsuperscript{2} Undoubtedly, credit market inefficiencies may influence moving costs and be in part responsible of the low geographical mobility in Italy.

In what follows we implement an econometric exercise and we add some empirical evidence to the fact that the specific institution attended matters for students’ wage prospects. The study is intended to evaluate if southern workers earn a wage premium from studying in an university located in a northern or central area of the country.\textsuperscript{3} The empirical evidence is based on 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. Tables 1 and 2 report the variables used in the empirical analysis and the main statistics.

Our empirical research cannot ignore the fact that selection bias may be a serious obstacle for causal inference from observational data. It is well understood that students are systematically sorted across institutions and operate their choice of moving on the basis of individual and family characteristics known to be associated with superior labor market outcomes, so that pre-college characteristics must be effectively controlled to obtain meaningful estimates of university effects. At the same time, the final individuals’ job location is also influenced by individual features and job opportunities.\textsuperscript{4} In order to take into account selection bias, we employ a propensity score matching method. We match on the predicted probability of moving, as determined by observed individual variables. As it is well known, propensity score matching is a method that allows to reduce the bias due to non-random assignment of subjects to the treatment and control groups.\textsuperscript{5} In practice, this bias is reduced if the comparison of outcomes is performed on similar treated and control subjects. The outcome of interest in the treated state is the wage $W_1$ that might be earned by southern workers that attended universities located in the north or in the central area of the country. We denote with $W_0$ the earnings associated with attending an university located in the South. These are potential outcomes, since we observe just one of $(W_1, W_0)$ for each person.

\textsuperscript{2} A paper of Guiso \textit{et al.} (2004) studies the effect of differences in local financial development and estimates an indicator of financial development for Italian regions.

\textsuperscript{3} The macroareas are the ISTAT geographical areas North, Center and South.

\textsuperscript{4} Recent studies of the effect of college attendance for the USA yielded mixed findings that depend on the different methods used to adjust for selection bias and on the specific data set used (Black - Smith, 2003; Dale - Krueger, 2002).

\textsuperscript{5} For a discussion see Cameron - Trivedi (2005), Becker - Ichino (2002), Black - Smith (2003).
We indicate with $D = 1$ the occurrence of the treatment (the individual studies in northern or central universities) and with $D = 0$ the absence of the treatment. Finally, we assume that $Z$ are the variables affecting both the university choice and the wage outcome. The propensity score is defined as the conditional probability of receiving a treatment given pretreatment characteristics:

$$p(Z) = \Pr(D = 1|Z) = E(D|Z)$$ (1)

**Table 1 – Summary statistics**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Percentages</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>48%</td>
<td>12153</td>
</tr>
<tr>
<td>Females</td>
<td>52%</td>
<td>12925</td>
</tr>
<tr>
<td>University North</td>
<td>36%</td>
<td>9278</td>
</tr>
<tr>
<td>University Center</td>
<td>45%</td>
<td>11609</td>
</tr>
<tr>
<td>University South</td>
<td>19%</td>
<td>5119</td>
</tr>
<tr>
<td>Employed</td>
<td>71%</td>
<td>25678</td>
</tr>
<tr>
<td>Employed temporary</td>
<td>19%</td>
<td>4948</td>
</tr>
<tr>
<td>Dependent worker</td>
<td>62%</td>
<td>11302</td>
</tr>
<tr>
<td>North</td>
<td>39%</td>
<td>10083</td>
</tr>
<tr>
<td>Center</td>
<td>32%</td>
<td>8312</td>
</tr>
<tr>
<td>South</td>
<td>29%</td>
<td>7611</td>
</tr>
<tr>
<td>Movers</td>
<td>17%</td>
<td>4328</td>
</tr>
<tr>
<td>University North and Job in South</td>
<td>6.1%</td>
<td>265</td>
</tr>
<tr>
<td>University South and Job in North</td>
<td>9.1%</td>
<td>393</td>
</tr>
<tr>
<td>University Center and Job in South</td>
<td>68.4%</td>
<td>2962</td>
</tr>
<tr>
<td>University North and Job in Center</td>
<td>8.4%</td>
<td>366</td>
</tr>
<tr>
<td>University South and Job in Center</td>
<td>8%</td>
<td>342</td>
</tr>
<tr>
<td>University in the city of residence</td>
<td>37%</td>
<td>9848</td>
</tr>
<tr>
<td>Degree needed for job</td>
<td>72%</td>
<td>15405</td>
</tr>
<tr>
<td>Father with a university degree</td>
<td>25%</td>
<td>6402</td>
</tr>
<tr>
<td>Mother with a university degree</td>
<td>17%</td>
<td>4362</td>
</tr>
<tr>
<td>Married</td>
<td>29%</td>
<td>7432</td>
</tr>
<tr>
<td>High school leaving grade</td>
<td>49.41 (mean)</td>
<td>26606</td>
</tr>
<tr>
<td>University leaving grade</td>
<td>82.06 (mean)</td>
<td>26606</td>
</tr>
<tr>
<td>Degree cum laude</td>
<td>71%</td>
<td>6278</td>
</tr>
<tr>
<td>Degree on time</td>
<td>27%</td>
<td>6957</td>
</tr>
<tr>
<td>Home ownership</td>
<td>1.7%</td>
<td>438</td>
</tr>
<tr>
<td>Actual wage</td>
<td>1129 (mean)</td>
<td>16252</td>
</tr>
<tr>
<td>Expected wage</td>
<td>1367 (mean)</td>
<td>7196</td>
</tr>
</tbody>
</table>

*Notes: “High school leaving grade” ranges from 36 to 60. “University leaving grade” ranges from 60 to 110. “University (·) and Job in (·)” are percentages on total movers. “Degree cum laude” indicates the percentage of individuals that received the *laude* on individuals that graduated with a 110/110 mark. “Home ownership” is a dummy variable indicating home ownership of movers in the city where the university is located. “Actual wage” indicates the actual monthly wage. “Expected wage” indicates the minimum monthly wage desired.*
If for a population of $i$ individuals the propensity score $p (Z_i)$ is estimated, it is possible to evaluate the mean effect of the treatment, i.e. studying in regions different from the region of residence, on wages. Hence, we are interested in evaluating:

$$ATT = E (W_{1i} - W_{0i}|D_i = 1)$$

$$= E [E [W_{1i}|D_i = 1; p (Z_i)] - E [W_{0i}|D_i = 0; p (Z_i)]|D_i = 1]$$ (2)

The validity of the propensity score matching relies on the Conditional Independence Assumption which states that the outcome in the baseline state is independent of the treatment conditional on some set of observed covariates $Z$. More precisely, observations with the same propensity score must have the same distribution of observable characteristics independently of treatment status. A variety of methods exist for implementing matching which differ in the specific weights assigned to each comparison group observation.

We estimate propensity score for southern employees using a specification that includes variables such as individual attributes, family background, high school leaving grade, degree subject, home ownership in the city where the university is located and the ratio of actual to expected wage. We select our $Z$ variables to include factors expected to affect both the students’ transitions and the outcome in the baseline state. In particular, home ownership should allow us to control for family income while the ratio of actual to expected wage should alleviate the problem of self selection in job location.
Propensity score estimations pass standard balancing tests. In Table 3 and 4 we show the average treatment effect on southern employees of moving toward universities located in northern and central areas respectively. Although these results have just a descriptive interest, they highlight that the impact of moving on wages is significant for southern workers. Using propensity score matching, the null hypothesis of no effect of transition on wages can be rejected. The evidence for a positive effect is stronger for southern individuals that attended universities located in the North (ATT = 0.193) than for students that attended universities in the central area of the country (ATT = 0.144)

### Table 3 – ATT estimation with Nearest Neighbor Matching Method for the impact of “University in North and Job in South” on wages

<table>
<thead>
<tr>
<th>N. treated</th>
<th>N. control</th>
<th>ATT</th>
<th>Analytical Standard Errors</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>97</td>
<td>1082</td>
<td>0.193</td>
<td>0.066</td>
<td>2.908</td>
</tr>
</tbody>
</table>

Notes: The propensity score specification includes individual attributes, family background, high school leaving grade, degree subject, home ownership in the city where the university is located and the ratio of actual to expected wage. The treatment is studying in a northern university on wage of southern workers. Control variables are dummies for: gender, degree subjects, degree on time, degree cum laude, degree needed for job, dependent worker, employed temporary.

### Table 4 – ATT estimation with Nearest Neighbor Matching Method for the impact of “University in Center and Job in South” on wages

<table>
<thead>
<tr>
<th>N. treated</th>
<th>N. control</th>
<th>ATT</th>
<th>Analytical Standard Errors</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>666</td>
<td>768</td>
<td>0.144</td>
<td>0.057</td>
<td>2.519</td>
</tr>
</tbody>
</table>

Notes: The propensity score specification includes individual attributes, family background, high school leaving grade, degree subject, home ownership in the city where the university is located and the ratio of actual to expected wage. The treatment is studying in a central university on wage of southern workers. Control variables are dummies for: gender, degree subjects, degree on time, degree cum laude, degree needed for job, dependent worker, employed temporary.

To some extent, these results are related to educational quality differentials between universities. In the presence of such differentials, we could reasonably expect significant disparities in the returns of education depending on the specific institution attended. However, it is not clear how these differences may arise in a context where universities basically manage the same amount of resources per student. In fact, Italian universities operate within a so called cost sharing system, where the students’ tuition fees have only a marginal impact on their budgets and the main source of funding are government allowances. While many works (among others see De Fraja - Iossa, 2002; Epple et al., 2000) try to explain differences in the supply of higher ed-
ucation by universities that autonomously set tuition fees, the issue of quality differentials in a centralized system has not been widely considered in the literature. We believe that at the root of educational quality differentials there might be the monopolistic power of the universities originated by the structural socioeconomic features of the regional economies. In this setting, in order to pursue a rent seeking behavior, a political governance of the non-profit institutions may arise. This may imply that in the less developed areas, the university governance maximizes the probability of re-election by reducing quality and devoting resources to activities that only generate political consensus.

3. THE THEORETICAL MODEL

We consider an economy that can be described as a circular city (Salop, 1979) where a finite number \( J = 3 \) of universities, exogenously located along a circle of circumference \( J \), compete to attract students supplying different levels of educational quality.

The universities are located at the same distance from each other and give rise to \( J \) regional markets. In each market, there is a continuum of individuals whose total number is \( \frac{M}{J} \), which are assumed to be located uniformly along the circle arch of length 1. An individual location is indexed by \( z \in [0, 1] \) in each regional market. The individuals choose to invest in human capital and may incur in moving costs to reach the universities. In this economy two firms operate (\( f = 1, 2 \)). The firms are exogenously located on the circle and set production on the basis of technology \( T \) and compete to employ individuals. The economy lasts \( p = 0, 1, 2, \ldots \infty \) periods, agents are risk neutral and they discount the future at a rate \( r \).\(^6\) We assume that \( r \) is not compatible with agents’ collusion.\(^7\)

We model a strategic interaction process where there are strategic complementarities between the educational choice of individuals and the technological choices of firms.\(^8\) At the same time, we assume that the universities choices in terms of quality spill over on productivity and wages.

---

\(^6\) Since individuals know their ability, all the following results would hold even if they were risk adverse.

\(^7\) In fact, any credible punishment arising from «Nash reversion strategies» in the presence of moving costs always gives rise to positive surplus/profits for firms and universities. Consequently, in this setup in order to have collusion we should observe very high discount rates.

\(^8\) Strategic complementarity is defined as in Acemoglu (1996).
Usually, the education quality is measured by some outcome or structure indicators such as the student-teachers ratios, the class size, the students’ marks or the proportion of students who terminate on time. However, these measures may contain some ambiguities. In our study we define the quality of education as the set of scientific and technical skills provided by the university that rise the individuals’ productivity.

We consider moving costs as determined by the characteristics of the local socioeconomic environment so that these costs may be influenced by the degree of efficiency of the local credit market, the educational and cultural background of the local collectivity, the performance of the labour market.

The theoretical setup considers exogenous location of firms and universities. An analysis of firms’ location choices is beyond the purpose of the present paper, and treating university location as exogenous is consistent with the Italian institutional setting, where decisions about the universities’ placement are taken by the central government on the basis of considerations that are not necessarily related to the model proposed here. Subscripts are suppressed for simplicity when this does not generate confusion.

The individuals

Individuals maximize an utility function, $u(\cdot)$, expressed in terms of wages $w(\cdot)$ and the cost of education $c(\cdot)$. Both functions $w(\cdot)$ and $c(\cdot)$ are determined by individuals’ ability. We assume that there exist two types of individuals with ability $\theta_i$, $i = h, l$ with $\theta_h > \theta_l$, and $\gamma = \text{prob} (\theta = \theta_h) \in (0, 1)$. The individual’s ability is his own private information as in the Spence (1973) model, but $\gamma$ is common knowledge. Hence:

$$u(w, e, q_j | \theta) = w(e, \theta_i, q_j, T) - c(e, \theta_i, q_j) \quad u_{q_j}(\cdot) > 0, \quad u_{\theta_h} q_j(\cdot) < 0 \quad (3)$$

where $q_j \in [0, q_{max}]$, $q_{max} > 0$, indicates the quality of education supplied by the attended university $j, j = 1, 2, \ldots J$.

Before entering in the job market the individual can obtain a level of education $e \in [0, \bar{e}]$, $\bar{e} > 0$, involving monetary and non-monetary costs represented by the twice differentiable function $c(e, q_j)$. We assume that:

$$c_q(\cdot) > 0, \quad c_e(\cdot) > 0 \quad (4)$$

Moreover, we assume that the so-called “single cross property” holds only if $q > 0$. Hence:

$$c_e (e, \theta_i, q_j) > c_e (e, \theta_h, q_j) \quad \text{iff} q_j > 0 \quad (5)$$

This implies that if the individual acquires education of quality $q = 0$ the single cross property disappears and the marginal cost of education is identical for individuals with different ability. We assume also that:
where \( c_{qe} \) is the cross partial derivative of the cost function with respect to the level and the quality of education. The implications of (6) are illustrated in Figure 1 where we show that a reduction in the quality of education lowers the effort of low ability more than the effort of high ability individuals. The net effect of a decrease in \( q \) results in the fact that the indifference curves become less distant from each other.

Each firm employs workers in order to produce the final output. Before hiring a worker the firm has to decide the technology to adopt. In particular, the firm can choose between high or low technologies. We indicate \( T = \{HT, LT\} \) the firm’s investment in high or low technology respectively. The cost of technology \( HT \) is given by \( \delta > 0 \) while the cost of technology \( LT \) is normalized to zero. Following Acemoglu (1997), the average productivity per worker is given by:

\[
y = y(e, \theta, q, T) = e_0 + e(q_j + \varepsilon \times 1_{\{\theta=\theta_j, T=HT\}})
\]

where \( e_0 \) is a constant and \( \varepsilon > 0 \). From (7) it appears that the high technology is complementary only to the high ability workers. The workers productivity is a linearly increasing function of education when \( q \geq 0 \). Equation (7) assumes a scenario where the effect of education on worker’s productiv-

**Figure 1** - The effect of a decrease in education quality on individuals indifference curves
ity depends on the quality of education and on the match between high ability individuals and high technology. *Ceteris paribus* a high ability worker from a university of high quality produces a higher output. The wage is set by firms competing *à la* Bertrand to hire workers.

The universities

The theoretical framework of this paper considers economies that use a kind of higher education financing method called cost-sharing, where the main sources of university funding are the government allowances, and the students’ fees have only a marginal impact on the university resources (for a detailed discussion see Johnstone, 2003).\(^9\) The existing literature on education supply discusses when it is appropriate to introduce profit maximizing behavior for the objective function of universities.\(^10\) In our theoretical model, we assume that the behavior of universities may be driven by political intents and the educational quality may be used as a strategic device.

We assume that the university’s objective function derives from the strategic behavior of the internal political membership in period \(p\), who maximizes the probability \(\rho\) (\(0 \leq \rho < 1\)) of being re-elected in period \(p + 1\). This probability may be expressed as:

\[
\rho_{p+1} = h[q_{j,p}, \pi_{j,p}(q_{j,p})]
\]

(8)

where \(h(\cdot)\) is a generic “well behaved” function, \(q_{j,p}\) is the quality fixed by university \(j\) in period \(p\) and:

\[
\pi_{j,p}(q_{j,p}) = [S - C(q_j)]X_j(q_j, q_{-j})
\]

(9)

is the revenue generated by the university’s governance, with \(X_j(\cdot)\) representing the enrollments’ demand for university \(j\), \(C(\cdot)\) the unit cost per student and \(S\) is the government subsidy per student.

\(^9\) The cost-sharing funding method became widespread in the European economies during the last ten years. The impact of student fees on the total university funding is less than 15% on average (see OECD, 2004, 2006).

\(^{10}\) Rothschild - White (1955) consider the issue of competitive pricing and allocative efficiency for higher education. At the same time, Winston (1999) puts forward the limits of the use of standard profit maximizing theory for the analysis of education supply. In any case, these approaches refer to universities that can set autonomously fees and admission rules. On the other hand, Dranove - White (1994) present theoretical arguments suggesting that no-profit organizations behave as profit maximizers and Kemnitz (2003) considers the universities as profit-maximizer agents because of the intent of having additional resources for teaching or research expenditures.
In equation (8) we are assuming that the probability of being re-elected in period \( p + 1 \) is a function of the quality \( q \) fixed in period \( p \). An increase in \( q \) obtained by increasing the quality of the academic staff rises the utility of high quality professors since they prefer to be employed in a high quality institution and, consequently they will sustain a membership investing in high quality. In this case, the higher is the quality set in period \( p \), the larger is the political consensus that the membership will have in period \( p + 1 \). At the same time, we assume that the probability of being re-elected is a function of the additional resources, \( \pi(\cdot) \), that the membership is able to generate given the subsidy \( S \). The membership can spend this surplus in activities (larger administrative staff, standard teaching activities) that do not directly affect the education quality but generate a general consensus and increase the probability of re-election.\(^{11}\)

In this context we assume that each university has the following objective function:

\[
\max_{q_j} \Pi^u_j = [S - C(q_j)]X_j(q_j, q_{-j}) + \alpha q_j
\]

\[
\text{s.t.}\]

\[
S - C(q_j) \geq 0 \]
\[
X_j(q_j, q_{-j}) > 0
\]

where \( \alpha > 0 \) is a parameter, the cost function is increasing in quality, and the demand is a continuous function of the quality \( q_j \) and of the quality supplied by other universities \( q_{-j} \) operating in the whole economy:

\[
C_q > 0 \quad C_{qq} \geq 0
\]
\[
\frac{\partial X_j}{\partial q_j} > 0 \quad \frac{\partial X_j}{\partial q_{-j}} < 0
\]

In Figure 2 we show how the university’s quality is determined assuming that there exists a value \( q^*_j \) that maximizes \( \pi(\cdot) \). Notice that given \( \alpha \) the quality choice \( q^*_j \) that maximizes \( \Pi^u \) depends on the size of \( \pi(\cdot) \).

The timing of the model

The strategic interaction process is analyzed considering sequential moves that lead education to be a signal of individuals’ ability unless the quality is set to zero.

\(^{11}\) The use of political economy models to justify the adoption of inefficient policies and inefficiencies in the bureaucratic organization of the state is not new in the literature. Acemoglu et al. (2006) show that the expansion of the size of bureaucracy may be an instrument to gain additional votes.
Following the Harsanyi (1967/68) approach, we assume that the timing is as follows. Each period $p$ is characterized by $t = 0, 1, \ldots, 4$ instants of time. At time $t = 0$ Nature chooses the ability of the individuals, at $t = 1$ elections take place in each university and then the elected membership sets the quality $q$ that all agents can observe. At $t = 2$, given the quality choices of the universities, the individuals decide where they want to study and the level of education, considering the distance from the universities. At $t = 3$, the firms observe the level and quality of education of the individuals and make the technological choices. At the same time, the firms make their wage offers. At $t = 4$ the individuals accept one of the wage offers. The game is repeated for $p = \infty$ periods. The equilibrium concept used to solve the model is the perfect Bayesian equilibrium (PBE) consistent with forward induction reasoning (Kohlberg - Mertens, 1986) that allows us to exclude PBE characterized by unreasonable beliefs. This is also consistent with the Intuitive Criterion (Cho - Kreps, 1987).
The equilibrium

We consider the equilibrium when individuals incur in moving costs which depend on their origin area.\textsuperscript{12} Figure 3 describes the general setup. We indicate the area delimited by universities $j = 1$, and $j = 2$ as area $A_1$; the area delimited by universities $j = 2$, and $j = 3$ as area $A_2$; the area delimited by universities $j = 1$, and $j = 3$ as area $A_3$. The total cost of acquiring education in university $j$, for an individual located at a distance $d$, is $c(e, \theta_j, q_j) + d\tau$, and $\tau/2$ can be thought of as the cost per unit of distance travelled by the individual in going to and from university $j$’s location. At the same time, the net wage obtained in firm $f$ is $w(e, \theta_j, q_j, T) - \nu\tau$, where $\nu$ is the distance of an individual from the firm 1’s location. To consider asymmetric moving costs, we assume that individuals located in the area $A_1$ incur in higher moving costs per unit of distance travelled, denoted by $\xi$, than people located in the area $A_2$ and $A_3$, which have costs indicated by $\tau$, with $\tau < \xi$. We first assume that firms are located symmetrically with respect to $A_1$. Later we discuss the implications of an asymmetric firms’ positioning.

While a detailed discussion of the equilibrium is presented in the Appendix, we point out some interesting results deriving from the analysis of the equilibrium strategies of the universities. The quality level set by the universities located in the area where individuals face high travelling costs is lower than the quality level set elsewhere. In particular, in equilibrium we have that:

\begin{align*}
q_j &= \hat{q} \quad \text{if} \quad j = 1, 2 \\
q_j &= q^*_3 > \hat{q} \quad \text{if} \quad j = 3
\end{align*}

(13)

High moving costs imply stronger monopoly power for universities, and lead them to supply lower-quality education and accept the resulting reduction in student enrolment. The low quality of education $\hat{q}$ also implies a separating equilibrium, in which the high ability individuals need to acquire a higher education level in order to signal their ability.

4. Policy implications

An interesting exercise consists in evaluating the impact of different policy measures in order to rise quality in different areas. First of all, we may show that an increase in governmental subsidies $S$, is more effective in in-

\textsuperscript{12} In Ordine and Rose (2007) we discuss and evaluate the equilibria that may arise in all possible scenarios without moving costs and with symmetric and asymmetric moving costs.
increasing the education quality in universities facing the demand of individuals from lower moving costs area. As proved in the Appendix, we have that:

\[
\frac{\partial q_3}{\partial S} > \frac{\partial q}{\partial S}.
\]  

(14)

At the same time we show that rising subsidies or changing moving costs may have an impact on quality which depends on the relative size of moving costs and on the margin of profits per student of the universities. We show that it is worthwhile to rise subsidies instead of reducing moving costs only if:

\[
\xi^2 + \tau \xi - \tau [S - C(\hat{q})] > 0
\]  

(15)

The values of \(\xi\) for which condition (15) is satisfied are graphically illustrated in Figure 4 where \(\xi_0 = -\frac{\tau + \sqrt{\tau^2 + 4\tau(S - C(\hat{q}))}}{2}\). Since \(\xi > \tau\) must hold, two scenarios may arise:

- \(\xi_0 \leq \tau \Rightarrow\) It is always worthwhile reducing the marginal moving cost instead of increasing the direct subsidy to the universities.
- \(\xi_0 > \tau \Rightarrow\) In case of extremely wide regional disparities (\(\xi > \xi_0\)) an increase in \(S\) generates a greater improvement in education quality than a reduction in \(\xi\). In case of small regional disparities (\(\tau < \xi < \xi_0\)) reducing the marginal moving cost yields to a greater quality improvement than the one obtained by increasing the direct subsidy.
In terms of the individuals’ wage and moving behavior we remark that the presence of travel costs makes some individuals strictly prefer working for one of the two firms even when wages are the same. In our model, the symmetry in firms’ location with respect to the area with the higher travel costs generates no differences in firms’ productivity. If we remove this symmetry assumption, the market power of the firm closer to the highest travel costs area can be used only on individuals that have a lower productivity, because of the low education quality received. In this case a firm always performs at low productivity. It is interesting to notice that in a dynamic setting this productivity gap may imply increasing regional disparities.

In a scenario characterized by productivity and wage differentials it becomes essential to consider the effects of using a vouchers scheme as a short run policy instrument in order to attain both social equity and productive efficiency. It is well known that “the” effect of voucher programs is hard to pin down, as outcomes may differ widely under various schemes. Details concerning funding, targeting and discretion in the use of vouchers may greatly affect the outcomes associated with any particular vouchers program. A vouchers scheme designed for students resident in less developed regions willing to study elsewhere, may increase the quality supplied by local universities by reducing moving costs and by increasing competition. However, the effectiveness of any vouchers scheme in terms of quality improvement depends on how strong is the monopoly power of universities competing to attract students. According to our model this solution may be effective only in case of limited regional disparities ($\tau < \xi < \xi_0$). As indicated above, details are crucial in determining the outcomes of the vouchers. In particular, it is essential to consider both ability and income sorting. This would reduce deadweight losses arising from financing students who would study far from home even without the voucher. The issue of timing is also relevant since vouchers issued late may be ineffective in improving quality in the presence of an imperfect credit market. Moreover, we cannot ignore that quality differentials could not be perfectly observed by individuals. In this case, a vouchers scheme could generate a sort of “university-race” increasing the amount of resources devoted to advertising. In this sense, ris-

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13 See Neal (2002) for a discussion on vouchers and the market of education.
14 Vouchers issued one or two years late would be completely ineffective in improving the quality of education both outside and within the less developed regions as they only work as a reimbursement for rich individuals. For example, the vouchers for “Alta Formazione” issued by Regione Calabria to finance post graduate education (www.osiridecalabria.it) in the POR program are liquidated to eligible students only years after the beginning of the post graduate course.
ing the individuals' information about universities characteristics and students' performance is crucial in order to improve competition and quality.

Another interesting issue is the evaluation of the impact of increased autonomy of universities in enhancing the effects of policy measures. There is currently a broad tendency towards decentralization of education systems. This process transfers decision-making powers, in administrative and/or financial matters, from central Ministries of Education to local governments, communities, and universities. There may be good theoretical reasons for decentralizing education systems, but the effects of decentralization reforms depend on a variety of factors. Decentralized education provision promises to be more efficient, better reflect local priorities, encourage participation, and, eventually, improve coverage and quality. However, decentralization raises a number of issues regarding efficiency of the various forms of university finance (Kemnitz, 2003) as well as the character and intensity of competition between universities (De Fraja - Iossa, 2002). In our model, a side effect of increased autonomy may arise through an increase in the monopoly power of local institutions.

Finally, considering the results of the empirical exercise we should observe that, if the advantage of attending universities located in the north of
the country is partly due to differences in instructional quality as conditioned by faculty-student interaction, then college effects would possibly grow over time as the correlation between the quality of students and the quality of faculty increases with improved sorting of students by ability. This would imply a further increase in regional disparities due to the emergence of peer effects (Epple et al., 2000).

5. Conclusions

In this paper we analyze the supply of higher education and we show that the quality of education is in part determined by student mobility costs, which may in turn reflect such features of the local socioeconomic environment as the efficiency of the local credit market, the educational and cultural background of the local collectivity, and the performance of the regional labour market. We show that if moving costs are asymmetric, in the areas where they are relatively higher, the quality of education is lower than the quality supplied elsewhere.

Moving costs determine an increase in the monopoly power of local universities which may choose to loose part of the potential demand of education and lower the education quality. In our model this implies that the level of firm productivity in less developed areas with high moving costs is also low. These results are relevant when discussing educational and growth policies of economies with regional disparities. This is the case of many European economies and of Italy among them. We argue that when the system of funding is centralized and based on a fixed amount of subsidy per student, increasing this subsidy may not be effective in improving the education quality in less developed areas. When regional disparities are limited, efficiency gains can be obtained by reducing moving costs instead of increasing direct subsidies. An increase in governmental subsidies might just rise the monopoly power of local institutions and might not be useful in reducing disparities. In this respect, the effectiveness of any vouchers scheme in terms of quality improvement also depends on the extent of regional disparities. These conclusions are consistent with the results of Aghion et al. (2005) who highlight that regions investing more in higher education do not necessarily grow faster. In our model it is crucial how governmental subsidies are distributed in order to improve the quality of education, the firms productivity levels and the regional macro performances. The monopoly power of local universities may effectively be regulated by modifying structural characteristics and institutions operating in the regional economies. Inefficiencies in the credit market and liquidity constraints, for example, may imply high mobility costs and consequently influence the supply of quality.
The labour market performance and the local rate of unemployment also might strongly influence the individuals' choice of moving and consequently the incentive of local universities to improve quality.

Our results give some hints for evaluating the outcome of the decentralization process that Italy, as well as many countries, is recently experimenting. While there may be good theoretical reasons for decentralizing education systems, in our model a side effect of increased autonomy may arise through an increase in the monopoly power of local institutions.

The results of the empirical exercise show that in Italy the returns to education are higher for southern workers that attended universities located in the north of the country. If the advantage of attending universities located in the North is partly due to differences in instructional quality, then college effects would possibly increase over time as the correlation between the quality of students and the quality of faculty increases with improved sorting of students by ability. This would imply a further increase in regional disparities.

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In order to find the PBE of the game we need to find the Nash equilibrium in the simultaneous move game among universities. To keep things treatable, we assume that it is always worthwhile for a high ability individual to acquire education so that:

\[ w(e, \theta_h, q_j, HT) - c(e, \theta_h, q_j) - \tau(v + d) > 0 \]  

(16)

We define the Bayesian equilibrium as the profile of strategies and beliefs \( \sigma^* = (\sigma^*_j, \sigma^*_M, \sigma^*_f, b(e)) \) where \( \sigma^*_j, \sigma^*_M, \sigma^*_f \), represent universities, individuals and firms strategies respectively and \( b(e) \in [0, 1] \) is the firms' beliefs function, i.e. the probability that a worker with education \( e \) is a high ability type derived using the Bayes rule.

**Proposition 1** The following profile of strategies and beliefs \( \sigma^* = (\sigma^*_j, \sigma^*_M, \sigma^*_f, b(e)) \) is the only PBE of this game consistent with reasonable beliefs:

\[
\sigma^*_j = \left\{ \begin{array}{l}
\text{set } q_j = \hat{q} \text{ if } j = 1, 2 \\
\text{set } q_j = \hat{q}_3 > \hat{q} \text{ if } j = 3
\end{array} \right.
\]  

(17)

\[
\sigma^*_f = \left\{ \begin{array}{l}
\text{choose } d = d_{\text{min}}, e = e^{sj} \text{ iff } \theta = \theta_h \text{ in A1} \\
\text{choose } d = d_{\text{min}}, e = e^{sj} \text{ iff } \theta = \theta_i, z \in [0, z] \cup \left[ \frac{1}{2}, 1 \right] \text{ in A2 or A3} \\
\text{choose } d = d_{\text{max}}, e = e^{sj} \text{ iff } \theta = \theta_h, z \in \left( z, \frac{1}{2} \right) \text{ in A2 or A3} \\
\text{choose } e = 0 \text{ iff } \theta = \theta_l \\
\text{accept the highest net wage offer} \\
\text{choose randomly in case of tie}
\end{array} \right.
\]  

(18)

\[
b(e) = \begin{cases} 
0 & \text{if } e < e^{si} \\
1 & \text{if } e \geq e^{si}
\end{cases}
\]  

(19)

\[
\sigma^*_f = \left\{ \begin{array}{l}
\text{choose } HT \text{ iff } e \geq e^{sj} \forall f \\
\text{choose } LT \text{ iff } e < e^{sj} \forall f \\
w = e_0 - \left( \frac{1}{2} J - v \right) \tau \text{ iff } e < e^{sj} \text{ for } f = 1 \\
w = e_0 - v \tau \text{ iff } e < e^{sj} \text{ for } f = 2 \\
w = e_0 \text{ iff } e < e^{sj} \text{ and } v = \frac{J}{4} \text{ \forall } f \\
w = y(e, \theta_h, q_j, HT) - \left( \frac{1}{2} J - v \right) \tau - \delta \text{ iff } e \geq e^{sj}, \text{ for } f = 1 \\
w = y(e, \theta_h, q_j, HT) - v \tau - \delta \text{ iff } e \geq e^{sj} \text{ and } f = 2 \\
w = y(e, \theta_h, q_j, HT) - \delta \text{ iff } e \geq e^{sj} \text{ and } v = \frac{J}{4} \forall f
\end{array} \right.
\]  

(20)
where $e_i$ indicates the level of education that generates a separating equilibrium with:

$$e^{s3} < e^{s2} \text{ and } e^{s2} = e^{s1}$$  \hspace{1cm} (21)

$d_{\text{max}}$ represents the maximum distance between the individual’s location and the contiguous universities, and $\tilde{z}$ indicates the location of an individual who is indifferent between studying in university $j$ or $-j$.

The proof of Proposition 1 is given in details in Ordine and Rose (2007) where a complete description of equilibria without assuming ex-ante exogenous differences is also presented. In what follows, we summarize the main arguments.

First we show that setting $q_j = 0$ implies that university $j$ looses all students. Suppose that $q_j = 0$. Since $q_j$ is common knowledge, education acquired in university $j$ is not a signal on individuals’ ability. The firms choose $T = HT$ and pay a wage $w^p = (e_0 + \epsilon e) + (1 - \gamma e_0)$ only if the expected profit from this choice is higher than the profit when $T = LT$ and $w_p = e_0$. Hence, the following condition must hold:

$$\gamma(e_0 + \epsilon e - w^p - \delta) + (1 - \gamma)(e_0 - w^p - \delta) \geq 0$$ \hspace{1cm} (22)

where the LHS represents expected profits in case of $T = HT$ while the RHS are profits in case of $T = LT$. Condition (22) requires $\delta \leq 0$. Since $\delta > 0$ firms never choose to invest in $HT$ and always offer a wage $e_0$ when individuals are from university $j$. Consequently no one chooses to attend university $j$.

Now consider the simultaneous move game among universities. We show that the quality level of education of university $j = 1$ and $j = 2$ is lower than the level of quality supplied by university $j = 3$.

Proof Indicate with $\tilde{z}_{An}$, $n = 1, 2, 3$; the location of an individual located in area $An$ who is indifferent between studying in university $j$ or $-j$, defined as follows:

$$u(.,q_1) - \tilde{z}_{A1}\xi = u(.,q_2) - (1 - \tilde{z}_{A1})\xi \hspace{1cm} (23)$$

$$u(.,q_1) - \tilde{z}_{A2}\tau = u(.,q_3) - (1 - \tilde{z}_{A2})\tau \hspace{1cm} (24)$$

$$u(.,q_2) - \tilde{z}_{A2}\tau = u(.,q_3) - (1 - \tilde{z}_{A2})\tau \hspace{1cm} (25)$$

Hence:

$$\tilde{z}_{A1} = \frac{u(.,q_1) - u(.,q_2) + \xi}{2\xi} \hspace{1cm} (26)$$

$$\tilde{z}_{A2} = \frac{u(.,q_2) - u(.,q_3) + \tau}{2\tau} \hspace{1cm} (27)$$
Consider the demand for education of university \( j = 1 \). This university competes to attract students from areas \( A_1 \) and \( A_3 \). Note that in searching for the best response to the quality choice of its rivals, university \( j = 1 \) can restrict itself to the intervals \( [u(\cdot; q_3) - \tau; u(\cdot; q_3) + \tau] \) and \( [u(\cdot; q_2) - \xi; u(\cdot; q_2) + \xi] \) since in other scenarios it can never increase its surplus:

\[
\begin{align*}
\tilde{z}_{A_3} &= \frac{u(\cdot, q_1) - u(\cdot, q_3) + \tau}{2\tau} \\
\text{(28)}
\end{align*}
\]

Since universities \( j = 1 \), and \( j = 2 \) are symmetric \textit{mutatis mutandis} the same scenarios are faced by university \( j = 2 \). For university \( j = 3 \) the only relevant scenario to consider is the following:

\[
\begin{align*}
X_3(q_1, q_2, q_3) &= (1 - \tilde{z}_{A_3})M + (1 - \tilde{z}_{A_2})M \text{ if } \\
\begin{cases}
\{u(\cdot, q_3) \in [u(\cdot, q_3) - \xi; u(\cdot, q_2) + \xi]\} \\
\{u(\cdot, q_1) \in [u(\cdot, q_3) - \tau; u(\cdot, q_2) + \tau]\}
\end{cases}
\text{(30)}
\end{align*}
\]

where, in equilibrium, \( \tilde{z}_{A_3} = \tilde{z}_{A_2} \). We indicate with \( q_i^* \) the best response to \( \hat{q}_i \), where \( \hat{q}_i \) is the rivals’ choice in each \( q_i \) best response search process. Since universities one and two are symmetric the Nash equilibrium must yield \( q_1 = q_2 = \hat{q} \) satisfying the following FOC:

\[
-C_{\hat{q}} \left[ M + \frac{M}{2\tau} (u(\cdot, \hat{q}) - u(\cdot, q_3^*)) \right] + u_{q_3^*} \left[ \frac{M}{2\xi} + \frac{M}{2\tau} \right] [S - C(\hat{q})] + \alpha = 0
\]

\[
\text{(31)}
\]

The maximization problem of university \( j = 3 \) gives the solution for \( q_3^* \):

\[
-C_{q_3^*} \frac{M}{\tau} \left[ (u(\cdot, q_3^*) - u(\cdot, \hat{q}) + \tau) \right] + u_{q_3^*} \frac{M}{\tau} [S - C(q_3^*)] + \alpha = 0
\]

\[
\text{(32)}
\]

We have that (31) is equal to (32) since they are both equal to zero, hence:

\[
-C_{\hat{q}} \left[ M + \frac{M}{2\tau} (u(\cdot, \hat{q}) - u(\cdot, q_3^*)) \right] + u_{q_3^*} \left[ \frac{M}{2\xi} + \frac{M}{2\tau} \right] [S - C(\hat{q})] =
\]

\[
-C_{q_3^*} \frac{M}{\tau} \left[ (u(\cdot, q_3^*) - u(\cdot, \hat{q}) + \tau) \right] + u_{q_3^*} \frac{M}{\tau} [S - C(q_3^*)]
\]

\[
\text{(33)}
\]
By contradiction assume that $\hat{q} > q^*_3$. In this case the RHS is negative since:

$$u(\cdot, q^*_3) - u(\cdot, \hat{q}) < 0$$

$$\frac{M}{\tau} C_{q^*_3} + \frac{M}{2\tau} C_{\hat{q}} > 0$$

$$\frac{M}{\tau} [C_{q^*_3} - C_{\hat{q}}] \leq 0$$

given the assumptions on first and second order derivatives of $u(\cdot)$ and $C(\cdot)$. The LHS can be negative only if:

$$[S - C(q^*_3)] \frac{M}{\tau} u_{q^*_3} < [S - C(\hat{q})] \left[ \frac{M}{2\tau} + \frac{M}{2\tau} \right] u_{\hat{q}}$$

Since:

$$[S - C(q^*_3)] > [S - C(\hat{q})]$$

and

$$\frac{M}{\tau} > \frac{M}{2\tau} + \frac{M}{2\tau}$$

we should have that $u_{q^*_3} < u_{\hat{q}}$. Since $q^* < \hat{q}$ we have that $u_{q^*_3} > u_{\hat{q}}$ and we have a contradiction.

Q.E.D.

The remaining strategies in Proposition 1 may be explained considering that, since $q^*_3 > \hat{q} > 0$ the single cross property holds and the strategies and beliefs $\sigma_M$, $\sigma_r$ and $b(e)$ represent a separating equilibrium similar to that discussed in Spence (1973) in a spatial competition setting. Intuitively, the location of an individual who is indifferent between studying in university one and three is $\tilde{z}_{A3} < 1/2$ due to quality differences between universities. In fact, in order to choose the low quality university ($j = 1$) the individual should be located closer to it. The same holds for $\tilde{z}_{A2}$. As a consequence, individuals located in the interval $(\tilde{z}_{A3}, 1/2)$ and $(\tilde{z}_{A2}, 1/2)$ choose to study in the university that is located at the maximum distance ($j = 3$) where a higher quality is supplied.
In the simultaneous move game between firms, the presence of travel costs makes some individuals strictly prefer working for one of the two firms even when wages are the same. Only individuals located at the same distance from the two firms \((v = \frac{d}{2})\) earn a wage equal to their productivity since they are indifferent about the direction of moving.

**Proof of (14)** In order to prove (14) we derive the following expressions:

\[
\frac{\partial q_3^*}{\partial S} = -u_{q_3} \frac{M}{\tau} - C_{q_3} \frac{M}{\tau} \left[ u_{q_3} - u_{q_3} + \tau \right] - u_{q_3} \frac{M}{\tau} C_{q_3} + u_{q_3} \frac{M}{\tau} \left( S - C(q_3^*) \right) - C_{q_3} u_{q_3} \frac{M}{\tau}
\]

\[
\frac{\partial q}{\partial S} = -u_{q} \left[ \frac{M}{\tau} + \frac{M}{\tau} \right] - u_{q} \frac{M}{\tau} C_{q} + u_{q} \frac{M}{\tau} \left( S - C(q) \right) - C_{q} u_{q} \frac{M}{\tau},
\]

Ignoring high order derivatives we may show that:

\[
\frac{u_{q_3} M}{u_{q_3} \left[ \frac{M}{\tau} + \frac{M}{\tau} \right]} < \frac{u_{q_3} 2M}{u_{q} \left[ \frac{M}{\tau} + \frac{M}{\tau} \right] C_{q}}
\]

This implies that:

\[
\frac{\partial q_3^*}{\partial S} > \frac{\partial q}{\partial S}
\]

**Q.E.D.**

**Proof of (15)** In order to prove (15) we compare \(\frac{\partial q}{\partial S}\) with \(\frac{\partial q}{\partial S}\).

We derive the following expressions:

\[
\frac{\partial q}{\partial S} = -u_{q} \left[ \frac{M}{\tau} + \frac{M}{\tau} \right] - u_{q} \frac{M}{\tau} C_{q} + u_{q} \frac{M}{\tau} \left( S - C(q) \right) - C_{q} u_{q} \frac{M}{\tau}
\]

and
\[
\frac{\partial \hat{q}}{\partial \xi} = \frac{u_\xi (S - C(\hat{q})) \frac{M}{2\xi}}{\tau \left[ M + \frac{M}{2\tau} (u_\xi - u_{\xi,1}) \right] - u_\xi \frac{M}{\tau} C_s + u_{\xi,1} \left[ \frac{M}{2\xi} + \frac{M}{2\tau} \right] S - C(\hat{q}) - C_\xi u_\xi \left[ \frac{M}{2\xi} + \frac{M}{2\tau} \right]}
\]

hence:

\[
\frac{\partial \hat{q}}{\partial S} > \frac{\partial \hat{q}}{\partial \xi}
\]

only if:

\[
\xi^2 + \xi \tau - \tau [S - C(\hat{q})] > 0
\]

Q.E.D.